

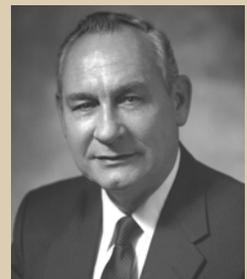
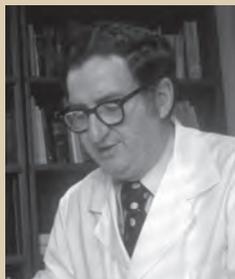
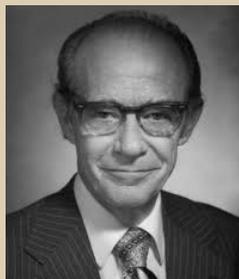


United States Department of Agriculture

Agricultural Research Service

November 2017

History of Human Nutrition Research in the U.S. Department of Agriculture, Agricultural Research Service: People, Events, and Accomplishments



On the cover:

Row 1, from left: Wilbur O. Atwater, Charles Ford Langworthy, Louise Stanley, Hazel Stiebeling, and Lelia Booher

Row 2, from left: Henry C. Sherman, Georgian Adams, Bernice Watt, Ruth Leverton, and Willis Gortner

Row 3, from left: Robert Rizek, Walter Mertz, D. Mark Hegsted, James (Jack) Iacono, and Gerald F. Combs, Sr.

Row 4, from left: Jacqueline Dupont, Barbara Schneeman, Joseph Spence, Johanna Dwyer, and Mary (Molly) Kretsch

Agricultural Research Service

**History of Human Nutrition Research
in the U.S. Department of Agriculture,
Agricultural Research Service:
People, Events, and Accomplishments**

Edited by Jacqueline L. Dupont and Gary R. Beecher

Abstract

Dupont, J., and G.R. Beecher, eds. 2017. History of Human Nutrition Research in the U.S. Department of Agriculture, Agricultural Research Service: People, Events, and Accomplishments, ARS-177. U.S. Department of Agriculture, Agricultural Research Service, Washington, DC.

Wilbur Olin Atwater (1844-1907), while an administrator at the U.S. Department of Agriculture (USDA) in the late 19th century, is credited with laying the groundwork for the science of human nutrition. His research encompassed four major areas: food intake, food composition, metabolism, and nutrition education, which he established in the programs of the Department. This publication details the major scientific accomplishments of the intramural human nutrition program of USDA from Atwater's initial efforts to the end of the first decade of the 21st century. Each chapter documents an era or segment of this program that ranges from "early beginnings" through the "Home Economics era" to more recent expansion of scientific inquiry into the relationship of foods, nutrition, and health among all age groups of this country. Many examples in these chapters demonstrate the role nutrition research plays for the American citizenry, as well as gaps in the knowledge base of diet-health interactions in guiding this mission-driven program.

Keywords: adolescents, adults, aged, Atwater, children, food composition, food intake, food preparation, infants, nutrition education, nutrient metabolism, pregnancy, research.

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November 2017

Preface

The genesis of this book came from two symposia. The first—the W.O. Atwater Centennial Celebration Symposium: An Evaluation of Progress in Human Nutrition—was held in Washington, DC, June 2-4, 1993. (The proceedings were published in the *Journal of Nutrition*, volume 124, pages 1707S-1890S, 1994.) The symposium briefly surveyed Dr. Atwater's contributions to the initiation of human nutrition research and education activities at the U.S. Department of Agriculture (USDA), but it focused primarily on the current status and future needs of these activities in the Department. The second symposium—Legacy of Wilbur O. Atwater: Human Nutrition Research Expansion in ARS/USDA—was held during the 2007 Experimental Biology (EB '07) annual meeting in Washington, DC. (The proceedings were published in the *Journal of Nutrition*, volume 139, pages 171-193, 2009.) Again, the symposium briefly reviewed Dr. Atwater's initiation of human nutrition research activities within the Department, but it highlighted the tremendous expansion of these efforts during the decades of the 1960s through the 1980s. Missing in the proceedings of the two symposia were the details and societal impacts of the achievements of USDA's many scientists and other staff members who quietly worked in their laboratories and offices for over a century since Dr. Atwater's era.

Shortly after the second symposium, Mary (Molly) Kretsch, USDA-Agricultural Research Service National Program Leader for Human Nutrition, and Pat Swan, Emeritus Professor at Iowa State University, met with Jacqueline Dupont, a co-editor of this volume, about the possibility of a manuscript that would detail the history of human nutrition activities in USDA since Dr. Atwater's initial efforts. An organizational meeting was held in early 2008 to discuss this concept, outline chapter topics, and identify potential authors.

Originally, it was conceptualized that this work would appear online only. However, as time elapsed and the wealth of information began to appear with each chapter submitted, it became apparent that a printed volume would be more appropriate to preserve this important historic information for posterity. Thus, a 13-chapter volume evolved that details scientific accomplishments and critical political development from W.O. Atwater's initial involvement to the end of the first decade of the 21st century. This volume also is available online at <http://www.ars.usda.gov/is/np/indexpubs.html>.

Each of the authors in this volume is recognized for his or her untold efforts as well as for his or her professional and detailed contribution to this work. The contributors' chapters offer a window into the operation and accomplishments of this critical nutrition-oriented governmental agency.

Jacqueline L. Dupont
Gary R. Beecher
Editors

Contents

Part I. Foundations

Chapter 1: Introduction..... 1
Jacqueline L. Dupont

**Chapter 2: Laying the Foundation,
1894-1923**..... 6
Patricia B. Swan

Part II. Advances of W.O. Atwater's Initiatives

**Chapter 3: The Bureau of Home
Economics**..... 15
Megan Elias

**Chapter 4: Research at the Beltsville
Human Nutrition Research Center,
1963-2010**..... 65
Gary R. Beecher

**Chapter 5: History of Food Composition
Activities at the U.S. Department of
Agriculture** 121
Gary R. Beecher

**Chapter 6: History of Food Consumption
Surveys Conducted by the U.S.
Department of Agriculture**..... 171
Alanna J. Moshfegh

**Chapter 7: History of Nutrition Education
at the U.S. Department of Agriculture,
1902-2011** 199
Susan Welsh

**Chapter 8: Coordination of Human
Nutrition Research Activities at the
U.S. Department of Agriculture** 239
Gary R. Beecher, Gerald F. Combs, Sr., and
J. Cecil Smith, Jr.

Part III. Regional Expansion

**Chapter 9: History of the Grand Forks
Human Nutrition Research Center** 263
Forrest H. Nielsen, Harold H. Sandstead,
and Gerald F. Combs, Jr.

**Chapter 10: Establishment of the
Children's Nutrition Research Center at
Baylor College of Medicine and Texas
Children's Hospital in 1978**..... 289
Buford L. Nichols

**Chapter 11: History of the Jean Mayer
Human Nutrition Research Center on
Aging at Tufts University**..... 299
Irwin Rosenberg

**Chapter 12: History of the Western
Human Nutrition Research Center** 303
Robert A. Jacob

**Chapter 13: Inception and History
of the Arkansas Children's Nutrition
Center**..... 326
Thomas M. Badger, Andrea C. Stokes, and
Michèle M. Perry

Index i

Recd July

Public 108

Thirty-Seventh Congress of the United States of America:

At the Second Session,

Began and held at the city of Washington, on Monday, the Second day of December, one thousand eight hundred and sixty-one.

AN ACT

Creating public lands to the several States and Territories which may provide colleges for the benefit of agriculture and the mechanic arts.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled,

That there be granted to the several States for the purposes hereinafter mentioned an amount of public land to be apportioned to each State a quantity equal to thirty thousand acres for each Senator and representative in Congress to which the States are respectively entitled by the apportionment under the census of eighteen hundred and sixty: Provided, That no mineral lands shall be selected or purchased under the provisions of this act. Sec. 2. And be it further enacted, That the land aforesaid, after being surveyed, shall be apportioned to the several States in sections or subdivisions of sections, not less than one quarter of a section, and whenever there are public lands in a State subject to sale at private entry at one dollar and twenty-five cents per acre the quantity to which said State shall be entitled shall be selected from such lands within the limits of such State, and the Secretary of the Interior is hereby directed to issue to each of the States in which there is not the quantity of public lands subject to sale at private entry at one dollar and twenty-five cents per acre to which said State may be entitled under the provisions of this act, land scrip, to the amount in acres for the deficiency of its distributive share: said scrip to be sold by said States and the proceeds thereof applied to the uses and purposes provided within this act and for no other use or purpose whatsoever: Provided, That in no case shall any State to which land scrip may thus be issued, be allowed to locate the same within the limits of any other State or any Territory of the United States but their assignees may locate said land scrip upon any of the unappropriated lands of the United States subject to sale at private entry at one dollar and twenty-five cents or less per acre: And provided further, that wherever there are mineral veins shall be located by such assignees in any one of the States: And provided further, that no new location shall be made before

Source: Act of July 2, 1862 (Morrill Act), Public Law 37-108, which established land grant colleges, 07/02/1862; Enrolled Acts and Resolutions of Congress, 1789-1996; Record Group 11; General Records of the United States Government; National Archives.

CHAPTER 1

Introduction

Jacqueline L. Dupont

Jacqueline L. Dupont, Ph.D., is a former National Program Leader for Nutrition, USDA, Agricultural Research Service, Beltsville, MD. She is currently Adjunct Professor, Department of Nutrition, Food and Exercise Sciences, Florida State University, Tallahassee, FL.



Early Recognition of Scientific Research as a Federal Responsibility

The funding of science (research and education) by the government was slow to be accepted by U.S. citizens and legislators. Recognition of the need was prompted by the James Smithson bequest to the United States in 1829 (1). There was a prolonged period of debate about use of the funds for the “...Smithsonian Institution, an Establishment for the Increase and Diffusion of Knowledge Among Men” (1). After the arrival of the Smithsonian funds, a proposal by a U.S. House of Representatives committee in 1838 called for an Agricultural Institute to be established in Washington, DC. Debate continued for years. In 1845, a bill was passed establishing the Smithsonian Institution, which did not include agriculture.

During the same era, Henry Leavitt Ellsworth, a Yale-educated attorney interested in improving agriculture, became Commissioner of Patents in 1836, a position within the Department of State (2). He began collecting and distributing new and uncommon varieties of seeds and plant materials through members of Congress and agricultural societies. In

1839 Congress established the Agricultural Division within the Patent Office and allotted \$1,000 specifically for “the collection of agricultural statistics and other agricultural purposes” (2). The Division continued to be a repository for new plant materials, began to collect data on crops in different regions of the country, and applied chemistry to agriculture. These efforts earned Ellsworth the sobriquet of “The Father of the Department of Agriculture.” The Patent Office was transferred to the newly created Department of the Interior in 1849, which heightened agitation for either a separate bureau within the Department of the Interior or for a separate Department of Agriculture.

The many years of debates by congressional committees, professional societies, and interested citizens set the stage for the establishment of the U.S. Department of Agriculture (USDA) and creation of agricultural colleges by the Morrill Act in 1862 (3,4). One of the problems encountered by the early attempts at establishing agricultural research centers was the shortage of individuals qualified as professors. The Hatch Act of 1887 led to establishment of agricultural experiment stations (5), which led to gradual increases in qualified scientists and teachers.

1894

The Yearbook of the USDA had a section devoted to physical activity in human nutrition research as it was being developed under the leadership of Dr. W.O. Atwater.



1935

The Bankhead Jones Act of 1935 required USDA to conduct research in various areas of nutritional science.

1946

The Bankhead Jones Act of 1935 was amended by the Research and Marketing Act of 1946 to more precisely define human nutrition research activities.

The emphasis in the present history is on the USDA’s intramural program of human nutrition research. As detailed in the following chapters, human nutrition research within the Department has been organized differently through the years. Over the past several decades, however, it has been organized and administered within the Agricultural Research Service (ARS), the major focus of this history. Though the USDA was the first Federal agency to conduct human nutrition research, today several other Federal agencies are engaged in important human nutrition research activities. Limiting the scope of this history to human nutrition research within the USDA is not intended in any way to diminish the importance of contributions from those other agencies.

Food and Nutrition Science Progress

Early agricultural research in Europe and later in the United States was concentrated on improving food crops and animal husbandry for human food. The State experiment stations were engaged in identifying nutrients and quantifying the quality of food based on its nutritive value to animals. This led to a greater focus on human needs, and later, requirements. The

1894 Yearbook of the USDA (6) had a section devoted to physical activity in human nutrition research as it was being developed under the leadership of Dr. W.O. Atwater (7). Human nutrition, of course, was of interest and importance to public health, medical sciences, and the military.

Debate among citizens, legislators, and professional organizations continued to be a hallmark of progress in Federal support of research including nutrition research. Agriculture appropriations bills specified nutrition research sporadically. The Bankhead Jones Act of 1935 required USDA to conduct research in various areas of nutritional science. That Act was amended by the Research and Marketing Act of 1946 (7 U.S.C. 427, 427i, 1621-1629) to more precisely define human nutrition research activities.

Continuing Legislative Oversight

Major events in the 1960s focused attention on the need for greater Federal support of all aspects of nutrition in the United States. Congressional hearings were held in 1967, and the Senate Select Committee on Nutrition and Related Needs was appointed. Prodding by the public and the nutrition

1967

Congressional hearings were held in 1967, and the Senate Select Committee on Nutrition and Related Needs was appointed.

1969

A White House Conference on Food, Nutrition, and Health was held.

1977

The Food and Agriculture Act of 1977 was passed.

1985

The Food Security Act of 1985 required the Secretary of Agriculture to submit to Congress “a comprehensive plan for implementing a national nutrition research program.”

professional community resulted in the Ten-State Nutrition Survey by the Nutrition Program of the Department of Health, Education and Welfare (HEW), now the Department of Health and Human Services (HHS) (8). These events led to a White House Conference on Food, Nutrition, and Health held in December 1969. The evolution of the public involvement and the consequences following the White House Conference, as well as their effects on the USDA, are described in this volume (9).

Culmination of all the debate was the passage of the Food and Agriculture Act of 1977. In Section 1421 (b), the Act states: “It is hereby declared to be the policy of the United States that the Department of Agriculture conduct research in the fields of human nutrition and the nutritive value of foods and conduct human nutrition education activities....” Other legislation reinforced this message.

Through the 1970s and 1980s, several reviews and evaluations of human nutrition research activities were conducted. They included a 1978 Report to the Congress by the Comptroller General (10), as well as plans for food and nutrition research and new initiatives for home economics research, extension, and higher education, both from

the USDA (11,12). The Food Security Act of 1985 (Section 1452) required the Secretary of Agriculture to submit to Congress “a comprehensive plan for implementing a national food and nutrition research program.” Such a plan was submitted in 1986 (13).

Human Nutrition Research Activity at USDA

The following chapters describe how the actual implementation of this historic evolution took place. The initial activity, from W.O. Atwater 1894 through 1923, is presented by Patricia B. Swan. The progress through the 1920s and 1930s, as well as the transfer of much of the program to ARS in Beltsville, MD, is presented by Megan Elias. Until the 1970s, Washington, DC, and the nearby suburbs of Maryland—Beltsville and Hyattsville—were the only sites for USDA intramural human nutrition activities. Following the events described through the 1970s, new research sites were developed (9). These are described with a chapter devoted to each of the centers, which include Grand Forks Human Nutrition Research Center in Grand Forks, ND; Children’s Nutrition Research Center, Baylor College of Medicine, in Houston, TX; Jean Mayer Human Nutrition Research Center

on Aging, Tufts University, in Boston, MA; Western Human Nutrition Research Center in Davis, CA; and Arkansas Children's Nutrition Center in Little Rock, AR. In addition, a chapter is devoted to research advances at the Beltsville Human Nutrition Research Center during the latter part of the 20th century and early 21st century. W.O. Atwater, in his infinite wisdom, also initiated programs that focused on food intake surveys, food composition research, and nutrition education. Chapters for each of these activities also are included, which detail their history and achievements within the Department and various agencies wherein they administratively resided.

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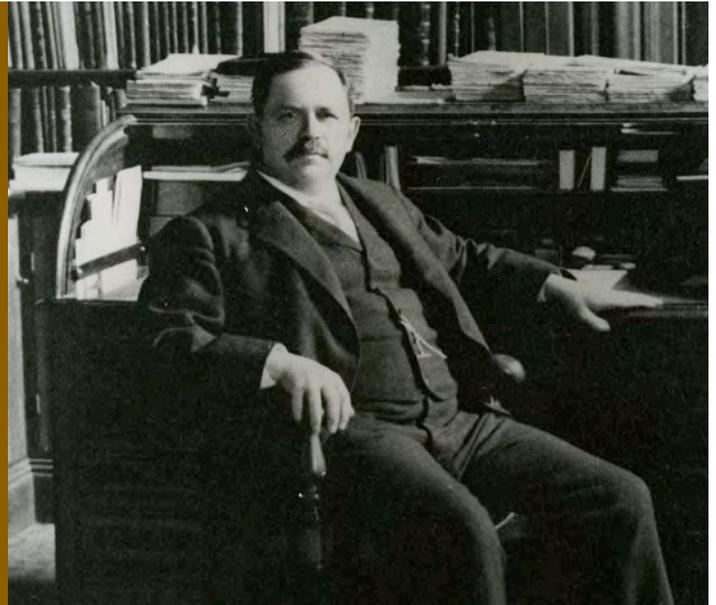
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CHAPTER 2

Laying the Foundation, 1894-1923

Patricia B. Swan

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The last quarter of the 19th century was a period of rapid change in America. Population almost doubled, largely due to immigration, as did the number of women working outside the home. People chose to settle in cities rather than on farms or in villages, and America was rapidly becoming an urban, rather than a rural, nation (1). After 4 years out of office, Grover Cleveland again won the presidency of the United States and began his second term in March of 1893. He was facing serious economic problems, both on the farms and in the cities. J. Sterling Morton, his newly appointed Secretary of Agriculture, wanted to sponsor programs that would improve the plight of both rural and urban dwellers. The ideal programs would be politically popular as well as economically helpful. With many Americans spending half of their income on food, might food provide a link between farmers and consumers and, in so doing, aid the economy?

Edward T. Atkinson, an influential businessman from Boston, MA, had some ideas for creating such a linkage. As a self-styled economist and social reformer, he was a proponent of the use of scientific and technological advances to allow the working poor to become more economically efficient.

To that end, he had invented an oven that used far less energy to cook a meal than did conventional methods, and one that he thought women could conveniently use if they had to work outside their homes. He also was interested in developing information that would allow the poor to make more economic choices for their food expenditures. While visiting Agriculture Secretary Morton soon after the Secretary took office, Atkinson suggested that the U.S. Department of Agriculture (USDA) should sponsor “food laboratories” in connection with the State agricultural experiment stations and that these laboratories would help to establish the “proper nourishment of human beings.” (2)

To test the popularity of such an idea, Secretary Morton asked Atkinson to describe it in a special bulletin (3). For additional help, Atkinson recommended that Secretary Morton involve his occasional collaborator, Wilbur Olin Atwater, a professor of chemistry at Wesleyan University and the first director of the Office of Experiment Stations within USDA, who had more experience than any other scientist in the country with studies of food composition and human food consumption (4,5,6). Welcoming the news that Atkinson had reached Secretary Morton



Charles Ford Langworthy was appointed W.O. Atwater's assistant for nutrition investigations.

Congress appropriated \$10,000 to be used for investigations leading to reports of "the nutritive value" of various foods and more "wholesome and edible rations," "more economical" than those commonly eaten.

so early in the new administration, Atwater swung into action.

Atwater had a plan. First, he suggested that a short USDA publication be issued, setting forth the studies that were needed. Then, the Secretary should offer some "inducements" to the States to undertake them (7). Atwater encouraged Secretary Morton to conduct such studies in cooperation with the agricultural experiment station in each State, noting that this would be both advantageous and feasible and the value of the studies would be "widely appreciated." (8). It would be necessary for Secretary Morton to recommend, and Congress to appropriate, special research funds as inducements.

The position of director of the Office of Experiment Stations had just become vacant, and Atwater recommended to Secretary Morton the promotion of Assistant Director Alfred C. True to fill it (9). The son of a Wesleyan professor of classics and himself an instructor in Latin, True had been associated with the office since its formation under Atwater in 1888, and Atwater emphasized the benefit of continuity. The Secretary agreed, and True became the longtime director of this office, effectively monitoring Congressional activity

in support of Atwater's push for funds for nutrition investigations (10).

In spite of an economic depression, it finally became clear that Congress would appropriate \$10,000 for the fiscal year ending in June 1895 to be used for investigations leading to reports of "the nutritive value" of various foods and more "wholesome and edible rations," "more economical" than those commonly eaten (11,12). Atwater sent Director True an outline of work to be accomplished in the first year of the new program, the structure of which became the framework for USDA's food and nutrition program for decades (13). Secretary Morton named Atwater the special agent in charge of nutrition investigations and placed the anticipated program within USDA's Office of Experiment Stations. Atwater's emphasis on scientific inquiry and his administrative abilities provided a strong foundation for the country's first national nutrition research program (14,15).

Atwater immediately sought collaborators both within experiment stations and in other institutions to begin studies of what people were eating, as well as measurements of food composition (16). He wrote a lengthy article for the Department's Yearbook (17) and also began writing the

1895

W.O. Atwater wrote the pioneering bulletin that summarized available data regarding food composition, food digestibility, known nutritional needs, and the ways in which investigations could be conducted to increase knowledge in these areas.

1896

Congress increased appropriations to \$15,000 for nutrition investigations.

1896

W.O. Atwater and Charles D. Woods published an extensive and important compilation of the composition of foods, including the energy values of many of them.

manual for potential collaborators that he had suggested earlier to Secretary Morton, setting forth the needed studies and methods to be used in conducting them. This pioneering 1895 bulletin (18) summarized available data regarding food composition, food digestibility, known nutritional needs, and the ways in which investigations could be conducted to increase knowledge in these areas. It also suggested the studies most urgently needed. For many years this bulletin served as the textbook on human nutrition investigations for researchers and educators in colleges and universities.

Atwater appointed Charles Ford Langworthy as his assistant for the nutrition investigations (19,20). A native of Middlebury, CT, Langworthy had returned from Germany in 1893 with a doctorate in chemistry and joined Atwater in his work at Wesleyan. After 2 years, USDA asked Congress to increase the annual appropriation for the nutrition investigations to \$15,000. At first, Congress vowed there would be no increased appropriations that year. Nonetheless, Atwater called on his collaborators, who were now located in all regions of the country, to urge their members of Congress to include the increase requested by the Department.

He also engaged his own effective political connections. As a result of his efforts, and with Director True carefully tracking Congressional activity, the appropriation was increased to \$15,000 beginning in fiscal year 1897 (21). By 1901, the appropriation was \$20,000 per year, remaining so for several years (22).

During the first decade of nutrition investigations, Atwater involved 22 experiment station collaborators in 16 land-grant and two 1890s colleges, as well as an additional 8 investigators associated with other institutions (23). Their work included measurement of the diets of groups such as African Americans, Mexicans, Chinese, and both wealthy and poor populations in rural and urban, institutional, and non-institutional settings. Their work also contributed information on food composition and the digestibility of foods (24). In 1896, Atwater and Charles D. Woods published an extensive and important compilation of the composition of foods, including the energy values of many of them (25). This bulletin was revised as new data became available and was the major source of such information until 1945, when a comprehensive table of food composition was published (26,27).

1901

By 1901, the nutrition investigations appropriation was \$20,000 per year and remained so for several years.

USDA Administration Building



1905

Charles Langworthy was put in charge of nutrition investigations and transferred the calorimetry work to Departmental laboratories in Washington, DC.

Atwater was keenly aware of the need to conduct fundamental research to increase understanding of the use (metabolism) of food by the body. Thus, at Wesleyan he chose to conduct his own part of the nutrition investigations by studying the energy value of foods and their ability to furnish energy in the human body. To study the energy cost of common activities, he and a physics professor constructed a respiration calorimeter in which human subjects could carry out various activities while their energy expenditure was measured (26,27). Using information about the release of energy when foods were burned in a closed laboratory system, and studies of the digestibility of these foods, he established the “Atwater Factors” that remain accurate and in use today to calculate the energy value of foods based on their chemical composition. (The “Atwater Factors” are 4 Kcals per g of carbohydrate, 9 Kcals per g of fat, and 4 Kcals per gram of protein when used to calculate energy from mixed diets.) In 1898, Atwater and Langworthy published a compilation of data from 3,600 metabolism experiments (intake of foods and subsequent excretion) that had been reported up to that time. Unfortunately, due to illness, Atwater was not able to continue his career and might have been unaware that Congress

provided funds for basic research at the experiment stations in 1906 (28). His strong advocacy of basic research during his association with the experiment stations had no doubt contributed significantly to this accomplishment.

In 1905, Langworthy was put in charge of the nutrition investigations (29), and in the following year, he transferred the calorimetry work to Departmental laboratories in Washington, DC. During the second decade of the nutrition program, he continued Atwater’s work, reporting that mechanical efficiency for subjects doing muscular work in the calorimeter was nearly 21 percent, but surprisingly, mental work took very little energy (30). No new significant areas of investigation were initiated, and emphasis within the program gradually began to shift toward more applied research on foods and their preparation for human consumption.

Around the turn of the 19th century, Langworthy had become involved with the home economics movement, playing a role in the founding of the American Home Economics Association. This led to Maria Parloa, a well-known teacher and writer on cookery, authoring two publications for the nutrition program. Shortly thereafter,

1915

Secretary of Agriculture David F. Houston formed the States Relations Service, incorporating the Office of Experiment Stations and a newly created Extension Service.

1923

Secretary of Agriculture Henry C. Wallace began reorganizing the Department's work, placing more emphasis on the home economics work by creating a separate Bureau of Home Economics.

Caroline L. Hunt, former dean of home economics at the University of Wisconsin, and Helen Atwater, daughter of Wilbur O Atwater, joined the Department's program. Both women were active in the experimental foods laboratory in Washington, DC, and both wrote several popular publications (31,32,33,34).

In 1915, the new administration of President Woodrow Wilson received pressure from farmers and consumers for more scientifically based information. In response, Secretary of Agriculture David F. Houston, working with Congress, formed the States Relations Service, incorporating the Office of Experiment Stations and a newly created Extension Service. In response to the home economics movement, Secretary Houston also included a separate Office of Home Economics, incorporating the nutrition investigations and initiating new programs in household management and textiles and clothing (35,36). Alfred True headed the States Relations Service, while Charles Langworthy headed the Office of Home Economics (37).

An almost insatiable demand from the newly created Extension Service for educational materials guiding food choice

and preparation dominated the attention of Langworthy's office. Moreover, the possibility of the Nation becoming involved in the war in Europe led to studies required for the development of a special ration for the military. After the United States became involved in World War I, the USDA, cooperating with the Food Administration, pushed for increased food production by farmers, and the Office of Home Economics advocated ways for consumers to conserve scarce food items such as sugar. This involved the production of many popular publications for consumer education (38,39,40).

By the end of the war, a new science of nutrition had developed that included the identification of several vitamins by researchers in the experiment stations and elsewhere. Not only milk but also fruits and vegetables were now considered "protective foods" and no longer "luxury items" in the diet. Ways to preserve these relatively expensive foods while they were in season and less expensive than at other times became important for farm families who were suffering as prices for their now-surplus production fell dramatically. The Office of Home Economics developed and tested guidelines for canning and other

means for preserving foods and published materials for teaching women these techniques (41). In 1921 Warren G. Harding became President of the United States, and Secretary of Agriculture Henry C. Wallace began reorganizing the Department's work, placing more emphasis on the home economics work by creating a separate Bureau of Home Economics in 1923 (37,42,43).

Thus, the nutrition program had matured over its first 30 years of existence, thanks largely to Wilbur O. Atwater, the well-known and politically astute scientist who had established the program on a firm basis by designing a program that was at the forefront of the science and by skillfully administering it, thereby fostering political support for the scientific work. Immediately following Atwater's tenure, the program periodically experienced difficulty in maintaining such support, but Charles Langworthy connected it to the home economics movement. As this movement gained popular support, so did the USDA's nutrition program. This source of support, as well as external forces such as World War I, pulled the USDA program toward application of previously developed basic knowledge rather than more fundamental research. Nevertheless, in future years, the Department would once again include basic research as part of its nutrition program, as it does today.

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CHAPTER 3

The Bureau of Home Economics

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The Beginning

For 2 days in June 1923, seven of the leaders of the home economics movement gathered in Washington, DC. Henry C. Wallace, Secretary of the U.S. Department of Agriculture (USDA), had invited them there to discuss the establishment of the national Bureau of Home Economics (BHE) scheduled to open July 1. Wallace asked the gathering to develop an organizing plan for the Bureau. The seven leaders suggested that it “be divided among the following subjects: food and nutrition, clothing and textiles, economics (including household management), equipment, eugenics (heredity and the environment, including child care), [and] art in the home (including the physical and psychological laws of color, line, and form)” (1). Wallace also asked the group to recommend a director for the new Bureau. He particularly specified that the candidate should be a “woman of executive ability.” Wallace’s belief that the position should go to a woman reflected the predominance of women in the field of home economics as well as his own apparent faith in the abilities of women to serve successfully in high-level administrative positions. One historian of the USDA also credits “considerable agitation by various women’s organizations” for Wallace’s decision to place a woman at the head of the Bureau (2).

History of USDA-ARS Human Nutrition Research

Louise Stanley—First Leader of the Bureau of Home Economics

When the advisory group chose a leader from among their own number, Louise Stanley became Chief of the Bureau of Home Economics and the highest paid woman scientist in the Federal Government. Her appointment was met with wholehearted approval from colleagues in the movement. The *Journal of Home Economics* noted that “Whatever woman had been appointed head of the Bureau, professional spirit would have put us behind her. With Miss Stanley in the position, we can pledge our support enthusiastically and confidently, individually and collectively” (3). Stanley herself felt that by the establishment of the Bureau, “The field of home economics was again broadened and this time dignified by the status of a bureau” (4).

Louise Stanley, whom the *Journal of Home Economics* described as “easy to work with” and of “broad sympathy and experience,” was born in 1883. She received a B.S. degree and a B.Ed. degree from the University of Nashville. She earned an M.A. from Columbia University and was awarded a Ph.D. in biochemistry from Yale University in 1911. She was first an instructor of nutrition in the Department of Home

Secretary of Agriculture Henry C. Wallace established the national Bureau of Home Economics (BHE) and recommended a woman be director.



Louise Stanley became Chief of the Bureau of Home Economics and the highest paid woman scientist in the Federal Government.

Economics at the University of Missouri and then, beginning in 1910, Professor and Chair of the Department, even as she was in the final year of earning her doctorate. This kind of promotion was not entirely unusual in the early days of the field of home economics, when departments were being created where there had never been any, and no pre-existing “experts” could be called in to lead the way.

As a scholar, Stanley produced work that was scientific, such as a 1911 study of phosphorus in cooked meat, and pedagogical, as when she wrote about the International Congress for the Teaching of Household Economics, held in 1913 in Belgium. In addition, Stanley had a comprehensive understanding of home economics as a movement and was active in drawing attention to developments as they happened. For many of the first generation of home economists, movement history was personal history as they defined their field and their own roles within it simultaneously.

Although she was trained as a nutritionist, Stanley saw the Bureau’s most important role as being “a link between consumers and producers.” Furthermore, the Bureau could help to shape a more efficient and responsive economy for it was “in a position

to give aid, directly toward a planned economy where consumers’ needs and production programs are coordinated” (4). Farmers would no longer have to guess at what might sell and consumers would no longer need to simply make do with whatever they found in their markets. One of the first things that Stanley did was to call a meeting of women’s groups from all over the country to find out what they wanted help with. Gladys Baker, writing of the history of the USDA, noted, “These organizations were to give her strong support throughout her tenure. She was to need them, for some of the work in home economics aroused a storm of controversy” (5).

Under Stanley’s leadership, the Bureau appears to have been a busy but also a collegial place to work. Memos from the 1920s have a humorous tone while also managing the details of Bureau life. In one 1925 memo, the entire staff is invited by one Mrs. Wharton to stop by, without calling first, at her family home any Saturday that they please to enjoy tea and sandwiches (6). Another wryly informs the staff, “It is the policy of the Bureau not to give out subject matter over the phone.” Acknowledging that some questions may be answered easily and safely, the memo goes on to note that “answers to such questions as ... what

to feed the baby, how to spend the family income, etc. should not be attempted in conversation” (7).

As part of the USDA, the Bureau had, from its inception, a responsibility to help American farmers find consumers for their products. Under Stanley’s direction, this responsibility was realized through the critical study of the nutritional aspects of agricultural products. An early study of the different nutritive qualities of yellow and white potatoes, for example, resulted in the development of a hybrid that American farmers could grow successfully and that would enrich the diets of American consumers. This particular potato study was performed in collaboration with the Bureau of Plant Industry, and it was typical for the Bureau of Home Economics to collaborate with other bureaus in the USDA as well as other government departments, such as the Food and Drug Administration.

The Bureau’s organization presented a simplified version of the divisions suggested by the 1923 advisory committee. Three divisions—the Division of Economics, the Division of Textiles and Clothing, and the Division of Food and Nutrition—covered the basic aspects of American home life. Notably lacking from this organization was the concept of eugenics, which was a topic of much popular interest in the 1920s.

As America and other industrialized nations experienced a surge of technological innovations, many assumed that humanity itself could be perfected. The dubious science of breeding humans for desirable qualities seemed exciting to many progressives of the era. In the early days of the home economics movement, Ellen Richards had recommended naming the field euthenics and organizing it as a sister to eugenics. Where eugenics would focus on the perfect individual, euthenics could supply the ideal environment for this new race. For a government agency,

however, it probably seemed unwise to create a division dedicated to something so speculative and potentially controversial as eugenics, especially as there was no obvious connection between the concepts of eugenics and the work of the USDA. The kind of breeding of animals that the USDA oversaw was not likely to be repeated with human beings. Likewise, it is not surprising that the Bureau of Home Economics did not include a division dedicated to “art in the home,” a common topic in college home economics courses. While government home economists could assist American cotton growers by working out ways to use their product in textiles and clothing, no easily identifiable group of agricultural producers would be aided by research and education in aesthetics.

A 1929 internal report on the organization of the Bureau explained the role of the Division of Foods and Nutrition: “It is important to set up food standards based on nutritional requirements, and to emphasize the importance of a more stable program of food production and distribution to meet these requirements. Flexible food standards which can be adjusted as the knowledge of nutrition increases have been developed.” The juxtaposition of the phrases “stable program” and “flexible food standards” reflected the Bureau’s dual commitment to public service and scientific innovation. Nutritional science is sometimes criticized by those who see it as simply the purveyor of the next fad, rather than an endeavor to constantly increase knowledge about humans and food. BHE nutritionists of this era were committed to keeping a collective open mind in the service of finding the best ways to feed the Nation (8).

The report went on to describe the day-to-day work of the Division, noting that it took place in “various kinds of laboratories,” each designed for a different kind of research. Studies of vitamin and mineral content of foods were performed in “nutrition

laboratories where rats and guinea pigs serve as subjects,” as many pages of invoices collected over the years can attest. The Bureau seems to have had a policy during these years of sending rats to other nutrition labs, particularly those of high schools, free of charge. Correspondence from this era indicates that the Bureau’s generosity was complicated by the fact that it only owned one travel cage. Many gentle reminders were sent out to science teachers informing them that by holding onto the cage in which their new rats had traveled, they were holding up delivery to some other equally deserving school.

Food composition work in these early years consisted of collection of data “from numerous chemical laboratories in the United States and other countries” (8). Through this data collection the Bureau performed an important service to other food scientists and nutritionists, consolidating a large body of knowledge in one place. Researchers at the Bureau could use this information to inform their own work, and the Bureau could also serve as a clearinghouse for all food composition work. As individual laboratories focused on single elements of composition, the Bureau kept track of who was conducting specific research in order to share potentially valuable information between laboratories. In 1925 Stanley headed the Committee on the Vitamin Content of Food in Relation to Human Nutrition, convened by the Association of Land Grant Colleges. Although the committee was not technically supported by the Bureau, Stanley’s work for it seems to have been part of her regular work as Chief. Her office sent out questionnaires to the heads of agricultural research stations in all the States. These research stations were affiliated with the land-grant universities. The committee had four goals: to find out what work was being done, to share that information, to establish uniformity in research practices so that results would be comparable,

and to encourage research in particular directions. The committee argued: “If the work in the different States is planned with big national problems in mind and the methods are standardized so the work will be comparable, it will be possible to prevent duplication and get a more complete study in a much shorter period of time” (9).

The two main directions for suggested research were the vitamin content of foods as affected by methods of production and the influence of methods of preparation. The committee suggested that the work could start with green vegetables and be taken up in a variety of ways—with some groups studying the variation in vitamin content, others looking at the effect of “cultural conditions” on vitamin content, and still others considering the effect of storage and canning. Responses to the committee’s questionnaires reflect the newness of the Bureau and its lack of authority in the field. Respondents, mostly male, routinely referred to the chief as “Miss Stanley” in their greetings despite the fact that the request came from “Dr. Stanley” and that some even included her title in the address on their letters. Many dismissed the request with one line stating that there was no vitamin work currently in progress and no plans to begin any.

Perhaps the least respectful response came from Nevada. The Director of the State Experiment Station for that State wrote to Stanley: “We are not conducting any vitamin projects in this Station for we have not yet found local problems in which vitamin studies will serve toward a solution.” Other experiment station leaders and extension agents answered more enthusiastically. P.F. Trowbridge, for example, of the North Dakota Agricultural Experiment Station described meat-cooking research under way for which he was scheduled to travel through his State and signed his letter “Chairman Cooking Committee.” Twenty States were involved in some type of vitamin

research at the time that the survey was conducted.

The dietary studies—the more sociological work of the Division—were performed by nutritionists in the field, and they were designed “to find out how the food habits that exist compare with the requirements usually recognized as essential for good nutrition.” Keeping both the vitamin studies and the food habits research in mind, food scientists worked in “kitchen laboratories” to develop effective methods of preservation and preparation, “working out facts about the prevention of food spoilage through canning, pickling, preserving, and refrigerating.” With the everyday consumer in mind, the Division also produced recipes “for making a wide variety of foods not only palatable and digestible, but also so attractive that they will be used in homes the country over to bring about good nutrition.” The multifaceted approach to human nutrition, making use as it did of both a central agency and State stations, seemed well designed to serve the people.

Reflecting the Bureau’s focus on the practical, one of the earliest projects under Stanley’s administration was a study of refrigerated foods. This study had the potential to help three groups: farmers, industrial manufacturers, and consumers. Electric refrigerators had newly become available for home use, and there was little understanding of how best to use them. In 1927-1928, the Bureau made a study of home refrigeration and found that out of the 2,350 homemakers from 37 States who responded to their survey, 1,337 had ice-cooled refrigerators, 56 had electric, and 857 had none. “In most cases,” the study found, “ice was used only for a portion of the year.” It seemed likely, given the common use of electric refrigerators in food processing, that these appliances would soon become more affordable for American families.

The Bureau of Home Economics study of the relationship between time, contamination, and temperature was a simple first step in helping Americans to employ new technology to their advantage. Two cubes of good-quality top round beef were stored, one in a covered dish, one uncovered, in five refrigerators kept at 35°, 40°, 45°, 50°, and 55 °F. BHE employee Anna Pabst tested the surfaces for bacteria and also tested for penetration by bacteria. The study results were “bacterial development markedly checked at temperatures of 40° F. and below” and “A decided increase at temperatures of 45° F. and above” (10).

In 1931 the People’s Ice Company seized on the findings of the study to promote their own economic interests. Noting that “A study was made of the effect of different temperatures on the increase of bacteria in meat,” the advertisement particularly drew attention to the finding that “spoilage proceeded more rapidly in tightly covered dishes.” Arguing that only ice could provide the proper temperature, humidity level, and air purity for such storage, the advertisement was designed to make readers think twice about buying one of the new electric refrigerators that used chemicals, rather than ice, to keep food cool (11). Stanley was involved in subsequent work to provide industry standards for refrigerators of both the icebox and the electric type.

Representatives from the food and appliance industries were very interested in the work of the Bureau from its earliest days, as reflected by correspondence. When Dr. Hazel Munsell, a research chemist in the Division of Foods and Nutrition, published results of a study that found that cod liver oil lost much of its vitamin content when bottled in extract form, a representative of the JP Meyer company, which had plans to produce a cod liver oil extract, wrote to ask the Division to test their product. Stanley informed the representative that this was not the Bureau’s business. Frozen food

1930

Hazel Stiebeling was appointed by Louise Stanley to head the Division of Food and Economics.



1943

Hazel Stiebeling succeeded Louise Stanley as Chief of the Bureau of Home Economics upon Stanley's retirement.

pioneer Clarence Birdseye himself, whose sister Miriam coincidentally worked at the Bureau, wrote to Munsell to ask about the effect of freezing on the vitamin content of foods. Munsell had to report that little was yet known on this subject. In the early years, this was a common refrain, as the BHE received letter after letter requesting information on some topic not yet studied. The letters showed a keen interest in the work of the Bureau and no doubt helped researchers to determine what kinds of projects would be most useful to the public.

Hazel Stiebeling—Head of the Division of Food and Economics

In 1930, Stanley made one of her most significant decisions as Bureau Chief: she hired Hazel Stiebeling to head the Division of Food and Economics. Stiebeling's first project was a survey of the eating habits of average Americans. The study would bring international attention to the Bureau, and Stiebeling would eventually replace Stanley as Chief when she retired in 1943. Stiebeling was from a farm family in Ohio. She studied at Columbia University with pioneer nutritionists Mary Swartz Rose and Henry C Sherman, earning her M.A. in nutrition in 1924 and her Ph.D. in Chemistry in 1928. With Swartz Rose and

another author, she collaborated on a study on “visualizing” nutrition that offered useful ideas about how to make nutrition knowledge accessible to non-scientists (12). The food “pyramid,” which captured the public imagination (not always favorably), is an example of this idea. With Sherman, she published a study on how to determine the quantities of vitamin A and vitamin D in diets, using rats for experimental purposes. In 1935 the *Science News Letter* reported on a similar study performed at the Bureau. The report included photographs of two dramatically different rats with the playful caption “This white rat had Vitamin D, this white rat had none” (13).

When Stiebeling and Miriam Birdseye started their survey, the Great Depression had just begun and American eating habits were in the first phase of profound change. The study was not inspired by these changes—those living at the time had no way to know how far-reaching they would be—but when the results were published, the Bureau and the public were both quick to recognize how they might help families struggling with decreased incomes. The findings were first published in 1931 as two bulletins: “Adequate Diets for Families with Limited Incomes” by Stiebeling and Birdseye and “The Family's Food at Low Cost” by Stiebeling, Birdseye, and Clyde B

Shuman, who was the Nutrition Director of the American Red Cross (14,15).

The study group included only families who were not on relief (a precursor to modern welfare), nor did it include African-American families. Although the reasons for designing the study in this way cannot be found in the records, we can guess that Stiebeling and Birdseye were attempting to study “normal” conditions, which would be a reason to exclude families on relief. In the era of pervasive discrimination and segregation, African Americans also were not considered by most European Americans to be “normal” members of American society. Specific studies of nutrition in African-American communities, however, had been conducted before the Bureau came into existence. Often, African-American colleges (Hampton and Tuskegee Normal Institutes) and their surrounding communities were the focal points for such studies (16,17,18). As early as the 1890s, W.O. Atwater, the purported “father of nutrition research in America,” and Isabel Bevier, a noted home economist, directed dietary intake studies in this population and subsequently calculated the nutritional completeness of their diets based on the then knowledge base. In 1949 African-American home economist Flemmie Kittrell published a study of nutrition of African-American families. The research, performed in cooperation with the BHE between 1935 and 1936, compared the food choices of African-American families with those of White families.

Kittrell reasoned, “The problem of proper food and nutrition is really in the hands of the one who selects and prepares the three meals a day.” In other words, nutrition is a matter of choices as much as culture and availability. Her study found “that Negro families spent money as wisely as White families. When the two groups spent the same amount for food, their diets rated good, fair, and poor in the same proportions.” How to explain, then,

that African-American families tended to have more nutrition-related illnesses than White families, proportional to their percentage of the population? Kittrell’s study revealed the intersection of race, class, and nutrition: “The records, show ... that on the whole Negro families have much lower incomes than White families and, therefore, have poorer diets in a larger proportion” (19). In later years, the work of the New Homemakers of America, the African-American version of the Future Homemakers of America, as well as home economics teachers in African-American communities, would attempt to battle this problematic convergence.

Nutrition researchers immediately began to apply the data Stiebeling and Birdseye had compiled and, even more extensively, to use the standards they proposed to study nutrition in particular populations. Stiebeling and Birdseye classified the population into groups shaped around age, gender, and level of physical activity and assigned to each an ideal calorie intake and dietary allowances for protein, calcium, phosphorus, iron, vitamin A, and vitamin C. The architecture of this classification system was integrated into the Recommended Dietary Allowances and, subsequently, into the Dietary Reference Intakes as they were developed. Stiebeling was careful to distinguish between “minimums” (the minimum requirement) and “allowances” (what was beneficial). The values that she proposed—1,500 calories for a boy between ages 4 and 6 and a girl between ages 4 and 7, for example—represented “a goodly margin of safety over the minimum” (20). The survey identified an adequate diet at minimum cost, an adequate diet at moderate cost, and a liberal diet. The diets were arrived at through scientific study but also through survey of the diets of healthy, active individuals. A.E. Harper has noted that a report Stiebeling published in 1933 based on this work “Included a set of what she called ‘dietary allowances,’” apparently

the first use of this term. Harper also credits Stiebeling with producing “the first dietary standard to include quantitative values for several vitamins and minerals” (21).

Using data from her study, Stiebeling collaborated with Martha Elliot and Agnes Hanna from the Bureau of Labor to produce the pamphlet “Emergency Food Relief and Child Health for Every Child Every Day,” which was intended as a guide for relief agencies (22). For nutritionists, in government and out, the giving of food as relief to needy families presented an opportunity to change American thinking about food. If food relief could be coordinated with the latest knowledge in nutrition, the national diet might actually be standardized in terms of nutrition. People of different cultural backgrounds and regions would continue to eat different foods, but all would receive the same *nutrition* from their food at a level adequate to their needs. Too often, critics have attacked nutritionists with the claim that they have wanted all people to eat the same food. In fact, Stiebeling was attempting to make sure that all Americans were adequately nourished, however they wanted to arrive at that state. Because it would be difficult for ordinary people to conceive of their food simply as nutrition, examples were given of types of food. However, there is no indication that by using examples common to their own foodways, nutritionists like Stiebeling were actually attempting to impose a single American cuisine.

Knowing in historical hindsight just how dire the crisis was to become, Stiebeling’s bulletin makes for poignant reading. The pamphlet’s cover provides the basic requirements for a child’s diet while simultaneously emphasizing that this is the bare minimum and not what children really should have in a soundly functioning economy. The requirements, referred to as the “irreducibles” were “At least one pint of milk (he *should* have 1½ to 2 pints);

two teaspoonfuls of cod-liver oil if he is less than 2 years old (he *should* have 3 to 4 teaspoonfuls); one vegetable or fruit (he *should* have three or four); *and also* plenty of bread, cereals and other energy and body-building foods.” Stiebeling used the important phrase “margin of safety” in this pamphlet to subtly argue that the bare minimum could not be acceptable when there was no crisis. One can sense that Stiebeling and her coauthors feared that if they gave these bare minimums, relief agencies would accept them as sufficient and not try to provide more. At the same time, they clearly wanted to make sure that these minimums were met. As the pamphlet explained, “The standard of *all* relief should be such as to provide a fully adequate diet, which allows variety and an ample margin of safety in all the nutritive essentials and every effort to maintain such a standard should be made even under emergency conditions.” The minimums were not an invitation to scrimp, rather a base upon which to build.

The pamphlet’s authors understood the conditions on the ground. They had, after all, been researching them and knew that many communities were running short of relief. In these cases, “at *least* enough money must be allowed to provide the ‘irreducible amounts’ of the protective and other foods,” but these were “*not* adequate for long-time use [*italics in original*].” Fearing, correctly, that the worst was yet to come, Stiebeling and her coauthors made suggestions for “Conditions of Extreme Economic Distress,” when “the need for relief may be so widespread as to resemble conditions following disaster.” In such circumstances, the government would need to step in. State or local agencies could buy milk in bulk to distribute it, particularly to children, and basic sustenance could be achieved if “Clean whole wheat or crushed wheat, locally prepared, [was] cooked in large quantities and distributed by a central agency.” Here the three authors were

subtly making an argument about national nutrition and government policy.

Contrary to President Herbert Hoover's strategy of relying on private and community aid, they suggested that it was the Federal Government's responsibility to make sure its people were fed and to take nutrition into account in doing so. Equating economic depression with natural disaster was not a rhetorical move that everyone would accept. For many conservatives, sending in the National Guard to sandbag in flood plains was one thing, feeding those who could not feed themselves was something else altogether. Essentially, the fear was that the citizen would become dependent on the government and, through dependence, become a strain on its resources. For government nutritionists, the idea that Americans would become "dependent" on a basic level of nutrition seemed like a good outcome from a terrible crisis. While they stopped short of suggesting a federally directed food relief effort, Stiebeling and her coauthors did warn that "Irregular, unplanned, or uncoordinated food relief given to a family by several agencies is undesirable" because it made it impossible to know whether the family was getting proper nutrition. It is easy to imagine, for example, that given poor funds, all relief agencies in an area would provide the cheapest food possible, perhaps bread, potentially stale. Families would receive food, certainly, but not nutrition. The kind of coordination required would probably be easiest at the county or State level.

Furthermore, relief must come with education or its potential would go unfulfilled. Families might "need help in learning to use and prepare unfamiliar foods to the best advantage and to adapt them to personal and national customs." Because so few Americans had knowledge of proteins, vitamins, and other basic principles of nutritional science, they probably would need help figuring out how to make the

best use of whatever relief they received. For an example not given in the pamphlet, rather than eating bread on its own, a family might make breadcrumbs that could serve to "stretch" meat or bean dishes. It is worth noting here, too, that Stiebeling advocated helping the hungry maintain their foodways rather than "converting" them to one particular cuisine. She clearly understood that food that was not palatable would not be eaten, even in dire straits. And if families could adapt and adopt new food sources, their chances for living nutritionally balanced lives after the Depression seemed much greater. Having assimilated soybeans during the crisis, for example, they might be more likely to try something else new and nutritious once times were not so lean. To reach the people, the pamphlet's authors recommended that "Relief agencies contact local home economics teachers as well as public health nurses, dieticians, and nutritionists." At the same time that she was doing the Bureau's work of helping the needy, Stiebeling was also creating broader social authority for home economics as a field, one way of insuring the Bureau's survival in tough economic times.

By 1932, Hoover and his limited approach to the Depression were out of favor, and the Nation had a president in Franklin Roosevelt who seemed to share Stiebeling's sense that the government had a responsibility to help the needy directly. In a 1934 article, Stiebeling took up the idea of wide-scale coordination and planning for an adequately nourished nation. She cited estimates made by Dr. O.E. Baker as to how many acres of land would be needed to produce enough food to keep all Americans at one of the three levels of diet. It was clearly Steibeling's hope that Baker's data would be used proactively by government agencies to ensure adequate diets for all Americans. Stiebeling acknowledged that this was not a foregone conclusion: "Whether we can succeed in the program of bringing fully adequate diets within the reach of

1939

The Yearbook of Agriculture provided much of the information that the public would need to achieve good nutrition.

1945

The Food and Agriculture Organization of the United Nations was founded and adopted Hazel Stiebeling's standards for determining adequate nutrition.

1948

The World Health Organization was established and chose to follow Hazel Stiebeling's standards for adequate diets.

all depends on how earnestly we apply ourselves to the challenge of entering an economy of planned abundance.” While the mere suggestion that the American Government might attempt a planned economy for the welfare of all citizens may surprise contemporary readers, Stiebeling was writing in a time of international interest in just such reforms. The Great Depression had prompted governments in Europe as well as America to try to establish some kind of control over the vagaries of the economy.

The standards that Stiebeling set for determining whether individuals were receiving adequate nutrition were quickly adopted by the Food and Agriculture Organization of the United Nations after its founding in 1945 and by the World Health Organization when it was established in 1948. They also quickly attracted the anger of flour millers, who felt that the bulletin “was designed to reduce the use of wheat and wheat products” (23). Stiebeling recalled the controversy: “Agricultural economists calculated that this country’s capacity to produce would find no problem in supplying demand if everyone in the population were consuming the nutritionally adequate diets at these food budgets, expenditure levels; and that there would follow an increased demand for milk and for deep green-and

yellow-colored fruits and vegetables, leafy greens in particular. But the meat industry was upset with the diet plans because the most economical budgets included less than average-per-caput amounts of lean meat. Wheat growers were unhappy because the most costly budgets included less of grain products than average-per-caput consumption” (24).

As a journalist noted in 1935, “It used to be conceded that a government bureau was safe in working out and publicizing diets the use of which would be of great value to millions of families on relief.” The Bureau, however, had “run up against a high pressure lobby which threatens its existence.” Led by lobbyist H.T. Corson, farmers, millers, and bakers, as well as Chambers of Commerce, flooded Congress with telegrams objecting to “an alleged BHE attempt to reduce wheat consumption.” This “attempt” could be found in “Diets at Four Levels of Nutritive Content and Cost” (25).

Debate erupted during consideration of the budget for the Department of Agriculture. U.S. Representative from Kansas Clifford R. Hope (R) claimed that “every one of these diets” described in “Diets at Four Levels” “suggests the use of a smaller proportion of cereals and wheat flour than the average consumption in this country

today.” Hope accused the BHE of “typical bureaucratic arrogance” in not consulting wheat producers, millers, and bakers as they developed the recommended diets. Dismissing the bulletin as “propaganda,” Hope supported a rider to the budget appropriation that would prohibit the USDA from publishing any material that called for limited consumption of any food produced by American farmers or manufacturers (26). Nutritionists, however, had enough friends in Congress to secure a proviso to the rider that essentially nullified it.

Ironically, journalist Rodney Dutcher calculated that the wheat consumption suggested in “Diets at Four Levels” was actually higher than the national average at the time. What wheat and bread industry lobbyists objected to was the setting of any limit, even if it was only suggested, for consumption of their product (25).

The 1930s were busy years for the nutritionists at the Bureau, who cooperated with researchers in other USDA divisions to improve foodstuffs in the interests of improving nutrition without asking Americans to change their eating habits. Writing in *Scientific Monthly*, a popular science newsletter, Louise Stanley reported on three projects that the Bureau was involved in during 1933. In collaboration with the Bureau of Animal Industry, BHE nutritionists worked to increase the levels of vitamin D in eggs with the goal of improving the nutritional quality of children’s diets without changing what children actually ate. Feeding castor oil to laying hens, the study revealed, translated into higher levels of vitamin D in the diets of children who consumed these eggs.

Stanley reported that, also in collaboration with the Bureau of Animal Industry, “Meat studies are in progress to determine the influence of such production factors as breed, sex, feed and age of the animal, on the edible quality of the meat” (27). These

studies drew the attention of the national press. In 1931 local newspapers across the country noted, “Uncle Sam is paying some of his employees to eat!” In the early days of the Depression, this would certainly have drawn attention. The article went on to reassure readers that all this was done in their own interest: “This eating is done to safeguard the health of food consumers and guarantee them the tenderest meats.” What the writer termed “epicurean exercises” were not performed “with the intent to fill an empty stomach,” and the testing was made potentially less enjoyable by the absence of seasonings (28). On the women’s pages of newspapers, too, the work of the Bureau was noted. “In the last four years,” one “Household Hints” column explained, “the bureau of home economics ... has been accumulating meat shrinkage data in connection with the nation-wide co-operative study of the factors that influence the palatability of meat” (29).

The palatability study was a remarkable attempt to provide an entire nation with reliable information on how to get the most out of the meats they were able to buy. Too often, nutritionists have been portrayed as uninterested in taste, seeing food as fuel rather than a part of sensory life. This study is a good example of the careful work nutritionists have done to understand not just what people ought to eat, but what they would like to eat. As a writer in *Scientific Monthly* noted in 1934, “until recently we have not been able to make definite comparisons of muscle to learn the effects of breeding, feeding, and management upon the palatability and food value” (30).

Over the course of their experiments, from 1925 to 1931, the Bureau “roasted 2,200 legs of lamb, 800 rib roasts of beef, 450 cuts of fresh pork, and about 50 cured hams for judging.” One of the most important outcomes of the Bureau’s meat research in this period was the popularization of the meat thermometer, a device that had not

been commonly used in American homes. The Bureau had a thermometer made to its own specifications and encouraged its use through publication of recipes that called for precise temperatures. Use of the thermometer would, it was hoped, make it “possible to write household recipes for cooking meat that are more definite than recipes ordinarily found in cookbooks.” Interestingly, although some recipes do specify a temperature for “doneness,” this has not over the intervening years become the standard in recipe writing. This gap between progress made at the Bureau and progress made in the home was not unique to the matter of meat thermometers. The story of the Bureau, and indeed of all nutrition work done by the USDA, is partly a story of this failure of the public to assimilate Bureau research into ordinary life. It is also a story of life-saving success, but the failures must be seen as equally important in looking to the future.

In 1939 the question of how to bring the results of Bureau research in nutrition into ordinary American homes was the topic of several articles in USDA’s *Yearbook of Agriculture*. Louise Stanley wrote about the major change that the development of the field of nutrition had brought. Where for generations families had relied on local traditions and folk wisdom to tell them which foods to eat, they could now turn to scientific results for guidance. Stanley expressed respect for folk wisdom, developed as it has been “by trial and error over long period, with much suffering by the way.” However, in modern society, food was different from that enjoyed by our ancestors. More of it was processed, and some of it was new in that it was eaten in parts of the world where it was not grown. “In this situation,” Stanley argued, “tradition and habit are no longer safe guides to the selection of foods.” Worse, “they can lead to dangerous mistakes.” Nutritional science was not out to replace folk wisdom, to “wipe out habits and traditions.” Tactfully, diplomatically,

Stanley reassured readers that they were not being dismissed as ignoramuses. Nutrition instead “supplements” traditions, perhaps sometimes “corrects them” and “shows how to use them intelligently” (31). While traditions might be important culturally and could very well be sound, the research of nutritionists must also be taken into account for health in the modern world.

How to blend tradition and science to the best effect was the difficult work of the Division of Foods and Nutrition. Hazel Stiebeling wrote thoughtfully about how traditions formed, while Paul Howe considered whether habits related to food could actually be changed. Both questions are vital to the practice of nutritional science. Stiebeling was hopeful in her outlook, assuming that education would be enough to change American food habits. The trouble was what form that education could take. She argued that people typically took their lead in foodways from those they considered their social betters. It is open to debate whether all social groups do take their cues about food in the same way, but accepting Stiebeling’s premise, this habit could be bad for public health, because whoever comprised that emulated group might not themselves have good nutritional habits. Perhaps Stiebeling was implying that by educating the wealthy in nutrition, a trickle-down effect could be counted on to improve nutrition across classes, because the middle class emulated elite foodways while the poor copied the middle class.

Another problem with nutritional education that Stiebeling identified was the human body itself. It would be useful if one could see the effects of bad nutrition clearly as they occurred and “if obvious manifestations of the effect of diet on nutritional well-being followed day-by-day food consumption with dramatic swiftness.” The body, however, inconveniently for nutritionists but very conveniently for human survival, has the ability “to store certain reserves during

periods of plenty to be drawn upon in times of dietary poverty.” While the effects of conditions like pellagra could be seen—and the BHE was able to make huge strides in wiping out pellagra—the results of other kinds of malnutrition were much subtler. Worse, the benefits of good nutrition were not visible as such to the average person. This continues to make it difficult to sell the idea of nutritional education to the American public.

Stiebeling believed that although much research remained to be done in nutrition, enough had already been completed to significantly improve the human diet if only “present knowledge, incomplete and far from precise though it is, were widely disseminated and put into common practice.” Inhibiting this beneficial shift in food habits, Stiebeling cited lack of understanding of the benefits of good nutrition, poor consumption habits, and, unusually severe in the era in which she wrote: “the lack of purchasing power on the part of many urban families, and especially in the case of rural families, insufficient success in planning and carrying out a food-production program designed to complement food purchases” (32). These same barriers to nutrition education continue to plague Americans in the 21st century.

In the same year that she published this more abstract musing on nutrition and society, Stiebeling also made important adjustments to the USDA’s dietary allowances. As Alf Harper relates, she and another important USDA researcher, Esther Phipard, “expanded the dietary allowances to include thiamin and riboflavin ... increased the number of age groups and ... proposed that to establish allowances, average requirements should be increased by 50% to allow for variability among the requirements of individuals in the population” (21). Harper identifies the increase of average requirements as a fundamental improvement in the work

of determining “dietary standards and daily allowances” across international organizations and up to the present day.

Paul Howe offered the imagined internal monologue of a “housewife who had good knowledge of nutrition,” planning her family’s dinner. The monologue is worth quoting at length and with commentary for the way in which it reveals nutritionists’ ideals.

“Soup?” the fantasy figure asked herself, “It’s appetizing and not too filling.” Howe recognized the importance of stimulating the appetite, aware that good nutrition could not be achieved where palatability was not considered.

“Meat?” Howe’s housewife continued, “Yes. No animal protein for the grown-ups so far today.” Good nutrition was not just a matter of knowing about vitamins; it required keeping track of the whole family’s food experiences throughout each day in order to achieve balance.

“Potatoes? Yes.”

“Other vegetables? Broccoli, turnips, beets, or carrots? Make it broccoli and carrots—not enough Vitamin A so far.” Here she performed a quick assessment of the meal and analyzed it for vitamin content. She would have to know not only that broccoli and carrots were good sources of vitamin A but also that the foods she had chosen so far were not.

“Salad? Lettuce with cottage cheese and pineapple—more carotene and more calcium.” Again she checked for what was missing and added it in a way that she thought would be palatable to the family.

“Dessert? Cottage pudding? No; calcium is still low.” In order to raise the meal’s calcium content, she decided to “make it pumpkin pie and a cup of coffee with cream.”

To double check, she then rattled off the meals of the day:

“We had grapefruit this morning, tomato juice this noon, and broccoli, carrots, butter, and salad tonight to provide sufficient vitamins C and A. The meat, bread, and cottage cheese, and the peanut-butter sandwiches this noon provide plenty of protein. The calcium may be a little low, but pumpkin pie has helped and there was skim milk in the bread. The children have had milk for breakfast and lunch, so their calcium intake is well taken care of.” And although “we only had white bread,” the “B factor,” could be accounted for because “there were meat, peanut butter, cheese, and vegetables to help out” (33).

While Howe admitted that “most of us do not go through an analysis such as this,” it seemed to be his wish that one day those “with the responsibility for inducing us to eat foods that are needed even though we may not like them” would receive the kind of education that would make this monologue not only possible but routine. Howe thought that, beyond education, habits might be changed by using the human attraction to novelty. “Man,” Howe reasoned, “likes what he is used to, but he also likes change.” Howe suggested using the insights of the new field of psychology to induce people to eat nutritiously. Good research and reasonable arguments would not be enough, for “man’s instinct is so overlaid by conditioning that he cannot be trusted to select food with any relation to his physiological needs.” Yet in the end, he had faith in early nutrition education for children and well-designed bulletins like the BHE’s “Market Basket” for adults to change the food habits of the Nation.

Other articles in the 1939 *Yearbook of Agriculture* provided much of the information that the public would need to achieve good nutrition. Using simple language and compelling examples, D. Breese Jones wrote

of “The Protein Requirements of Man,” Henry Sherman and three other authors described “The Mineral Needs of Man,” and Lelia Booher and five other authors presented “The Vitamin Needs of Man.” The coauthors for Sherman’s article were Mabel Dickson, Margaret Cammack Smith, and Esther Petersen Daniel; and those for Booher’s were Elizabeth C. Callison, O.L. Kline, Sybil L. Smith, Frederick W. Irish, and E.M. Nelson.

As of 1939, Booher and Callison could report, “with dramatic rapidity, the vitamins are now being purified, definitely isolated and even produced synthetically in the laboratory”—all of which made it much easier to perform experiments testing their properties. Vitamin A had been found in many foods, particularly “fatty food products of animal origins” and was associated with the presence of carotene and cryptoxanthin in vegetables. The best food sources of vitamin A, Booher and Callison reported, were animal livers, particularly those of certain fish. Milk and eggs, the latter depending on the hens’ diet, could also be good sources. The first sign of deficiency in vitamin A was night blindness, for which tests on young infants had been devised.

To better understand the vitamin A needs of the human body, a study was performed on five adult volunteers between 1937 and 1938. Three women and two men “consented” to be participants in this 6-month study by the BHE. During this period, the five ate only food that was prepared for them in a BHE kitchen laboratory. “Literally every bite these people ate was weighed.” Although “the diet was neither unpleasing nor unduly monotonous,” the vitamin A content was kept as low as possible. In order to reassure readers that the experiment did not qualify as torture, a sample menu was given. Breakfast, “the least variable of the meals,” was “grapefruit, toast, bacon, oleomargarine (with no added Vitamin A), honey, skim milk, and black coffee.” A “representative

dinner” would consist of “chicken, potatoes and oleomargarine, cauliflower, a small portion of cranberry sauce, pears, and skim milk.” For supper, the lucky five might dine on “navy bean soup, saltines, a small serving of apple, celery, and nut salad with lemon juice dressing, cocoa, and angel food cake.”

The subjects neither gained nor lost weight during the experiment, but all lost night vision. The length of time it took for night vision to be lost varied from subject to subject. Booher and Callison surmised that this was probably because each person had different amounts of vitamin A stored in their livers based on pre-experimental diets. When night blindness set in, adding doses of cod liver oil to the diet restored night vision. Once it returned, the cod liver oil was taken away, and night blindness returned. Subjects were then given supplements of carotene crystals dissolved in cottonseed oil. To restore night vision, much more of this second supplement was needed than the amounts of cod liver oil that had performed the same function. As of 1939, it was “not understood exactly why this should be true.” Because vegetable sources of vitamin A were important parts of “low-cost dietaries,” the Bureau was working to discover why it was that vitamin A from these sources was “not better utilized.”

Reporting on studies of vitamin B, O.L. Kline of the Bureau noted that although vitamin B1 had been first recognized at the end of the 19th century, it was not until 1936, just 3 years before the report, that it had been synthesized in a laboratory. The crystalline form was now “being widely used in the study of the physiological function of the vitamin in the human body.” As yet, researchers had only been able to determine minimum vitamin A requirements, and “there is little agreement as to the increased amount that may be required for optimum conditions.” Kline expressed the hope that “improvements in methods for determining

the Vitamin B1 content of blood and urine and the use of crystalline B1 in clinical studies will yield in the future more reliable information on the minimum, as well as optimum, requirement.” While the Bureau had not repeated its vitamin A experiment for B1, data from a study of American family diets indicated that most were getting at least the minimum required amount of B1 in their diets. Beriberi, the main B1 deficiency, was not common among American families.

Like vitamin B1, Sybil Smith reported, vitamin C had only recently been recognized as the reason that green vegetables, oranges, and lemons cured scurvy and had only about 6 years previously, been “finally separated from foods, identified as a chemical compound of known structure, and manufactured for use in laboratory and clinical work.” However, also like B1, “there is still considerable uncertainty as to how the vitamin acts in the body and how much of it is needed by people of different ages.” One problem was that although scurvy was now very rare, many other conditions of vitamin C deficiency existed with much more subtle symptoms so that it was very hard to tell when people were suffering from it. Other difficulties in studying C were that it is “quite unstable and easily lost” in consumption and that it was difficult to use color tests to determine its presence in foods. As Smith explained, “thus far no test has been found that will react with vitamin C and not with other reducing agents,” so, because C reacts more rapidly than most other agents, test results had to be read very quickly to get any idea of the C content of foods. Using guinea pigs, researchers had been able to determine that C helps to keep intercellular material “in a stiff jellylike ... state.” It seemed also to help prevent infection and to speed healing from wounds. Like vitamin B1 researchers, vitamin C researchers were not attempting to understand the relationship between minimum and optimum levels of C in the diet. Capillary strength, urine, and blood

tests were all methods to study C content and the effect of differing levels of the vitamin. Smith admitted that although experiments like those performed for vitamin A were “a tedious process beset with many difficulties, open to many errors, and subject to many interpretations,” they were also the most popular kind of study and “most of the attempts that have been made to determine human requirements have been based” on the model.

One of the controversies involved with these studies was the question of whether the optimum level of a vitamin was the saturation point—the point at which the vitamin was no longer being absorbed and began to appear in urine. In the case of C, Smith reported, research seemed to suggest that saturation was the optimum because C had so many health benefits. Despite much research using guinea pigs to study the relationship between C and gingivitis, stomach ulcers, and recovery from wounds, “there are many unanswered questions that make it difficult to give requirements for vitamin C with certainty.” It did seem, however, that minimum and saturation levels had been determined and that within this range, age would determine individual needs.

Reporting on contemporary knowledge of vitamin D, Frederick Irish, a chemist with the Food and Drug Administration (FDA), echoed the theme that all the previous writers had sounded: much was still to be learned. “The mechanism by which vitamin D functions,” he explained, “has not been determined with finality.” What was understood so far was that D helped the body to absorb calcium and phosphorus. Recognizing that vitamin D needs varied significantly through the year, with sunlight replacing the vitamin when days were longer, experts still were unable to agree on D minimums for infants and young children. This disagreement arose “in part from the use of different criteria in judging

the adequacy of a particular vitamin D intake.” Some used prevention of rickets as the standard, while others looked at total calcium retention. Optimal vitamin D amounts for older children, adolescents, and adults had not yet been determined, though data from a study of children in orphanages in and around New York City suggested that summer sunshine was sufficient, even in areas of urban air pollution.

E.M. Nelson, chief of the Vitamin Division of the FDA, began his report with the admission that “The vitamin E requirement of man is not known.” Only recently had it been “reported that a substance having the properties of vitamin E has been synthesized in the laboratory.” In rats, E deficiency was associated with reproductive difficulties, and there was some thought that it might be responsible for miscarriages in humans. Goats, however, seemed to manage fine without it. By 1939, “studies on human requirements for vitamin E have been confined” to studies of the effect of wheat germ oil on sterility and repeated miscarriages. So far, wheat germ oil, a source of vitamin E, had had no effect on either condition. Nelson reasoned that should vitamin E be found at some later point to be essential to human nutrition, it was found in so many foods that there would be no threat of deficiency in the population at large.

As with vitamins A, B1, and C, Lelia Booher reported that the significance of riboflavin was not truly understood until very recently. In 1933, English and American scientists working independently both announced the “discovery of the biological significance of this substance,” the “water soluble, yellow pigmented vitamin” that could be found in many foods. Booher, who was Chief of the Foods and Nutrition Division at this time, described the gruesome effects of depriving laboratory rats of riboflavin while feeding them a diet adequate in all other nutrients. Loss of hair, dermatosis, and the loss of

digits, joint-by-joint, were, however, happily halted and (except in the case of lost digits) reversed by the restoration of riboflavin. Booher explained that many foods contained small amounts of riboflavin and that it was thus very difficult to test for the substance. Even as she wrote, “methods strictly chemical in nature are in the process of being developed.”

In contrast to E.M. Nelson’s tone of disinterest in vitamin E, Booher’s writing suggested real excitement at being part of a new science finding its way one experiment at a time. The data on riboflavin that existed in 1939 had mostly been acquired through the “biological assay” method, like that used for the vitamin A studies, but with rats as subjects rather than humans. Because riboflavin was so widespread in the foods humans eat, Booher explained, deficiency was probably not a problem. She did note, however, that a recent study by Henry Sebrell and Roy E. Butler had reported on what appeared to be riboflavin deficiency connected to cases of pellagra in humans.

Once readers had discovered the vitamin “needs” of their own bodies, they could turn to Esther Daniel’s explanation of the “Vitamin Content of Foods” to learn how to fill those needs efficiently. Charlotte Chatfield and Georgian Adams explained how to read food composition tables, a skill that could be invaluable to the consumer but which few had acquired, leaving such understanding to experts without realizing both how accessible and how important this information can be. The pair gave lists of foods that would help readers think of meals in terms of nutritional value as well as flavor. Far from pushing on the public foods that were healthy but unpalatable, the article offered many choices within categories of foods that were “excellent” or “good” sources of particular nutrients.

The lists included foods such as sesame seeds, sweet potato tops, and burdock

roots that might not have been familiar outside regional cuisines, giving the national public an opportunity to make an exercise in good nutrition also an exercise in newness. This was the tactic Paul Howe had suggested: appealing to the human interest in change that coexists with our love of continuity. Chatfield and Adams noted that contemporary knowledge of nutrition, even among experts, was far from complete and that much more work must be done before the public would have the best possible information with which to make food choices. For example, while the authors could list foods rich in calcium, magnesium, or iron, “It is not enough to know how much of each of these elements is present in the food materials. Chemists are now being called on not only to give the quantity of calcium or iron in different substances but also to supply information that will throw light on the availability of these elements to the body.” After all, knowing that turnip greens are rich in calcium would be useless if it was determined that this calcium was not accessible to the metabolisms of those who ate the greens.

The lists that Chatfield and Adams provided suggested a new way of thinking about food—the model proposed by Howe’s fictional housewife. Using this method, one thought about nutrition and the composition of foods first and flavor second. Flavor was essential, but it was not the driving force in decision-making. Because of this ranking, it has been hard both for the message of nutrition to spread and for critics to see that nutritionists do not dismiss palatability, only rate it differently from the hungry person in the restaurant.

Faith Clark and Hazel Stiebeling offered further help to the average consumer with “Planning for Good Nutrition,” and Miriam Birdseye addressed “What the Modern Homemaker Needs to Know” about food in order to get the most food value for her family’s budget. The main point of Birdseye’s

article, which contrasted a Christmas dinner of the 17th century with one of 1939, was that the majority of Americans' foodstuffs were now industrially processed where once they had been produced in and around the home.

Stiebeling, Marius Farioletti, F.V. Vaughn, and J.P. Cavin took a broader view of the problem in "Better Nutrition as a National Goal." The 1939 *Yearbook of Agriculture* provided not only a report on the state of food in the United States but also a platform for action on the individual level and the national stage. Articles by Harry Gorseline and A.K. Balls discussed issues of food preservation, while Edward Joss, Ernest Kelley, and Marius Farioletti wrote about national food standards and inspections, both of which were the result of efforts by consumer advocacy groups. Beyond piecemeal legislation to protect the food supply chain, Stiebeling suggested a national program that would integrate ideas of nutrition both with citizenship and with Federal regulation of the economy. Bringing Americans to proper nutritional status, "is far more than an individual problem," she warned, and to solve it "would require a great deal of education; increased purchasing power, or lower food distribution costs, or both." And if existing problems were really to be solved, "considerable increases in production of the so-called protective foods" would be necessary. Contrary to American cultural and social traditions, the government might have to tell farmers what to grow.

As of 1939, the average American's diet was nutritionally inadequate despite the fact that "if our present knowledge of foods and nutrition were generally applied, it would revolutionize dietary habits and have far-reaching implications for national health and agriculture." In an interview the same year for *Country Gentleman*, Stiebeling's language was even more dramatic: if Americans could apply existing nutrition

knowledge, "we would be a different race" (34).

To bring Americans to good nutrition, consumption of leafy green and yellow vegetables would have to be increased by 100 percent, tomatoes and citrus by 70 percent, eggs by 35 percent, and milk and butter by 20 and 15 percent, respectively. Better nutrition would mean lower hospital expenses (and since most of those who were poorly nourished were themselves poor, this meant public expense), higher productivity in industry and agriculture, and longer life spans, also resulting in greater demand for agricultural products. Stiebeling was making the economic case for better national nutrition. The government, industry, and agriculture—no one could afford poor national nutrition.

Studies of family food expenditures had revealed the fascinating information that well-to-do families spent a smaller proportion of their income on food than did poor families. Indeed, the richer a family was, the smaller a proportion of its weekly budget went for food. To Stiebeling, this was an indicator of mistaken priorities, and "the question is often asked whether families, particularly those at low-income levels, would spend appreciably more for food if incomes were increased or whether the extra income would go chiefly for automobiles or clothes, or other uses." Studies had determined that wealthier families tended to consume more of the "protective" foods than poor families did. The question, then, was how to get these foods to those with low incomes. Could prices be reduced, either by simply reducing prices relative to incomes or by raising incomes? And if they could be reduced, how low would they have to go to increase consumption? However, the problem was not purely an issue of economics; the public had to learn what it needed. Many agencies existed that were dedicated to propagating nutritional information. Extension agents and workers

Prior to America's entry into WWII, the National Research Council established the Committee on Nutrition. Hazel Stiebeling, Helen Mitchell, and Lydia Roberts provided a "tentative standard" to be used in evaluating both civilian and military diets.

in public health clinics, among many other evangelists, were working with great commitment to educate the people. The question was, Stiebeling concluded with a hint of bitterness, "whether the general public can be persuaded that the matter is worth its attention and worth the price." The price, presumably, would be a major overhaul in the national management of production and employment.

While the general public may have remained largely uninterested, Federal authorities became intensely interested in national nutrition just 2 years after Stiebeling's report, when America entered the Second World War and large numbers of recruits were found unfit to fight because of poor nutrition. By 1940, in anticipation of the possibility of America's entry into the war, the National Research Council established the Committee on Nutrition, a government advisory board. Responding to a national sense of urgency, the council's chair, Russell Wilder, gave three people less than 24 hours to come up with a standard to be used in evaluating both civilian and military diets. Stiebeling was a natural choice for this group and was joined by Dr. Helen Mitchell and Dr. Lydia Roberts. Given their task in the evening, they were requested to provide a standard by the next morning. The team, as directed, delivered a "tentative standard" to use in continuing research into the problems of national defense (21). Beginning with a synthesis of existing research, the larger working group then consulted with scientists active in related research and opened the topic up to a meeting of the American Institute of Nutrition. The standards were first released in 1941 and then more widely published in 1943, thereafter serving as a starting point for all future research in standards (21).

In 1941 President Franklin Roosevelt called together leaders in the field of nutrition and emergency management

for a National Nutrition Conference for Defense, recognizing that "if people are undernourished, they can not be efficient in producing what we need in our unified drive for dynamic strength." Although doubtless fully committed to the effort of the moment, some nutritionists might have wondered why poor nutrition only seemed to be an emergency during wartime. Reporting on the conference, Rowena Carpenter of the BHE noted data provided by the Bureau that 45 million Americans lived on diets that were nutritionally inadequate even "when measured by the most conservative standards" (35). The problem went far beyond cases of pellagra, beriberi, rickets, and scurvy, Carpenter reported, to the more widespread "hidden hunger" of those who had lived for long periods on barely adequate diets. Over time, malnutrition took its toll on their muscle tone, teeth, stomachs, and psyches. It was now the task of Helen S. Mitchell—under the direction of Paul V. McNutt, Coordinator of Health, Nutrition, Welfare, Recreation, and Related Activities for the Federal Emergency Management Administration—to pool the resources of all the States to raise levels of nutrition throughout the Nation.

For the most part, these resources consisted of educators of various backgrounds and

President Franklin Roosevelt called together leaders in the field of nutrition and emergency management for a National Nutrition Conference for Defense.

The Bureau of Home Economics moved to the 12,000-acre facility in Beltsville, MD.

affiliations. In every State, “Every person professionally trained in medicine, public health, nutrition, dietetics, nursing, social service, and allied fields should be mobilized for nutrition work in their own communities.” Some practical measures already agreed upon were the extension of existing school lunch programs and the Food Stamp Plan, part of the USDA’s Surplus Marketing Administration, created during the depression to help manage the fact that widespread hunger occurred despite agricultural surpluses.

At the 1941 conference, Dr. Lydia Roberts, of the University of Chicago, presented “diet standards” devised by the Food and Nutrition Committee of the National Research Council. “The new defense diet standards,” presented in the form of Recommended Dietary Allowances, were “suitable for any time but especially important to follow right now” (36). Although an attempt was clearly being made to help Americans consider the standards as permanently useful, the language of emergency—“right now”—simultaneously undermined that message. The standards as announced were “one pint of milk daily for an adult, more for children. One serving of meat. One egg daily or some suitable substitute such as beans. Two servings

of vegetable daily, one of which should be green or yellow. Two servings of fruit daily, one of which should be a good source of vitamin C, such as citrus fruits or tomatoes. Bread, flour and cereal, most and preferably all of it whole grain or the new enriched bread, flour and cereals. Some butter or margarine with vitamin A added. Other foods to satisfy the appetite.”

A lasting benefit that came from this conference was the establishment of enriched breads and flours as the industry standard. The Committee on Food and Nutrition, which became the Food and Nutrition Board, set “minimum and maximum limits for the enrichment of bread and flour with thiamine, riboflavin, niacin and iron.” This was a controversial move, as E. Neige Todhunter remarked years later: “Some have maintained that the public should be educated to the use of natural foods that would supply all nutrients.” What, after all, were all the bulletins for, if nutritionists were going to admit that no one was following their advice to consume whole grains? Todhunter the realist admitted, “Experience of centuries has shown that people are reluctant to change their food habits and that education regarding food choices is a slow process. Nutritionists could (and did) continue recommending whole grains, but in the meantime the slow-changing public might as well get its nutrients from enriched flour” (37).

1941 was also the year that the Bureau moved to Beltsville, MD, an adventure chronicled humorously by Ruth O’Brien. “To get its research units into less crowded quarters,” O’Brien explained, the laboratories were moved to the 12,000-acre facility in Beltsville. The day of the move was a “cold, rainy day,” which presented a problem for the Bureau’s “living test tubes,” or rats. O’Brien reported that “more than 3,000 of the ‘very special’ ones made the 17-mile journey in stylish fashion

(carried in air-conditioned ambulances); the remainder of the rat colony went in heated trucks.” This was because “as parts of long-term experiments, they represented large investments.” The utmost care was taken to protect them, including spreading canopies between trucks and buildings to keep the rain off their scientifically precious backs (38).

Once the relocation was completed, a press release announced, “The Bureau’s staff, being foresighted, is looking ahead into the home freezing of foods, as well as studying the effect on palatability and nutritive values of different methods of processing and packaging foods.” In addition, “there are the home-front information programs on nutrition, food conservation, and the use of temporary food abundances.” Truly, “the Bureau cooperates manfully (even if it is mainly staffed by the ‘opposite sex’) with [the Office of War Information]” (39).

Throughout the duration of the war, newspapers and magazines published advice from BHE nutrition experts on how to make the most of rations nutritionally. For example, an article published in the *Science News Letter* in 1942 reported the BHE response to sugar rationing: “To help [homemakers] meet their families’ cravings for sweets, the Department of Agriculture’s Bureau of Home Economics has published a carefully tested list of more than a score of reduced-sugar recipes.” Using professional advice, “Americans will discover that even with less sugar it’s a sweet world after all” (40).

In the film *Wartime Nutrition*, produced by the Office of War Information, Surgeon General Thomas Parrish urged viewers to “make a real effort to choose a nutritious diet” and argued, “Every citizen should have a down-to-earth working knowledge of modern nutrition.” Each one of us “must do this,” Parrish declared, “for today we have

no choice. War demands that no one waste food.” In order to learn how to make the most of what was available, an announcer noted that public nutrition courses had been established in “churches, schools, and factories.” A classroom full of young women watching attentively as instructors prepared a meal, while frequently referring to a food chart, underscored the film’s message that “appetite alone is not a safe guide to good nutrition.”

One of the more unusual ways in which government nutritionists attempted to help Americans make the most of what they could get in wartime was a series of “nutrition tests” of wild game in 1944. The research was performed in the College Park, MD, laboratories of the National Fish and Wildlife Service, but the goal was to determine what role game animals could play in human nutrition. Vitamin assays were made, protein and fat content determined, and moisture assessed for the following: boiled, roasted, and baked beaver; roasted muskrat; broiled and roasted opossum; baked, broiled, fried, and roasted rabbit and parts of rabbits; and boiled and roasted raccoon and raccoon livers (41).

The growing recognition of the “vital importance of nutrition in a national crisis” was reflected in the reorganization of the Bureau in 1943. That year, BHE was merged with USDA’s Division of Protein and Nutrition Research in Beltsville, MD, to become the Bureau of Human Nutrition and Home Economics (BHNHE). The nutrition work of the Office of Defense Health and Welfare Services was also placed within the newly named bureau. Gladys Baker, historian of the USDA, argued, “these administrative moves helped to establish the preeminence of the Department of Agriculture as the seat of nutrition research and programs among government agencies” (42). Stanley stepped down as Chief of the Bureau but continued

The Bureau of Home Economics was merged with USDA's Division of Protein and Nutrition Research in Beltsville, MD, to become the Bureau of Human Nutrition and Home Economics. The nutrition work of the Office of Defense Health and Welfare Services was also placed within the newly named bureau.

Louise Stanley stepped down as Chief of the Bureau but continued working as Coordinator of Research in Home Economics for USDA's Agricultural Research Administration.



Henry Sherman was placed in charge of the newly reorganized Bureau, but he only served one year.

working as Coordinator of Research in Home Economics for USDA's Agricultural Research Administration. She was given the important responsibility of consulting with other nations concerning food problems and research.

The *Journal of Home Economics* reported proudly, "Because of Dr. Stanley's rich background, she was the one asked to head up this work." The appointment was significant in the history of home economists, especially nutritionists, and of women. It reflected well on the efforts of nutritionists that the Federal Government viewed their work as a point for international collaboration and support; and it was a milestone in the history of gender ideologies in America that a woman should be chosen to represent the United States in this strategic area. Stanley retired from the Agricultural Research Administration in 1950, completing almost 30 years of government service. Her work had paved the way for home economists internationally by providing a model for fruitful scientific involvement of the government in the issues of daily domestic life. Under her leadership, the American public became aware of, and to some degree educated in, the science of nutrition and how it could improve lives and strengthen communities. The fact that

that important effort continued after her departure reflected well on the standards she set for the Bureau in particular and the field of human nutrition in general.

Hazel Stiebeling—Leader of the Bureau of Human Nutrition and Home Economics

Henry Sherman was placed in charge of the newly reorganized Bureau, but he only served one year and was replaced in 1944 by Hazel Stiebeling, who had served as his assistant director. The fact that Stanley, Sherman, and Stiebeling were all nutritionists reflected nutrition's rapid rise to an accepted science and its power, greater than that of any other division of home economics, to capture the attention of the public and their leaders.

Stiebeling was to shepherd the Bureau through the next 19 years as America entered the Cold War and an era of rising spending power and consumerism. While political leaders emphasized the need for a nation strong in every way, consumer goods manufacturers, including food producers, attempted to create new markets by appealing to the individual's sense of entitlement rather than to his reason. After a depression and a war, didn't a

1944

Hazel Stiebeling replaced Henry Sherman and shepherded the Bureau for the next 19 years.

1945

Disney released the film "Something You Didn't Eat," produced for the USDA and the Office of War Information and intended for classroom use.

1946

The Journal of Home Economics reported that "a weak spot has been remedied" in the "Basic 7" chart that the Bureau produced to popularize knowledge about nutrition.

The BASIC 7 FOOD GROUPS



working man or busy housewife *deserve* a cream-filled cake or salty snack? What if nutritionists shook their heads in dismay? The crises passed; did we still really need to listen to those killjoys? Nutritionists in the USDA found themselves called on to resist communism by ensuring a well-nourished populace and simultaneously help consumers resist or at least understand the lures of industrial capitalism, especially when it came to food.

Stiebeling's years of research into diet were put to use in 1944 when agricultural production goals were set and "the nutrition research that had been carried on in the Department [of Agriculture] all through the thirties" was used to define production goals. A 1943 study conducted by the BHNHE in collaboration with the Bureau of Agricultural Economics had "indicated that certain changes in American production and consumption habits would result in more efficient overall use of" the Nation's productive capacity (42). In order to set viable goals, one historian of the USDA wrote, "it was necessary to forecast the extent to which farmers could and would shift production patterns and the degree to which consumers would accept dietary changes." The example given was that of skim milk, a staple of many American

diets in 2008, but considered better for livestock in 1944. Studies, however, had indicated that skim milk could "provide essential nutrients more efficiently than pork chops, poultry, or eggs," so farmers were encouraged to raise production levels while, presumably, food science and consumer research staff at the BHNHE were charged with the responsibility of teaching Americans how to use it.

By 1945, the year the war ended, it seemed that the work of the Bureau's nutritionists had made real changes in the American diet. According to a study comparing food consumption data from the years between 1909 and 1945, the yearly per capita consumption of tomatoes and citrus had more than doubled, rising to 119 pounds from 44. One writer argued that this was due to "an extensive educational campaign" designed to promote the importance of vitamin C. It now seems clear that the expanded use of refrigeration and the growth of the canning industry also contributed to this increase and to the simultaneous increase in per capita consumption of leafy green and yellow vegetables from 77 to 134 pounds (43). Where technological developments made these fruits and vegetables more available, the work of nutritionists had helped to make them more desirable.

In 1946, the *Journal of Home Economics* reported that “a weak spot has been remedied” in the “Basic 7” chart that the Bureau produced to popularize knowledge about nutrition (44). The Bureau had been working towards this chart since the 1930s when Stiebeling and Birdseye produced their recommendations for relief agencies. A wartime eating guide had been issued in 1941 and another chart issued in 1945. It seemed essential to nutritionists at the Bureau for Americans to have nutrition information in the simplest and most compelling form possible.

As of 1945, the chart had lacked recommended daily consumption figures for the food groups. It had been hard to assign figures “with shortages and surpluses still plaguing us,” in the aftermath of the war, but “our nutrition staff took on the job,” Ruth Van Deman was proud to announce, and quantities had been added to the chart. Moving from an era of scarcity through a period of rationing suddenly into bounty and prosperity, Americans would need to think carefully about consumption. Taking a cue from the field of advertising, nutritionists simplified their message and made it graphic with their basic seven-food chart. “A Guide to Good Eating” featured bright color illustrations of foods against a blue background. The basic seven and their recommended daily servings were milk—two to three glasses for an adult, three to four for a child; vegetables—two or more servings (other than potato); fruits—two or more servings; eggs—three to five, one a day optimal; meat, cheese, fish, and poultry—one or more serving; cereal and bread—two or more servings; and butter—two or more tablespoons. Smaller print encouraged use of whole grains for bread and cereal and suggested dried beans, peas, or peanuts to take the place of meat and cheese “occasionally.”

Lest Americans lack the culinary imagination to turn this chart into three meals a day, the Bureau also produced a chart of suggested menus for a day of full nutrition. Breakfast would be fruit, cereal, toast, bread, and a “beverage.” Lunch and dinner both featured a meat/fish/cheese/egg dish, vegetables, bread, and butter, but lunch also included fruit and milk while dinner included potatoes, salad, an unidentified “dessert,” and an unidentified “beverage.” In the accompanying photos, the dessert appeared to be something like ambrosia—which might have contained one fruit serving—while the beverage was coffee. The inclusion of dessert in these sample menus was interesting, as sugars were not included in the basic seven. Perhaps the chart’s designers worried that if they did not include the dessert that was traditional to mainstream American foodways, readers would not accept their recommendations as real meals. Recognizing that the American family was undergoing change as the war ended and millions of GIs returned home to new brides, the Bureau issued a popular bulletin titled “Food for Two” to help these small families begin their lives together with good nutrition. Existing cookbooks tended to be directed at an audience of large families, and some still assumed the presence of a household servant despite the fact that the war had largely put an end to the use of servants by American families of the middle class.

A related bulletin was “Food for the Family With Young Children,” which responded to the beginning of the baby boom. Parents of young children who had themselves been raised during the Depression, a time of scarcity and a time before widespread knowledge of nutritional science, were not necessarily able to turn to their parents for guidance on all issues of childcare, because the postwar era was so different. Younger parents had larger numbers of children, and there were many more consumer goods available, including food.

A writer in *What's New in Home Economics* declared, "Thousands of GI couples have stretched their food dollars and, at the same time, lived well because Hazel Stiebeling and her staff provided them with this direct and simple guide" (45). The bulletin's authors used a real family, Richard and Margaret Wright and their two children, to reach readers and assure them of the information's relevance. The style of the bulletin was similar to a particular kind of spread that appeared in popular magazines like *Life* that followed a day in the life of a celebrity. With this kind of article, readers experienced a sense of intimacy and familiarity with the family. Because readers were already familiar with this formula, BHNHE writers could rely on the public to respond to it positively and, more importantly, to identify themselves with the Wrights. When celebrities participated in this kind of journalism, they did so to sell their own work—the movies they were appearing in or books they had produced. For the BHNHE, the "feature" on the Wrights was selling ideas and behavior that would improve nutritional status.

The Wrights, like an increasing number of young American families, lived in a single-family home in a suburban setting. Both children were younger than school age, and Margaret's day revolved around housework and childcare, while Richard worked outside the home. This traditional gendered division of labor, which put women in charge of family nutrition, had been somewhat disrupted during the war, as large numbers of men were away from home and women had gone into the paid workforce. During the Depression, too, families had experienced unfamiliar domestic arrangements. Unemployed men had stayed home while women—who tended to work or be able to find work in sectors not as affected by the Depression as the industrial sector—were out of the house during the day. In addition, in many families, all members had to work

to discover and exploit new food sources. For example, children might get their only meal of the day at school while women working as domestics might be fed by their employers. Postwar foodways and thinking about nutrition represented an attempt to return to an idea of "normal," which was now complicated and potentially enriched by the spread of nutrition education. Indeed, in answer to the question "How does Margaret select food and prepare meals?" the bulletin's authors explained that "she follows good nutritional advice, practicing what she learned in classes" (46).

This mention of classes could serve to jog the memory of female readers and remind them that they, too, had taken home economics classes that could help them manage the new role of family meal provider. Unlike former generations of women in her family, Margaret had been educated to think of her husband and children in terms of their nutritional needs, not just their likes and dislikes. She knew the quantities and kinds of food they needed for optimum health, and she took a rational approach to her children's diets, introducing new foods in small amounts and when the children were hungry. The Wrights' food sources were somewhat different from those of the typical suburban family and more reflective of older foodways. Milk was delivered to the house, as were chickens and fresh eggs. The family grew vegetables in their own small garden, and Margaret canned and preserved some of them, although the bulk of their food was purchased from a local market. Notably, the bulletin encouraged readers with infants to breastfeed them, using the phrase "feeding a baby nature's way," rather than the blunter modern term. Where social conventions of the time tended to favor formula feeding, the BHNHE nutritionists came out subtly in favor of "mother's milk" because it "increases the baby's chances for growing up without sickness or feeding difficulties."

The bulletin emphasized the importance of milk for young children, a concept that was still new to the general public. Because many Americans had not grown up consuming the amounts of milk now considered healthy, the recommended quantities could seem overwhelming. Margaret Wright dealt with this problem by being creative about how she served milk to her children: “Instead of having the children drink all of their milk, Margaret often uses part of it in custard, ice cream, junket, or milk soups for variety.” Mothers, who were (and still are) largely responsible for family nutrition, would have to learn to think of meals in terms of their composition of numerous chemical elements, not just as a combination of dishes or flavors. The ideal diet of “foods that are good for the whole family,” and that which the Wrights enjoyed, included at least three cups of milk per day for each member and “citrus fruits and tomatoes, eggs, liver, green leafy vegetables, and whole grain or enriched cereals and breads.” Notably missing from the list was red meat, a staple of traditional American diets. While the Wrights’ weekly shopping list included 7 ½ to 8 ½ pounds of meat, poultry, or fish, and one of these was served “at least once daily,” traditional cuts of meat were deemphasized and “at least once a week, Margaret tries to serve liver, heart, or kidneys, for these variety meats are particularly high in iron and vitamins.” Her menu list also included beans, peas, and eggs as alternates for animal protein. Lunches were very light and essentially vegetarian, including unusual dishes like apple-cabbage salad and cottage cheese and nut sandwiches. These choices made the Wrights unusual among their peers, and the otherwise enthusiastic reader’s interest might falter here, for organ meats were not typically enjoyed in mainstream American foodways. Similarly, *Wartime Nutrition* recommended “chicken, fish, liver, or sweetbreads” as “excellent main dishes” for the evening meal, despite the fact that the

last two were not popular among American consumers.

Further setting the Wrights apart from their national cuisine, sweets were limited to “simple puddings made of milk and eggs and fresh and cooked fruit.” Instead of candy, the children enjoyed chewing on soft dried fruit. To an American woman raised to think of the perfect layer cake as her crowning achievement and in a land where taffy pulls could be major social events, this kind of rethinking might feel like too much too soon. Even if adults were treated to the occasional pie—pastry was considered inappropriate for children—adopting the Wrights’ diet was farther than most families would be willing to go. Nonetheless, the grocery lists and menus included in the bulletin could encourage readers to begin thinking differently about food.

Advice on “how to reduce your food bill” encouraged readers to think seasonally, because produce tends to be cheaper when it is in season, and to remember that “you pay for the fat on the meat you buy,” so it makes sense to save and use the fat for cooking. To help families save money, the bulletin also suggested using dried or evaporated milk and buying cheaper cuts of meat, as well as the “variety” meats that were “bargains in vitamins and minerals.” Beans and peas, including soybeans, were suggested as main dish fare, and molasses was praised as a healthier sweetener than white sugar. Whole grains were, of course, preferred, and “expensive ready-baked items” were to be avoided for their cost but also, presumably, because they tended to lack significant nutritional value.

Margaret’s model menus are notable for their variety as much as for their resourcefulness. A pot roast served on Sunday supplied meat for a beef casserole on Monday and hash on Wednesday, while a lamb shoulder (another unusual

meat for Americans) became minced lamb on riced potatoes for Saturday dinner. Oatmeal left over from Monday morning's breakfast became a pudding with prunes for dessert on Tuesday at lunchtime. The innovation here was that Margaret Wright was planning her leftovers, rather than coming up with something to do with scraps as they occurred. This kind of forethought, which was not usually showcased in sample menus, took careful planning and a broad knowledge of nutrition and cuisine.

Lest this life of calculation seem too complicated, the bulletin reassured readers, "Most of the time Margaret is able to plan the same meals for all. Otherwise the days would never be long enough for housework, nor would she have enough energy left to enjoy her little family." This acknowledgement that thinking about nutrition could seem time-consuming could have another positive effect aside from giving readers the courage to try a new way of thinking about food. Preparing the same foods for children and adults probably meant improving the diet of most adults. Where most Americans would have recognized that children needed a particular diet to achieve proper development and health, when it came to adults, the issue seemed less important. Thus to serve to adults the same balanced meals served to children would be more than just convenient.

Battling the idea that nutrition was a drag on culinary pleasure, the bulletin boldly declared, "Eating is fun at the Wrights' table." The family tried new things and Mr. Wright always modeled good behavior by complementing Mrs. Wright "when something is especially good." This was a family who did not overanalyze, but who also did not take food for granted. To help American families make their own wise food choices, the Bureau published a useful guide to *Food Values in Common Portions*, which outlined the quantities of all the

basic nutrients and vitamins in average servings of commonly consumed foods such as milk, eggs, and meat when these foods were prepared in the most popular ways. Thus, a reader could learn not just the nutritive value of a glass of milk, but also of a serving of pudding made with milk, and of different cuts and preparations of beef (47). Just as Bureau nutritionists had borrowed from the techniques of advertising to create the basic seven charts, advertising copywriters quickly picked up the language of nutritional guidelines and used it to sell goods. Maltex cereal, for example, was advertised in the *Journal of Home Economics* as central to the "Maltex 100% Breakfast," offering "four of the "Basic Seven" types of food in a single meal: fruit, buttered toast, milk, and Maltex—the hot brown, Toasted Wheat and Malted Barley cereal" (48). The company even offered to send readers a free "Daily Diet Record" so that they could keep track of their consumption of the Basic Seven (49). In 1945 Disney released the film "Something You Didn't Eat," produced for the USDA and the Office of War Information and intended for classroom use. A pamphlet about the film showed a family marching together under the call to action, "US Needs Us Strong. Eat the Basic 7 Every Day." The 9-minute cartoon about the "basic seven" was shown to college and adult home economics clubs as well as to school children. A review in the *American Journal of Nursing* found the film an "unusually good presentation, entertaining and convincing" and praised sound, editing, and "technic" as "excellent" (50). Administrators at the BHNHE were clearly thinking of the most modern means of getting their message to the public.

In the meantime, they were also continuing an ambitious program of research into foods and nutrition. Bernice K. Watt and Margaret A. Attaya, for example, brought together the results of 17 studies to report on "Vitamin Retention in Quantity Cooking of Vegetables" in 1945. Although the BHNHE

The Journal of Home Economics published a study by two Bureau of Human Nutrition and Home Economics researchers that revealed the amount and “Nutritive Value of the US Food Supply.”

Hazel Stiebeling was the U.S. representative to the Food and Agriculture Organization (FAO) of the newly formed United Nations and attended the group’s conference in Copenhagen, Denmark.

always considered individual homemakers its audience, institutional managers were an equally important group, because through good nutrition in institutional settings, many people might be subtly but permanently educated in the nature of a nutritionally sound diet. While many studies had so far determined the vitamin content of foods, Watt and Attaya explained, none had yet explored the effect of cooking on the vitamin content compared to the raw food. This was data that nutrition-minded cooks would need to know in order to make wise purchasing and preparation decisions. Interestingly, and a source of frustration for Watt and Attaya, some of the studies had been made “in actual feeding operations” rather than “under experimental conditions” (51). In some cases, preparation included adding ingredients, which could complicate calculations of vitamin content remaining after cooking. Although their data were clearly imperfect, Watt and Attaya were able to produce a range of vitamin loss for potatoes, sweet potatoes, carrots, tomatoes, squash, a variety of dark leafy greens, peas, beans, asparagus, broccoli, cauliflower, cabbage, turnips, parsnips, and rutabagas. Their major conclusion, not surprisingly, was that more study under more perfect conditions was needed before truly reliable figures could be given.

In 1946 the *Journal of Home Economics* published a study by two researchers with the BHNHE revealing the amount and “Nutritive Value of the US Food Supply.” Faith Clark and Jeanette McCay calculated that simply as a matter of supply data, the United States produced enough food to keep each man, woman, and child healthily nourished and with calories to spare. This was truly remarkable in comparison to the situation in other countries in the immediate post-war period. However, Clark and McCay cautioned that simply because the food existed did not in any way mean that all Americans had access to an equal share of it (52). By taking data from the USDA that indicated how much food was produced for domestic human consumption and taking into account non-edible parts of edible foods such as pits and bones and by dividing this quantity by the national civilian population, Clark and McCay arrived at figures for the nutritive values available if all Americans had an equal share of the national food supply. What they found surprised them.

Clark and McCay thought that “every nutrition student who studies” the tables they had produced “will be struck by facts he has never appreciated before.” Among the “surprises” they listed were the fact that “milk contributes much of our protein”

In the Journal of Home Economics, Hazel Stiebeling argued that sharing the world's resources was not just ethical but actually essential to world peace.

The Flannagan-Hope Act provided Federal funding for agricultural production research, including research into "the problems of human nutrition and the nutritive value of agricultural commodities."

and that grains supplied almost as much protein as meat, fish, and poultry combined. American diets had increased by more than 10 percent for six nutrients since before the Second World War, and they had increased in calories by 2 percent and in protein by 14 percent. Thiamin consumption had increased nearly 50 percent, largely due to the enrichment of bread flour. The authors of the study generously concluded that America could share its food wealth with less fortunate nations and still feed its people well.

In a 1947 article in the *Journal of Home Economics*, Hazel Stiebeling argued that sharing the world's resources was not just ethical but actually essential to world peace. The world would never "have lasting peace until we make considerable progress in eliminating the present great disparities in health and levels of living." She identified food as a central element to health. The world food situation was improving but still grim. Although estimated shortfalls had decreased, the world would still be 8 million metric tons short of "grains, bread, or its equivalent" (53). Stiebeling was reporting the findings of the Food and Agriculture Organization (FAO) of the newly formed United Nations. She was the U.S. representative to the FAO and had attended

the group's conference in Copenhagen, Denmark, in September 1946. Although the FAO had managed to compile interesting data on the composition of diets in countries with high-calorie, medium-calorie, and low-calorie diets, Stiebeling cautioned that data were lacking on what individual families actually ate versus what was theoretically available to them. Studies of family consumption must be made before the truth about national diets could be known. It was very likely, she suggested, that many people in high-calorie diet countries were living on diets much like those of people who lived in low-calorie diet countries. Bringing this data and these issues to the general population of nutritionists was an important service in that it might inspire new and sorely needed research.

Federal support for such research came in 1947 with the Flannagan-Hope Act, which directed that Congress make available funds for research into improvement in agricultural production and research. Title I of the Act also directed that funds be made available for research into "the problems of human nutrition and the nutritive value of agricultural commodities." Foods, textiles, and building materials were included in these commodities, so the bill was really a boost for several divisions of the Bureau

(54). The law supported cooperation among Federal, State, and local agencies by specifying that “research facilities owned by the federal government, state agricultural experiment stations, and the facilities of the federal and state extension agencies shall be used in carrying out the provisions of Title II.” Title II involved improvement of the marketing and distribution of farm products. In particular, the USDA was encouraged to research possible uses for anything that American farmers produced or could produce in excess of demand. For research into “the utilization of agricultural products involving the development of present, new, and extended uses,” USDA laboratories were to be used as much as possible, although the option to contract the work out to private agencies was left open.

Perhaps most exciting for home economists, projects funded through this legislation were to be taken up “in addition to” and not instead of existing projects. The Act would expand the work of home economics research groups throughout the country. Although no appropriations had yet been made, leaders in the field were busy preparing to take full advantage of funds once they became available by sketching out research ideas. A committee of the Land Grant Colleges Association that included Agnes Fay Morgan, Lita Bane, and Hazel Stiebeling was providing leadership, and “many regional and national conferences are being held for joint thinking and planning.”

By January 1948, Ruth O’Brien and Georgian Adams could report that many projects funded through the Flannagan-Hope or Research Marketing Act were underway. Many were not directly of interest to home economists, but some, particularly those funded through section nine of the Act were of interest to home economists. As an example, O’Brien and Adams described the “nutritional status study,” a cooperative project of researchers at the Bureau and at the Western, North Central, and

Northeastern regional experiment stations. It was “planned as a comprehensive study of the nutritional requirements of different population groups as indicated by the nutritional status of individuals in relation to their food intake (55). Simultaneously, the Bureau was collaborating with experiment station researchers in the Southern region to collect data on the “food consumption and food habits by families in typical tobacco farming communities, in typical cotton farming communities, and in typical mountain farming communities of the South.”

At the same time as these conferences were meeting, Americans were being asked to think about food internationally. President Harry Truman convened the Citizens’ Food Committee (CFC) in 1947 to encourage Americans to reduce their use of foods that could be shared with the Nation’s former allies who were still struggling in the postwar period. Taking up the work initiated by Katherine Fisher of *Good Housekeeping Magazine*, who served on the Committee, Callie Mae Coons, Assistant Head of the BHNHE, prepared menus and recipes that the CFC published daily in an attempt to get Americans to “Save Wheat, Save Meat, Save the Peace.” Coons’ suggested meals were published in newspapers as the “Peace Plate,” reflecting the belief that in a volatile postwar world, peace could only be assured if everyone had enough to eat. Wheat- and meat-free “peace plates” included such treats as “Golden Fish Sauté” and “Baked Caramel Custard.” Despite the herculean efforts of Coons and her coworkers at the BHNHE to help Americans conserve food, pressure from meat producers (especially poultry producers angered by the call for eggless days), brewers, distillers, and the restaurant industry proved too much, and the Federal Government’s support for the program faded within a year. Home economists were not eager to abandon the campaign, and one wrote in 1948 in the *Journal of Home Economics* that “the food

1948



The Bureau of Human Nutrition and Home Economics celebrated its 25th anniversary.

conservation program is still on. The food emergency will last for some time—through this crop year, next crop year, and maybe the next. A group of home economists has formulated a workable program. Hundreds of others have contributed to its effectiveness. All of us can continue to carry it out through our individual professional activities and our own personal lives.” Intelligent use of food resources might be a fad for the Federal Government, easily forgotten when business interests objected, but for home economists, it was a basic responsibility (56).

In 1947, the American Home Economics Association legislative committee committed to support legislation that would provide appropriations for the BHNHE, as well as supporting work of the home economics experiment stations and cooperative extension services. Some of the important studies completed over the next decade included a series of studies to investigate whether a “growth factor” could be passed from hen to chick in the egg. This series of studies, carried out by Frank Csonka with collaboration from other researchers, could presumably have an impact on diets fed to poultry but might also serve as a starting point for further research in human prenatal nutrition. Another series of studies, conducted by BHNHE researchers Madelyn Womack and Mary Marshall, looked at nitrogen balance and amino acids in rat diets. Womack was also involved in research that discovered a quick way to find the nutritional value of cottonseed proteins, offering innovation in methodology as well as scientific findings.

While many researchers worked on projects of their own design, others made use of the great collection of data provided by their peers. Summing up several years’ worth of studies involving more than 1,000 rats, D. Breese Jones and Alvin Caldwell made the interesting discovery that, regardless of the purpose of the experiment, female

rats had a greater ability than male rats to survive on low-protein diets. In 1951, another team of BHNHE researchers asked the simple question of what kinds of conclusions could be drawn relevant to human nutrition from work with rats as the experimental model. Feeding rats a diet of “foods cooked as for human consumption” did not produce ideal health for the rats. Therefore, the authors concluded, “it is evident that the application of the results of animal studies to recommendations for human dietary practices should be undertaken with caution, and the task of interpreting experimental data in the light of human needs should be kept in mind in planning such studies” (57). Researchers must keep in mind physiological differences, differences in metabolism, and the different rates of aging between rats and humans, as well as the different signs and symptoms of nutrition-related diseases in the two species.

25th Anniversary of the Bureau

The BHNHE celebrated its 25th anniversary in 1948. During the annual meeting of the American Home Economics Association in Minneapolis, MN, 600 conference attendees went to a celebratory banquet where they dined on “Minted fruit cocktail.

Beef tenderloin with fresh mushrooms. Parsley potatoes. Garden asparagus. Spring salad. Relishes. Hot rolls. Ice cream” and a birthday cake with coconut frosting (58). A photograph from the event shows a smiling Stiebeling, bride-like, wielding a cake knife. The crowd was urged to join in singing “Gone Are the Days” to the tune of “Old Black Joe.” The words to this song, apparently composed for the occasion, celebrated the increased participation of women in the public sphere:

“Gone are the days when only men can roam,
Gone are the days when the girls all stay at home
For now you’ll see women working everywhere,
There’s not a single line of work they will not dare
These women, these women,
How they do love to roam;
You’ll find them almost any place
Except at home.”

A celebration at the Bureau itself took place on July 1, 1948. Employees and guests were treated to a lively afternoon of tributes, followed by dinner in the USDA cafeteria. The fare on this occasion was no doubt a little blander than that served in Minneapolis, although selections from the usual cafeteria menu were apparently followed later by cake and ice cream. Stiebeling asked Ruth O’Brien to find out how other divisions of the USDA, such as the Forestry Service and the Soil Conservation Service, had celebrated their anniversaries. O’Brien found that these bureaus, headed by men, had enjoyed very little in the way of birthday parties. The difference might have been one of gender roles, since women are typically expected to observe anniversaries more faithfully than men, or it might have been a question of subject matter. Those who studied aspects of everyday life, including food and housing, might be expected to have parties on the mind more than those who studied soil and trees.

In preparation for the party, Kathryn Cronister of the Information Division sent out a call for limericks on the theme of the BHE. To start them off, she provided this frame:

“There was a queer lady from Maine
Who thought all our work was in vain

And now days she counts it all gain.”

Busy researchers only needed to come up with one rhyming couplet to show their love of the Bureau. Rising to the challenge, the staff provided 72 couplets, among which were the following:

“Til our figures she checked/Found them correct”
“Til we heeded her hollers/on spending her dollars”
“Then we helped her with canning/And financial planning”
“We showed her examples of well-laundered samples”
“With soaps and detergent/We proved it was urgent”
“In her kitchen by preaching/We cut stoops and reaching”
“We kept right on pitchin’/Came up with a kitchen”
“Til our taste-testing of spuds/Helped her buy some new duds.”

While most of the “poets” expressed pride in the Bureau’s work, one employee submitted the less self-congratulatory “By golly she’s right/But we put up a fight” (59).

For the press statement announcing the anniversary, Stiebeling described the Bureau’s origins: “Our Bureau was established because women of the country ... and particularly those in the American Home Economics Association, kept asking the Department of Agriculture and State Colleges for information on food, clothing, and housing, which could come only from research” (60). That Stiebeling credited both experts and amateurs for the Bureau’s existence reflects the huge role that the Bureau was able to play in the development of the many fields that together made up home economics. After 25 years, the BHNHE

was “considered a small bureau”; it had a staff of 240 serving the 32 million American women who, as full-time homemakers, were the “nation’s largest occupational group,” according to Stiebeling. Stiebeling was obviously proud of the immense amount and high quality of work her bureau produced, but the juxtaposition of the small staff with the huge audience certainly suggested that resources might be improved through greater funding that could support a larger staff. Even the anniversary celebrations suffered from lack of funding, as a poem in the archives mourns that the planning committee “put out a plan with bated breath/But everyone gave it the kiss of death. In a land that flows with milk and honey/No one in Home Economics had any money” (61).

The theme of insufficient resources emerged again in a skit prepared to celebrate the Bureau’s anniversary with a little comedy at the expense of legislators. In the skit, a fictional Senator Claghorn asked preposterous questions of the Bureau’s staff before he would approve its funding. Addressing Kathryn Cronnister, the fictional senator said, “Many of my clients, and some members of Congress, charge that your division is causing strife in the land by telling the truth. I need not point out to you that this is a serious charge against a Government Bureau.” An example of one way to remedy this terrible truth telling problem, he suggested, was to “change your publications so as then to advise people to eat more cereals which will keep easily and less of the perishable fruits, vegetables, and milk.” As for the ever-popular bulletins, Claghorn asked why they needed updating at all, “Since Mrs. America lives in an obsolete house, is now busily adjusting obsolete clothing to present needs, has obsolete equipment for home canning, why not continue the obsolete canning direction? Why not help Mrs. America to be consistent?”(62).

Bureau employees also celebrated the silver anniversary with the release of a film, *Research for Better Living*, which provided a virtual tour of the Beltsville facilities. A script and shot list indicate that the film showed a wide variety of food and nutrition research in process. One shot showed “Hammerle inoculating jars: Gilpin inserting thermocouple and putting jar in canner,” while a voice over explained “We come first to the laboratories where we work to improve home methods of food preservation and preparation. Here are carrots, being canned experimentally in family-sized equipment. Some of the jars are inoculated with spoilage organisms. After processing, they will be incubated ... and later examined for keeping qualities” (63).

More appetizing shots of palatability tests on turkey legs and frozen strawberries (not served together) were offered along with the image of a Bureau employee assembling a cake that used dried apples. For the turkey leg, the voice over explained, “Some of our work deals with unfamiliar forms of foods. Many of the turkeys now raised are too big for the average buyer. But a turkey leg ... or quarter ... or a turkey steak may be just right.” Frozen strawberries were assessed by “trained judges from our staff,” who tested “the berries for natural flavor, for sweetness, tenderness, and general acceptability.” Not only “trained judges” were used, the film revealed. Dishes designed for school lunches were tested by school children, shown enjoying (or perhaps not enjoying) creamed carrots and peas.

The Bureau’s favorite “living tool[s],” lab rats, also were featured in the film, as was a newer technology, the “power pack,” which “by its ten thousand volts ... can separate materials differing only slightly in physical or chemical nature.” Lest the Bureau’s work seem too technical and perhaps self-contained, a conference of “policy makers,” was portrayed, discussing “milk charts.”

The film summed up the work of the Bureau as “(1) food preparation and preservation, (2) composition and nutritive value of food, and (3) nutritional requirements. A fourth and relatively new area relates to food and nutritional problems of the school lunch program.”

This “relatively new area” came to be part of the Bureau’s work with the passage of the National School Lunch Act in 1946. The Act gave the USDA the power to administer a school lunch program through State agencies. States hired dieticians to design menus and oversee lunchrooms while USDA nutritionists set to work researching children’s nutrition. Susan Levine, in her history of the school lunch program, has referred to the passage of the Act as “an uneasy compromise among an unusual set of allies” (64). It was, she argues, “a historic act and a triumph for a generation of home economists, nutritionists, and child welfare advocates who had long struggled to improve American diets.” But it was “also a triumph for the Department of Agriculture and a generation of farm policymakers who believed that government-supported price supports were essential to the growth and prosperity of the farm sector.” The interests of the farm sector were not always aligned comfortably with the best possible nutrition for America’s school children or with feeding the poor. Because the Act required schools to accept agricultural surpluses, farmers came to see the lunch program as a kind of insurance against overproduction. Beyond guaranteed “staples such as dry milk, lard, flour, rice, and cornmeal,” Levine writes, lunchroom administrators and staff “never knew what other foods might appear. One year, for example, the Department of Agriculture distributed six million dollars’ worth of beef but the next year offered only half that amount.” Participants in a national conference on nutrition held in 1952 and discussed in greater depth below, noted that this “plentiful foods program,” while potentially a good thing for national

nutrition, seldom provided much advance warning about which foods would be plentiful when, making it difficult to plan balanced meals. A discussion group reported “the [plentiful foods] program was only indirectly related to improving the nutrition of the Nation’s population, but that its value could be greatly increased if information on nutritional characteristics could be included with information on supplies” (65). This would be especially helpful to school lunch programs, struggling not just to feed the hungry but also to educate the Nation’s future consumers in the tenets of good nutrition.

Another problem with the administration of the Act was that while the Act created the need for school dieticians in each State to design nutritious menus, many States scrimped on funding, hiring only one dietician to supervise all schools and leaving daily food production to untrained and poorly paid cafeteria workers. According to a 1959 report by Marvin Sendstrom of the USDA, however, funding was provided for “inservice training for local school lunch workers” and the Federal Government also supplied “aids in menu planning, food buying, standardized quantity recipes, food handling, and storage, and equipment requirements for preparing and serving foods” (66). The Consumer and Marketing Services of the USDA administered the program. Guidance in nutrition and training for workers were administered through the State educational agencies with the cooperation of “colleges and universities within the state.” To assist local agencies in meeting dietary guidelines, the Bureau prepared a set of recipe cards for use in school lunchrooms. Published in 1947, these “school lunch recipes for 100” suggested “main dishes which conform to the recommended protein requirements, vegetables, salads, and salad dressings, breads, desserts” (67).

The Second Quarter-Century—Its Start

Meanwhile, having made important progress in understanding food composition, Bureau researchers embarked on a series of studies of food consumption that attempted to create a map on which to draw dietary battle lines. Finding out what people really ate could help nutritionists identify weak points in national nutrition. Once these weak points were identified, researchers might use studies of food habits to develop meaningful ways to intervene or offer new food options. In the winter of 1948, for example, Bureau researchers studied “the Nutritive Content of Homemakers’ Meals” in four American cities. Knowing what the people who made most of the Nation’s meals were themselves eating could serve as a starting point for changing habits and improving nutrition. The study included “approximately 1,000 homemakers” in Birmingham, Al; Buffalo, NY; Minneapolis, MN; and San Francisco, CA; and it was “based on reports of their meals for a 24-hour period.”

Having completed a number of studies of family nutrition that looked at the family as a single unit, Bureau researchers were shifting their focus to individuals within the family to get a clearer picture of the complex that was family feeding. Faith Clark and Lillian Fincher chose to look at homemakers for several reasons, including the fact that because they were responsible for most family meals, homemakers were likely to have a good sense of quantities and thus be good at self-reporting. Homemakers were chosen also because “several investigators have reported that the homemaker may have the poorest diet in the family” (68). Despite the difficulty of calculating exact quantities of individual foods consumed, Clark and Fincher were able to determine that the average homemaker in their study consumed approximately 1,780 calories per day.

While this number was above the basal energy requirements for “a woman corresponding to the average height and age of the group,” it was below the 1948 Recommended Dietary Allowances (RDAs) of 2,000 calories for a sedentary woman, 2,400 calories for a moderately active woman, and 3,000 calories for a very active woman. The difference between recommendation and practice “raised several questions about the interpretation of food consumption data in relation to recommendations for food intake.” Although many of the women seemed to be overweight, “the data for 1 day suggest ... that many of the diets may have been low or borderline in protein.” Of the nutrients studied, diets were most deficient in calcium, reflected by the finding that “the average homemaker in this study used a little over a cup of milk a day or its equivalent in cream, ice cream and cheese.”

In general, older homemakers consumed fewer calories and had lower levels of essential nutrients in their diets. The higher the family income, the higher the level of education a homemaker had; and the younger she was, the more likely she was to have a diet approaching the RDAs. Clark and Fincher made the interesting suggestion that “their food habits may thus be indicative of changes that take place as new generations are influenced by nutritional knowledge.” A valuable discovery of the study might well be that such studies (and the dissemination of their findings) had value.

For 3 days in 1952, “more than 400 representatives of governmental and nongovernmental agencies” involved in food and nutrition programs gathered in Washington, DC, to discuss the state of nutrition science and education. They were there to attend the National Food and Nutrition Institute sponsored by the USDA, the National Institutes of Health, the Food and Nutrition Board of the National Research Council, and the Interagency

Committee on Nutrition Education and School Lunch. In the foreword in the published proceedings of the meeting, Stiebeling wrote that the “broad base of sponsorship for the conference, which included participation by many other agencies within and outside the government, resulted in a conference that gave perspective to a wide range of problems,” all related to “our common interest—the nutritional betterment of our people”(69).

Speakers at the meeting celebrated the amount of discovery about human nutrition made in the past 20 years and urged their colleagues to expand their research to build on this foundation. They presented summaries of the latest research on the nutrition of adults, children, the elderly, and rural and urban families, which yielded a rich portrait of the Nation’s nutritional status and prospects. Experts in the field addressed laws affecting food supplies and the effect of food processing on nutrition. Presenters also spoke about nutritional deficiency as a factor in disease as well as addressing a newer problem, the threat of atomic warfare. Roy Lennartson, Assistant Administrator of Marketing of USDA’s Production and Marketing Administration, discussed the need to organize food supplies for emergency preparedness while Vincent B. Lamoureux, Radiological Defense Consultant with the Federal Civil Defense Administration, offered the grim advice that “food animals ... that have received a heavy dose of radiation should be slaughtered immediately and used for food.” The radiation itself would not make livestock “unfit for consumption,” but the longer an animal such as a cow suffered the effects of a blast, the less appealing its meat would be (70).

Dealing with less grisly but perhaps more pressing matters, National Institutes of Health Director W.H. Sebrell, Jr., an authority on human nutrition, noted that most of the deficiency diseases had been

controlled nationally through the successful introduction of fortified and enriched dietary staples. But another danger loomed: “Obesity has replaced the vitamin deficiency diseases as the number one nutrition problem in the United States.” Sebrell reported that one quarter of the Nation’s adults were obese and that obesity was associated with a host of illnesses as well as shorter life spans (71).

While it was important to focus on solving global nutrition problems, obesity of the U.S. population deserved close attention from nutritionists in the future. Sebrell felt confident of the abilities of the Nation’s food and nutrition researchers to solve future problems, because their past work had made a significant difference to the population. By markedly reducing rates of dietary deficiency diseases, nutrition programs had contributed in an “outstanding” way to the strength of the Nation’s economy. Nutrition programs “and allied sciences—to speak in purely economic terms—have led to a more productive population, and thus to higher purchasing power and consumption.” Noting that most of the existing work on nutrients had been done “*in vitro*,” Sebrell called for more research into “actual body processes.”

Charles Glen King, Scientific Director of the National Nutrition Foundation, Inc., and a professor of chemistry at Columbia University, singled out recent research in fats as the most important ongoing work (72). Esther Phipard, Assistant Head of the Family Economics section of BHNHE, supported both Sebrell’s worries about obesity and King’s interest in fat with her report that the percentage of protein remained constant while that derived from fat in the average American diet had risen “rather markedly” over the 43 years between 1909 and 1952. Phipard noted, “whether or not this shift in the source of our calories ... is nutritionally desirable is questionable” (73). Phipard reported that while consumption of important nutrients

appeared to be rising in diets at all economic levels, the rich and well educated still ate better than the poor and less educated, and most people did not achieve perfect nutrition no matter their socioeconomic status or education. In particular, calcium and vitamin C were in shortest supply in the diets of average Americans.

Discussion groups tackled the topics of food supplies, food distribution, nutrition education, food laws, and emergency food planning, bringing together the Nation's experts to reflect on current conditions and propose action for future improvements. A panel discussion on coordination of nutrition programs gave as a good model for organizing the collaborative efforts among the Public Health Service, the American Dietetic Association, and the American Diabetic Association in putting together materials to educate diabetics on the role of diet in their disease. The panel saw elementary school lunches as the most important site for collaboration, noting that in these schools there were "26,000,000 boys and girls at the age when food habits were being established and are susceptible to the concerted influences" of the adults around them (74). Most heartening of all the Institute's recommendations was the exhortation for nutrition educators to remain "aware of the importance of maintaining a healthy attitude toward food and of retaining some of the fun of eating."

In 1953, the same year the proceedings of this important meeting were published, the Bureau was "abolished" by the order of the Secretary of Agriculture. Despite the harsh terminology, in reality, the work continued much as before, with the Bureau now a division within USDA's Agricultural Research Service (ARS). This might be seen as an attack on the work of home economists, a group that was predominantly female, except that many other bureaus, such as the Bureau of Entomology and the Bureau of Animal Industry, mostly staffed

by men, also became divisions of the ARS as part of this major reorganization. In 1957 ARS was reorganized again, and all home economics work was centralized in three divisions under the Institute of Home Economics. Stiebeling was Director of the Institute, Callie Mae Coons headed the Human Nutrition Division, Gertrude Weiss headed the Household Economics Division, and Esther Batchelder headed the Clothing and Textiles Division (75).

Throughout the 1950s, food and nutrition researchers in the ARS published an important series of bulletins on staple foods. Each of these bulletins, subtitled "Facts for Consumer Education," focused on a single foodstuff—tomatoes, peaches, pork, milk, bread—and provided all known nutrition information, a history of usage and national consumption data, as well as instructions for purchasing, cooking, and/or preserving. Bulletins concerning fruits and vegetables also gave values for seasonal and regional availability. Meat bulletins discussed different cuts. The bulletins also included a section of "Questions from Homemakers" that reflected the massive amount of correspondence received by ARS food experts. Here, a reader could find answers to such common questions as "is an iridescent or 'rainbow' film on the cut surface of ham a sign of spoilage?" or "Is bread fattening? Should it be included in a reducing diet?"(76, 77).

By 1954, Stiebeling could confidently claim that "Progress has been made in getting knowledge about nutrition to the public, and families have become increasingly conscious of the importance of good nutrition to health" (78). Gertrude Weiss noted of homemakers, "When they are asked about their food choices, references to vitamins and minerals are frequent in their answers. Many are specific and accurate about the food value they are seeking." Although "some still have false ideas about the nutritive value of foods ... the important

point for marketing is that the consumers are nutrition-conscious” (79).

While the average homemaker typically responsible for family meals was the main intended audience of bulletins produced by ARS’s Human Nutrition Research Branch, the Branch also produced material to assist professionals in the field. Probably the most important publication of the 1950s for practicing nutritionists and food scientists was the 1955 *Energy Value of Foods: Basis and Derivation*. Updating the work of Atwater, Annabel L. Merrill and Bernice K. Watt wrote that their book had been “prepared to provide more background information on food energy data than that given in current textbooks and food tables and to show the basic data drawn upon in deriving the revised calorie factors now used in tables of food composition in this country” (80). As up-to-date as the work was, Merrill and Watt acknowledged that there was much yet to learn. In particular, like Sebrell, they saw the need for more research in fats. There were, the two wrote, “problems with direct bearing on the digestibility of protein, fat, and carbohydrate that have not been resolved satisfactorily at this time.” Revisions were “anticipated” as more research was conducted on “the various constituents in the nitrogenous matter, fat, and carbohydrate of food.” Certainly no nutritionist who read the work would have disagreed that theirs was still a new and evolving science.

To make important choices easier for the nutrition-conscious public, the Human Nutrition Division of the ARS published new food guidelines in 1958 (81). The Basic Four was, according to ARS historian Dr. Helen Souders, “a new and simplified dietary guide based on most recent research on food consumption habits, nutritional needs, and nutritive value of foods” (82). Taking what they knew not only of food composition but also of how Americans ate, Division workers were able to assemble a guide that

they believed could be understood and therefore acted upon by the ordinary person. Simple and colorful, with a contemporary design style, Leaflet No. 424 was designed to make good nutrition look easy, modern, and even fun. Daily allowances from each of the four groups—milk, meat, vegetables, and bread/cereal—were provided in the simplest possible terms. Adults were encouraged to have two or more cups of milk or milk products, two or more servings of meat including fish, poultry, and eggs (with dry beans, peas, or nuts as suggested alternatives), four or more servings of fruit and vegetables (with one serving a citrus or another source of vitamin C), and four or more servings of whole grain, enriched, or restored bread or cereal.

The fine print at the bottom of the page invited supplementation: “plus other foods as needed to complete meals and to provide additional food energy and other food values.” What the average reader would make of this addendum is not clear. The vagueness of the wording “complete” made room for cultural differences in meals. The authors might be referring to foodstuffs that were used for flavor rather than sustenance, things like herbs, spices, or onions and garlic. They might be referring to sweets, which were notably missing from the four groups, though they could certainly be assembled from elements of each group.

Where the “Basic Four” pamphlet was aimed at the consumer with the least amount of nutritional education, another bulletin published the same year was designed to help diet and nutrition professionals such as extension agents and home economics teachers convey this important information to the public. Louise Page and Esther F. Phipard, both employed in ARS’s Household Economics Research Branch, wrote *Essentials of an Adequate Diet: Facts for Nutrition Programs* in consultation with workers in the Human Nutrition Research Branch (83).

Here, the message in the fine print of the Basic Four pamphlet was made clear. The recommended daily servings of the four groups were designed to provide a “*foundation* for a good diet.” In real life, very few would restrict themselves to the foundation: “To round out meals and to satisfy the appetite, many people will use more of these foods and everyone will use foods not specified—butter, margarine, other fats, oils, sugars and unenriched refined grain products.” Often, these extra foods would be “combined” with those from the Basic Four in “mixed dishes, baked goods, desserts and other recipe dishes. Other foods, such as oils and sugar, would be added to the basics “to enhance flavor and improve appetite appeal.” Ever mindful of the fact that palate is king, Page and Phipard encouraged nutrition workers to be understanding of menus that used more than just the basics.

Based on past research, “experience shows that with the patterns of eating in this country, the additional foods will bring the calorie level up to or beyond 100 percent.” This in itself should not worry workers involved with nutrition programs; what mattered was whether dietary needs were being met. Was the foundation there, in other words, or was most or all of the meal “extras?”(83). To make it easier for nutrition workers (and potentially the public) to understand the differences among foods that supplied the same nutrients, the bulletin assigned points to foods. The points were assigned based on milligrams of each important nutrient within a foodstuff. Thus, a cup of whole milk counted for 10 points toward calcium allowance, while one-quarter cup of cottage cheese earned 2 points. The goal was to reach about 20 calcium points, or at least 600 milligrams of calcium in one day’s diet.

Since Americans had rather quickly caught on to the idea of calories and the possibility

(for better or worse) of counting them, this system theoretically made sense. Twenty meat points per day, which could be reached using a variety of protein sources including dried beans and eggs, would provide about 30 grams of protein daily. Because milk products also supply protein, any quantities above those required to meet calcium requirements could also be counted in this category. Many vegetables contain, in common serving sizes, more than the recommended daily allowance of some vitamins. The bulletin therefore encouraged readers to think in terms of weekly consumption of foods in the fruit and vegetable category. Page and Phipard recommended “at least 140 vitamin A points *a week*,” which of course came to 20 points per day but which could be eaten in whatever way that made sense to the individual or family.

Using the points system to ensure basic nutrition, one would still come up short on recommended calorie intake, so Page and Phipard suggested that most people would eat more servings in any one category than what was required, and that some of the foods not considered to be among the basic four would also add to calories. Variation was, they stressed, as essential to understanding diets and working with individuals as food values themselves. Convenient as it might be, it would not be possible to design one diet for all people because of “differences in nutritional needs of individuals and variation in nutritive value of foods.” A food guide that would serve the Nation would also need to be “flexible enough to allow for regional and seasonal differences in food supplies, for food preferences, and for different food budgets.” Nonetheless, the bulletin did include sample menus for 2 days, interesting from a modern perspective for their generous inclusion of iced cake at lunch and chocolate sauce on ice cream with dinner. Despite the acknowledgment of regional differences, the meals are

resolutely of the Northeastern or Midwestern cuisine that had come to be understood as mainstream American. The nutrition extension worker in any other region would simply have to work out for herself how much cornbread or tortilla was the equivalent of a “roll, enriched” that appeared with lunch.

Taking up the question of regional variation not in diet but in nutrition research, the ARS participated in a nationwide study, which was published as the *Nutritional Status of the USA* in 1959 (84). This publication represented the contributions of experiment stations in all 50 States as well as the activities of the Human Nutrition Research Branch. The report was something like a nutritional census of the Nation. Paul Sharp, Director of the California Agricultural Experiment Station, prepared the introduction to the report. The goal of the study, he explained, “was to obtain factual information of the nutritional level of the nation by means of sampling appreciable numbers of the population of the United States with reference to such variables as age, sex, geographical location, etc.” The study would serve “as a bench mark for the nutritional status of our people.” Noting that “Never before has a program involving such breadth and depth of information been undertaken,” Sharp suggested that it be repeated in 5 to 10 years to learn if the “nutritional status of our people is improving or deteriorating” (84).

Four technical committees, each assigned a region, conducted the study. The committees were composed of researchers from each State in the region and a representative of the Human Nutrition Division of the USDA. The Northeast group investigated how best to collect nutritional data. In some studies, skilled nutritionists interviewed people who had been trained to keep food diaries. In others, food inventories were made at the beginning of a week and rechecked at the end of the week. The quantity missing at

the end of the week was then divided by the “household size in equivalent persons,” a number determined by dividing the number of meals served in the house by 21. A problem with this kind of calculation, which the report acknowledged, was that this gave information of meals prepared, not what was actually eaten. Despite national abundance and widespread availability of nutrition education, researchers in the project found American diets lacking in vitamins A and C, calcium, and iron. Americans needed more fruits and vegetables, specifically, Agnes Fay Morgan suggested, “the choice should be in favor of dark green and deep yellow vegetables, and tomatoes, berries, citrus fruits and melons.” Despite these deficiencies, which seemed to stem from national foodways in which these strong-flavored foodstuffs were not preferred, Morgan confidently declared that the national nutritional status “on the whole was found to be good, probably the best that has ever been reported for any similar population groups.”

The research that the USDA nutritionists had been doing received the greatest recognition when Hazel Stiebelling was awarded the Distinguished Federal Civilian Service Award in 1959 (85). Stiebelling was the only woman among the five to receive the award. The award noted “the translation of her vast scientific knowledge into practical dietary guides has improved the health of all Americans.” While Stiebelling’s ability to consolidate and disseminate nutrition research earned her the award, the efforts of the many scientists who produced that “vast scientific knowledge” and worked to make it accessible to ordinary Americans were being recognized at the same time. One Chicago journalist mourned that Stiebelling’s award did not get more attention from the press. Guessing “She’d rate high with Saint Peter,” Edwin Lahey speculated that the Distinguished Service Awards did not attract much attention from the public because nobody cares about “payrollers”—

the Federal employees whose work was recognized by the award (86). Furthermore, only one of the awardees, Lahey wrote, really deserved the award. Stiebeling “made a truly wholesome contribution to our lives,” he informed his readers, “She has been working for your federal government since 1930.” Despite Stiebeling’s noble service, however, Lahey rather floridly continued, “She is just another one of the tired middle-aged women you see on the bus in Washington when the day is done.” In fact, an article published just 2 years later rescued Stiebeling from this inaccurately drab portrait. She “uses her Buick car for pleasure trips and also for journeys to Beltsville, where she visits the laboratories,” a writer for the *The Milk Industry* explained (87).

In 1959, the year the *Nutritional Status, U.S.A.* was published, the *Yearbook of Agriculture* was once again dedicated to research on food. In the 20 years since the last “Food” *Yearbook*, much had changed, but nutritionists still had a sense of their field as new and full of potential. Elizabeth Neige Todhunter declared the story of nutrition, “a story of a fight against ignorance and superstition,” an old story, but also “primarily a story of progress in this century—indeed in the last few years; a story so new that it is far from its end” (37). She noted, “The problems of nutrition continue to grow more complex.” It was not enough to have identified nutrients, for “New discoveries reveal that there is close interrelationship between many of the nutrients.” Because “Numerous factors affect the availability of the different nutrients as they exist in food,” she explained, “the biochemical individuality of each person must be kept in mind.” In other words, there would be no one-diet-for-all solution to the problems of malnutrition.

The information that each individual would need to understand her own nutritional needs was collected and disseminated at

the national level by the Food and Nutrition Board of the National Research Council. In the 1959 *Yearbook of Agriculture*, Stiebeling explained how this organization operated: “This Board, made up of 24 scientists from universities, research organizations, and industry, interprets scientific opinion on problems of food and nutrition for the Government.” Representatives from each of the government branches “concerned with food and nutrition attends the meetings.” Once consensus was reached, and here it is important to remember that industry representatives were part of the conversation, the Board then “publishes dietary allowances that say how much of each nutrient is recommended for persons differing in age and activity” (88).

These recommendations were then translated into simpler language and a more usable form by USDA nutritionists and published as “food guides and weekly market lists.” The diet plans were “revised from time to time” to pass on the newest knowledge in nutrition to ordinary Americans. Stiebeling was able to report marked improvement in national nutrition. Referring back to the 1930s, when she herself published the first important studies of American nutrition, Stiebeling explained, “A third of our families then had diets that were classed as poor.” If the studies were repeated in 1959, however, “only about 10 percent of households would have poor diets.” This was cause for pride, but Americans still tended to “neglect” certain foods, those rich in vitamin A, vitamin C, calcium, and riboflavin, so that “the food consumed by some families in the United States still falls somewhat short of scientific goals.” Years of nutrition research had also revealed to Stiebeling and other nutritionists that diet was but “one of the complex set of conditions” contributing to health. As one of the indications of the success of nutrition education and of bread and flour enrichment, as well as improvements in food processing, American children were

growing up to be “sturdier and taller” than their ancestors. Asking what the value of this change might be, Stiebeling made what now seems like an odd claim that there was some connection between body build and intelligence, citing the work of Dr. Ales Hrdlicka of the Smithsonian Institute and Francis Galton, the most famous proponent of eugenics. The fact that she would refer to studies that were hardly scientific seems strange, but it perhaps can be attributed to her enthusiasm for the great improvements of the past 20 years.

Faith Clark and Berta Friend also celebrated improved nutrition over the half-century between 1909 and 1958, but they simultaneously drew attention to a potentially troublesome trend (89). Americans were getting more of their calories from fat than had their ancestors. This was the same trend Esther Phipard had noted in 1952 at the National Nutrition Institute. Clark and Friend attributed the “increasing richness of our diet” to the increasing richness of the Nation. “Foods high in fat,” they noted, “generally are expensive. It has been said that a country’s wealth can be measured by its consumption of fat.”

Four chapters in the *Yearbook* dealt with the difficult problem of how, in a capitalist, free-market society, ordinary people learned about food and nutrition. Of particular concern to ARS nutritionists were food fads and misinformation (90). As slow as Americans were to adopt the research-backed recommendations of government experts, they were just as quick to fall for the latest diet offered by the least qualified charlatan. Helen Mitchell offered the sobering calculation that “Ten million Americans ... waste 500 million dollars a year on quack diets and fake pills and the junk of non-scientific medicine men.” With evident rage, Mitchell warned readers away from food fads, taking time particularly to debunk the Dr. Hay diet, devised by

William Howard Hay, which was based in the idea that acid and alkali foods could not be digested together. She described the workings of the for-profit diet quack in an attempt to empower readers to resist his lures. Most insidious, she noted, were those who used the language but not the research of nutrition to sell their products with “half-truths and misinterpretations of scientific data.” These people “know how to use lingo that sounds like science to promote their own moneymaking projects.” Unscientific diets were potentially dangerous to the person who followed them, but even more frightening, especially from Mitchell’s perspective, they discredited the field of nutrition itself. A food fad that recommended some particular way of eating as a cure for illness “tends to undermine public confidence in scientific nutrition and threatens true progress in the sciences supported by true agencies.” Because the public had come to rely on science for answers, unscrupulous people were able to use scientific-sounding terminology to win confidence, which in turn, because their claims were false at best and fatal at worst, cheapened the public’s opinion of science itself. Despite the muckraking work of the Committee on Government Operations, which published a report on false and misleading advertising of diet products, and despite the strong influence of “tradition” in American foodways, “High-power advertising has had a significant effect on the buying and eating habits of Americans,” and advertisers have not always felt “a responsibility to consumers to the extent of checking the authenticity and implications of their claims.”

Hazel Stiebeling also commented on the relationship between tradition and aspiration in food choices (91). Although “the group in which we are born and develop first determines what tastes good to us and what first tends to bring physical and psychological pleasure,” our choices

were also shaped by whom we aspire to be. A study had revealed, for instance, that nearly 90 percent of married women avoided serving foods that their husbands did not like. In the interests of being a “good wife” as the role was culturally defined—a woman who pleased rather than challenged her husband—these women avoided foods that they or their children might very well like or need.

Stiebeling also understood that “Many people come to like foods that they think will enhance their social position and to avoid foods they fear may lower their status.” This aspirational eating could have negative consequences as, for instance, in the case of “White bread, white sugar, white rice,” which were once “prestige foods and still are for some groups,” or when food was gendered as when “Some think salads belong to women’s parties and rabbits and are not for men.” Looking at how we make our food choices, Stiebeling mused, could tell us a lot about our society: “Advertising and other promotion bring familiar and new food products to our attention and influence our choices in countless blunt and subtle ways. There is much in all this to give us thought about human behavior.” Stiebeling advocated keeping an open mind and inquisitive palate in the interests of both health and pleasure and encouraged readers to learn to like what was good for them, clearly considering taste as much or more a matter of nurture than of nature.

Whether because of the strength of tradition or the persistence of ignorance or issues of supply, one-tenth of the American population had diets that could be classified as “poor” in 1955. Two researchers in the Division of Household Economics, Faith Clark and Corinne Le Bovit, assessed the nutritional health of the Nation in relation to a variety of factors, such as education, location, and family wealth (92). Clark and Le Bovit compared figures from 1936, 1942, 1948, and 1955 to determine what changes

had occurred and to answer again the question “Are We Well Fed?” They found that among those who did not have a generally poor diet, there were nevertheless significant nutrient deficiencies, especially in thiamine. Although the poor had been catching up to the middle class in terms of nutrition from 1936 to 1948, their progress seemed to have stalled by 1955, although those who were better off economically were still not meeting 100 percent of recommended consumption of all nutrients. Challenging the persistent myth of the “picture of the dining table in the farm home groaning with dishes of meat, vegetables, and milk and pie,” Clark and Le Bovit found that although farm families consumed more calories, there was no difference between them and urban families in terms of “allowances in all nutrients.”

Looking to the future of national nutrition, Ruth Leverton published the latest revised Recommended Dietary Allowances (RDAs) in the 1959 *Yearbook of Agriculture* (93). Over the previous 40 years, the idea of the calorie had captured public imagination, and many diets were based on half-truths or outright lies about how many calories the human body needed to function and what else it needed, besides calories, to maintain health. Carl Malmberg had written as far back as the 1920s of a trend to “eat and puke” as a way of staying slim, and there were more diet books, pills, teas, and “salts” on the market than anyone could keep track of. Leverton’s information, as up-to-date as she could make it, had the potential to replace a fog of impressions with a simple science of eating. Giving different recommended calorie intakes for people of different age, sex, height, and weight, Leverton made it clear that there was no one magic number for all. The amounts recommended were “intended for persons normally active in a temperate climate,” a sort of middle ground. Using the recommendations, a person could judge his or her own level of activity and climate and adjust accordingly.

The RDAs were not minimums, as those published in Canada, nor were they designed for the average person, as the British standards were. Instead, they were “intended to cover the needs of substantially all healthy people and to provide a margin of safety as well.” It was this margin of safety that made the RDAs unique, as postwar Americans could feel comfortable about their food supply. As Leverton noted, however, they were not the final word on nutritional requirements. “The recommended allowances are not referred to as optimal—the best possible—amounts,” she explained. Nutritionists knew that these amounts were better than minimums and included the margin of safety, but future research would have to determine whether “larger amounts will bring additional benefits in health.” Likewise, requirements for a variety of nutrients such as zinc, potassium, and importantly, fat and carbohydrates were not yet known. A continuously researched and periodically revised set of dietary allowances would thus be “the tools for planning food supplies and consumption for a healthy individual, family, and Nation.”

Among the articles in the *Yearbook* to address some of these nutrients, perhaps the most important for future research was Callie Mae Coons’s discussion of fats and fatty acids (94). Coons summarized several years of research into the properties of fats and fatty acids, noting that really sophisticated research in this field had become possible only after the Second World War. Coons credited “the use of radioactive elements” for making it “possible to follow fatty acids, cholesterol, and other lipids (fatlike substances) through digestion and absorption to their destination in the body organism.” Simultaneously, the role of fats and fatty acids in the American diet was undergoing change as more and more calories were derived from fat and as dietary fats became less visible, through the increasingly complex processing of foods that marked modern foodways, particularly

in the northern region of the Nation. As yet, “the chemist has not found out all that happens to a fat or oil during processing” and “Biochemists and physiologists cannot yet tell us how the body utilizes some of the products formed during hydrogenation, such as isoacids, transisomers, and conjugated fatty acids.” Nonetheless, much was already known about mortality rates and cholesterol levels, and Coons pointed to interesting studies of how rising dietary cholesterol levels increased mortality levels. Supplying average cholesterol levels as well as charts of grams per 100 grams of fatty acids in a wide variety of foods, Coons brought the most up-to-date knowledge on this topic to the public and suggested important avenues for further research.

Hazel Stiebeling Retires

On June 30, 1963, Hazel Stiebeling retired from public service “after a fruitful and distinguished career of 33 years of public service.” The American Home Economics Association passed a resolution recognizing her achievements, specifically celebrating her promotion of “practical interpretations of research for the betterment of families, and ... [development of] methods for obtaining data on food consumption and nutrition of population groups” (95). New York State Congressional Representative Benjamin Rosenthal (D) honored Stiebeling’s commitment to public service but worried that her departure was part of a movement to limit the effectiveness of the ARS. The same day that her retirement was announced, Rosenthal noted, “the Department announced that the two research divisions formerly headed by Dr. Stiebeling would be consolidated with the four research divisions assigned to development of improved utilization of farm commodities.” Rosenthal feared that this reorganization would be “a sad case of a whale swallowing a valiant fish” in which “the Department’s consumer-oriented

research will inevitably be subordinated to its vastly larger program of commodity utilization research which is conducted primarily in the interest of producers” (96). How nutritionists of ARS negotiated their role as intermediaries between producer and consumer forms an important part of the story of the years since Stiebeling’s retirement.

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In 1941, the food and nutrition research activities of the Bureau of Home Economics moved from Washington, DC, to Beltsville Building 307 (Beltsville, MD), pictured above. Many of these activities remained in this facility for six decades before moving to new buildings nearby. The Bureau of Home Economics was administratively incorporated into the Agricultural Research Administration when it was formed in 1942. The agency was renamed the Agricultural Research Service in 1953. Redirection of research programs and reorganizations in the late 1950s and early 1960s resulted in the removal of “Home Economics” from organizational names.

Source: National Agricultural Library Digital Exhibit “Apron Strings and Kitchen Sinks: The USDA Bureau of Home Economics.”

CHAPTER 4

Research at the Beltsville Human Nutrition Research Center, 1963-2010

Gary R. Beecher

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Abbreviations

AOAC	Association of Official Analytical Chemists	NHLBI	National Heart, Lung, and Blood Institute
ARS	Agricultural Research Service, USDA	NI	Nutrition Institute
APHIS	Animal and Plant Health Inspection Service	NIH	National Institutes of Health
BARC	Beltsville Agricultural Research Center	NIST	National Institute of Standards and Technology
BHE	Bureau of Home Economics	NMD	Nutrition Monitoring Division
BHNRC	Beltsville Human Nutrition Research Center	NRFL	Nutrient Requirements and Functions Laboratory
CFEI	Consumer and Food Economics Institute	PER	protein efficiency ratio
CFERD	Consumer and Food Economics Research Division	PNL	Protein Nutrition Laboratory
CNC	Consumer Nutrition Division	PL	Phytonutrients Laboratory
DLW	double labeled water	RDAs	Recommended Dietary Allowances
DRI	Dietary Reference Intakes	SCOGS	Select Committee on GRAS Substances
EPNL	Energy and Protein Nutrition Laboratory	SEA	Science and Education Administration
FAO	Food and Agriculture Organization of the United Nations	UMCP	University of Maryland-College Park
GFHNRC	Grand Forks Human Nutrition Research Center	USAID	United States Agency for International Development
GRHNRL	Grand Forks Human Nutrition Research Laboratory	USDA	United States Department of Agriculture
		USFDA	United States Food and Drug Administration
		WHO	World Health Organization

GRAS	generally recognized as safe
GTF	glucose tolerance factor
HDL	high density lipoprotein
HNC	Human Nutrition Center
HNIS	Human Nutrition Information Service
HNRD	Human Nutrition Research Division
HPLC	high performance liquid chromatography
IOM	Institute of Medicine of the National Academies
LDL	low density lipoprotein
NASA	National Aeronautics and Space Administration
NCI	National Cancer Institute
NCL	Nutrient Composition Laboratory
NFCS	National Food Consumption Survey
NHLBI	National Heart, Lung, and Blood Institute
NI	Nutrition Institute
NIH	National Institutes of Health
NIST	National Institute of Standards and Technology
NMD	Nutrition Monitoring Division
NRFL	Nutrient Requirements and Functions Laboratory
PER	protein efficiency ratio
PNL	Protein Nutrition Laboratory
PL	Phytonutrients Laboratory
RDAs	Recommended Dietary Allowances
SCOGS	Select Committee on GRAS Substances
SEA	Science and Education Administration
UMCP	University of Maryland-College Park
USAID	United States Agency for International Development
USDA	United States Department of Agriculture
USFDA	United States Food and Drug Administration
WHO	World Health Organization

Introduction

In the late 19th century, W.O. Atwater established an extensive and comprehensive research program on all aspects of human nutrition. He directed these programs within USDA's Office of Experiment Stations, while concurrently a professor of chemistry at Wesleyan University and Director of the new Storrs (CT) Experiment Station (1,2). Following Atwater's illness (1904) and death (1907), many of his research programs were transferred to the USDA in Washington, DC. His successor at the Office of Experiment Stations, Charles F. Langworthy, maintained Atwater's research focus for a while, but he soon became interested in practical issues of food preparation and storage. These interests predominated throughout the first half of the 20th century, as evidenced by the formation of the Bureau of Home Economics (BHE) in 1923 (3). Nonetheless, a research program was maintained that investigated nutrient and dietary requirements, the composition of foods, and tabulation of the consumption of these foods. Often this research was conducted at State's experiment stations and later under contracts from BHE and its successor organizations. In an earlier chapter in this volume, Megan Elias traces activities within this Bureau (3). This present chapter describes accomplishments and activities in nutrition research from about 1963 to 2010. Other chapters describe food consumption, food composition, and nutrition education activities within USDA (4-6).

Administrative Chronology

As noted above, all human nutrition-related activities within USDA were originally located in Washington, DC. However, due to space constraints, research activities requiring laboratory and animal facilities were moved in 1941 to generous, new space at the Beltsville Agricultural Research Center in Beltsville, Maryland (BARC),

1969



Willis A. Gortner, appointed Director of the Human Nutrition Research Division in 1964, completely reorganized the division in 1969.

where these functions remain today (3). The Consumer and Food Economics Division, which included diet appraisal, food consumption, food composition data tabulation, family economics, and survey statistics, was relocated to offices in Hyattsville, MD, in 1963; and it has moved several times since.

In 1963 Senator Milton R. Young (R) of North Dakota submitted a proposal to Congress for substantial increases in funding of the food and nutrition program of USDA (7). The proposal was adopted. It called for physical expansion of the "Beltsville Center," doubling of the scientific effort, and considerable increase in funding. In addition, the appropriation language established three regional human nutrition research laboratories; however, only the centers at Grand Forks, ND, and Houston, TX, were developed under this initiative (8,9). The concept for the Jean Mayer USDA Human Nutrition Research Center on Aging at Tufts University in Boston, MA, came from the White House Conference on Nutrition in 1969, other national meetings, and political activities of the era (10). At BARC, the immediate response to Senator Young's proposal was to hire several "new" scientists and staff, including Willis A. Gortner as Director of the Human Nutrition Research Division (HNRD) (table 1).

1972



Walter Mertz was appointed Director of the newly renamed Nutrition Institute after ARS underwent a major reorganization.

Gortner, son of world-renowned biochemist Ross A. Gortner of the University of Minnesota, was trained in the Department of Biochemistry and Pharmacology at the University of Rochester. He had been a faculty member of Cornell's School of Nutrition and later transferred to Beltsville from the Pineapple Research Institute in Honolulu, HI (11).

Perhaps Gortner's boldest action was to completely reorganize the Human Nutrition Research Division (HNRD) in 1969 and redirect programs to expand research on human nutrient requirements and nutritive value of foods (table 1). "Food science" research was greatly diminished with administration of applied investigations, e.g., food preparation, transferred to the Consumer and Food Economics Division, although staff and facilities remained at Beltsville. The reorganized HNRD consisted of four laboratories, each responsible for research on a broad class of nutrients, i.e., carbohydrates, lipids, proteins, and vitamins and minerals. Each laboratory had at least two investigative units that focused on nutrient requirements and food composition (table 1). Simultaneously, strong research/administrative leaders were recruited for each laboratory. This leadership team consisted of Gortner, Director; C. Edith Weir, Associate Director; Leon Hopkins, Assistant to the Director (and Acting Laboratory Chief, Carbohydrate Nutrition Laboratory, until Sheldon Reiser arrived); and Sheldon (Shelly) Reiser, James (Jack) Iacono, David Vaughan, and Walter Mertz as leaders of Carbohydrates, Lipids, Proteins, and Vitamins and Minerals laboratories, respectively. Except for Gortner and Weir, who were already ARS scientists, the other team members were recruited as follows: Hopkins from the U.S. Food and Drug Administration (USFDA); Reiser from the Veterans Administration Hospital, Indianapolis, IN; Iacono from the University of Cincinnati College of Medicine, Cincinnati, OH; Vaughan from the U.S. Air Force Arctic

Aeromedical Laboratory, Fairbanks, AK; and Mertz from Walter Reed Army Institute of Research, Washington, DC. Although the original laboratories have changed leaders, modified their mission and name, and new laboratories and groups have been added or transferred to/from the "Beltsville Center," the primary focus of research has remained to "...define ... the role of food and its components in optimizing human health and in reducing the risk of nutritionally related disorders in the diverse population." (A. Yates, personal communication).

During 1972, the USDA Agricultural Research Service (ARS) underwent a major reorganization to regionalize administration of its many field stations and units (table 1). At the same time, a National Program Staff was established to coordinate nationwide research programs within the agency. One effect of this change on the newly renamed Nutrition Institute (NI) was to separate the Grand Forks Human Nutrition Research Laboratory (GFHNRL) into an independent research center (GFHNRC). This laboratory, instituted as part of the general program expansion nearly a decade earlier, had been a satellite of the Vitamins and Minerals Laboratory and had provided human studies facilities for HNRD. Because the Grand Forks facility became independent,

Table 1. Organizational changes and related events of Beltsville human nut

Date	Detail of events
1963	<p>Nutrition and Consumer Use Research merged with ARS Utilization Research (regional utilization laboratories) under one Deputy Administrator (Fred Senti, Deputy Administrator; Ruth Leverton, Assistant Deputy Administrator for Nutrition-Related Activities).</p> <p>Two divisions were formed: Human Nutrition Research Division (HNRD) (C. Edith Weir, Acting Director) and Consumer and Food Economics Research Division (CFERD) (Faith Clark, Director).</p> <p>HNRD laboratories—Experimental Nutrition, Food Composition, Food Quality and Use, Human Metabolism</p> <p>CFERD—Family Economics Branch, Food and Diet Appraisal Branch, Food Consumption Branch, Survey Statistics Staff. CFERD relocated from Washington, DC, to Hyattsville, MD.</p>
1963	<p>Report to Congress, “Proposed Program for Expanded Research in Food and Nutrition,” in part called for the expansion of the “Beltsville Center” and thus the doubling of scientists and five-fold increase in funding over 3 years.</p>
1964	<p>Willis Gortner was appointed Director of HNRD.</p>
1969	<p>Human Nutrition Research Division was reorganized and programs were redirected to emphasize research on human requirements of nutrients and on nutritive value of foods. Research on “food science” was discontinued, and research on food preparation, quality, and acceptability was transferred to CFERD (W. Gortner, Director, C.E. Weir, Associate Director, and Leon L. Hopkins, Assistant to Director.) Research programs were divided among four laboratories: Carbohydrate Nutrition, Lipid Nutrition, Protein Nutrition, and Vitamin and Mineral Nutrition. Each laboratory had two investigations units: food composition and human requirements. Carbohydrate Nutrition Laboratory also had a Human Nutrient Metabolism Investigations Unit, and Protein Nutrition Laboratory also housed the Histopathology Investigations Unit.</p> <p>CFERD renamed Consumer and Food Economics Institute (CFEI).</p>
1970	<p>Human Nutrition Laboratory at Grand Forks, ND, was dedicated and was established as a “field station” of HNRD with mission to investigate trace elements and conduct human metabolic studies.</p> <p>Robert Rizek was appointed Director of CFEI.</p>
1972	<p>The Agricultural Research Service (ARS) was reorganized to regionalize administration of research programs into four regions—Northeast, North Central, South, and West. The National Program Staff was established to coordinate nationwide research programs. W. Gortner was appointed the first National Program Staff Scientist for Nutrition and Family Living.</p> <p>HNRD was renamed Nutrition Institute (NI); Walter Mertz was appointed Director.</p>

Nutrition research programs 1963 to 2010

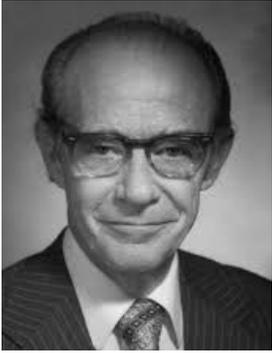
Date	Detail of events
	<p>The Dairy Products Laboratory located in Washington, DC, was transferred to the Eastern Regional Research Center, Philadelphia, PA. Cheese and Butterfat Investigations Section of this laboratory, located in Building 157 at the Beltsville Agricultural Research Center (BARC), was transferred to NI as Dairy Foods Nutrition Laboratory. Several other scientists and technical staff of the Washington, DC, operation transferred to various NI and CFEI laboratories/branches.</p> <p>Non-Ruminant Nutrition Laboratory, Nutritional Microbiology Laboratory, and Ruminant Nutrition Laboratory, which focused on animal nutrition, transferred from Animal Sciences Institute at BARC to the NI.</p> <p>Human Nutrition Laboratory at Grand Forks became an independent research center—Grand Forks Human Nutrition Research Center (GFHNRC).</p>
1973	Building 308 at BARC was renovated to accommodate meal preparation and supervised feeding of human subjects.
1975	Nutrient Composition Laboratory (NCL) was formed in response to the request from NIH National Heart, Lung and Blood Institute (NHLBI) for accurate and extensive data on fatty acid, cholesterol, and selected mineral content of foods.
1976	Dairy Foods Nutrition Laboratory was abolished. Personnel retired or transferred to other laboratories within NI.
	Gortner retired.
1977	James (Jack) Iacono was appointed National Program Staff Scientist for Nutrition and Family Living
1978	Science and Education Administration (SEA), USDA, was formed under the new Democratic Administration. All human nutrition research activities moved from ARS to a parallel organization, Human Nutrition Center (HNC), within SEA.
	D. Mark Hegsted was appointed Administrator, and James (Jack) Iacono Associate Administrator. Research programs were coordinated from the Administrator's Office.
1978	CFEI was renamed Consumer Nutrition Center (CNC).
	Animal nutrition-oriented laboratories were transferred back to the Animal Sciences Institute at BARC.
1980	Energy metabolism program was initiated within Protein Nutrition Laboratory. It was renamed Energy and Protein Nutrition Laboratory.
1981	SEA was abolished under the new Republican Administration. The Human Nutrition Research Centers were integrated into ARS regional organization.
	NI was renamed Beltsville Human Nutrition Research Center (BHNRC).

Table 1. Organizational changes and related events of Beltsville human nutrition research

Date	Detail of events
1981	<p>Gerald F. Combs, Sr., was appointed Nutrition National Program Leader to coordinate human nutrition research activities within USDA and among Federal agencies in response to the 1977 Congressional mandate that USDA coordinate human nutrition research in areas of mutual interest between USDA and the Department of Health, Education, and Welfare.</p> <p>CNC formed a new agency, Human Nutrition Information Service (HNIS). It was administratively placed under the Assistant Secretary for Food and Nutrition Service separating it from the Assistant Secretary responsible for ARS. Consumer Nutrition Division (CND) and Nutrition Monitoring Division (NMD) were developed within HNIS. Food Consumption Research Branch (food consumption surveys) and Nutrient Data Research Branch (food composition data) were organized within NMD, with Robert Rizek as Director. Food and Nutrition Information Center of the National Agricultural Library also was administratively transferred to HNIS.</p>
1982	<p>Collaboration initiated between NIH's National Cancer Institute (NCI) and BHNRC on metabolic research of nutrients and food components as related to changes of markers for cancers.</p>
1990	<p>Jacqueline L. Dupont was appointed Nutrition National Program Leader.</p>
1992	<p>W. Mertz retired.</p>
1993	<p>Joseph Spence was appointed Director of BHNRC.</p> <p>W.O. Atwater Centennial Celebration Symposium was held "to commemorate 100 years of human nutrition research in the U.S. Department of Agriculture and to honor the memory of its initiator and mover, Wilbur O. Atwater." Proceedings were published as a supplement to the <i>Journal of Nutrition</i> (1994;124(9S):1707S-1890S).</p>
1994	<p>HNIS activities were transferred to ARS (HNIS was abolished). Food consumption survey and food composition data activities were administratively moved to BHNRC as Food Surveys Research Group and Nutrient Data Laboratory, respectively. Nutrition education component (Dietary Guidelines, Pyramid, etc) of HNIS was moved to USDA Center for Nutrition Policy and Promotion (CNPP). Metabolism-related laboratories of BHNRC were renamed with minor reorganization: Diet & Human Performance, Metabolism & Nutrient Interactions, and Nutrient Requirements & Functions.</p>
1995	<p>Carotenoids Research Unit was formed—a new organizational unit to bring together scientists conducting research on health-related metabolism of carotenoids and to make research more visible. Beverly Clevidence was appointed first unit leader.</p>
1995	<p>Food Surveys Research Group and Nutrient Data Laboratory moved from Hyattsville to Riverdale, MD; occupied building jointly with several Animal and Plant Health Inspection Service (APHIS) organizations.</p>
1997	<p>Phytonutrients Laboratory (PL) was formed. Carotenoids Research Unit activities were integrated and its mission was expanded to include metabolic studies on a broad range of health-related plant components. Beverly Clevidence was appointed first Research Leader.</p>

Nutrition research programs 1963 to 2010—*Continued*

Date	Detail of events
	Scientists with expertise in plant physiology and in plant isotope labeling techniques transferred to PL from other BARC laboratories.
1998	Carla Fjeld was appointed Nutrition National Program Leader.
1999	Food Surveys Research Group and Nutrient Data Laboratory moved from Riverdale, MD, to Building 005, BARC. Kathleen Ellwood was appointed Nutrition National Program Leader. Community Nutrition Research Group was formed, primarily from Food Surveys Research Group, and with specific mission to monitor and assess the capacity of communities to meet their food and nutrition needs for a better understanding of linkages between nutrition, agriculture, health, and community. Ellen Harris was appointed Group Leader.
2000	Immunology program moved from Animal Sciences Research Institute to BHNRC and was incorporated into Nutrient Requirements and Functions Laboratory. It was renamed Diet, Genomics, and Immunology Laboratory. Joe Urban was appointed Research Leader. Expertise was added to use swine as model for immunological and associated research relevant to humans.
2002	Joseph Spence was appointed Acting Nutrition National Program Leader.
2003	BHNRC occupied facilities in two new buildings on BARC campus.
2004	Joseph Spence was appointed Deputy Administrator for Nutrition, Food Safety and Quality. Mary “Molly” Kretsch and David Klurfeld were appointed Nutrition National Program Leaders.
2006	Allison Yates was appointed Director of BHNRC. Phytonutrients Laboratory was abolished. Some of its personnel retired, transferred to other BHNRC laboratories, or moved to academia.
2007	Metabolism units of BHNRC were reorganized, with a total of six laboratories/groups: Food Surveys Research Group; Nutrient Data Laboratory; Food Composition and Methods Laboratory; Food Intake and Energy Regulation Laboratory; Food Components and Health Laboratory; and Diet, Genomics and Immunology Laboratory.
2008	Joseph Spence was appointed Director of Beltsville Area, which included BARC.
2009	Molly Kretsch was appointed Deputy Administrator for Nutrition, Food Safety and Quality. John Finley was appointed Nutrition National Program Leader.
2011	Allison Yates was appointed Associate Director of Beltsville Area.



D. Mark Hegsted was appointed Administrator of the Human Nutrition Center within the newly formed Science and Education Administration.



James (Jack) Iacono was appointed Associate Administrator of the Human Nutrition Center within the Science and Education Administration.

renovations began on the third floor of Building 308 on the Beltsville campus to convert it into facilities for controlled meal preparation and feeding of human subjects. During and following facility modifications, collaborative studies were conducted at universities that had the required facilities and access to an appropriate population of subjects, e.g., University of Maryland at College Park (UMCP). Also, Gortner was appointed the first National Program Staff Scientist for Nutrition and Family Living, Mertz was appointed Director of NI, and several laboratory units were added to the Institute (table 1).

Shortly thereafter, James C. Smith, Jr., at the Veterans Administration Hospital, Washington, DC, joined the Institute as the Leader of the Vitamins and Minerals Laboratory, the position vacated by Mertz when he became Director. Mertz, a native of Germany, was trained as a surgeon at the University of Mainz, University Hospital of Frankfurt, and County Hospital in Bad Hersfeld, Germany (12). As part of his medical training and early in his career, he chose experimental research in the field of diabetes as a thesis topic. In 1953 he was awarded a research fellowship funded by the US Brewers' Yeast Council to work at the National Institute of Arthritis and

Metabolic Diseases, part of the National Institutes of Health (NIH). At the NIH, Mertz teamed with Klaus Schwarz, and they identified glucose tolerance factor (1959) as an organic complex that contained trivalent chromium and demonstrated its effect on glucose uptake by fat tissues. This was the first indication that a form of chromium was biologically beneficial. From 1961 to 1969, Mertz was Head of the Department of Biological Chemistry at Walter Reed Army Institute of Research, Washington, DC, where he and his colleagues showed that chromium nutrition affects glucose metabolism in humans (12). These studies were the first to show that chromium (III) is an essential nutrient for humans and that it potentiates the action of insulin in glucose uptake. In 1969 he moved to HNRD as Chief of the newly organized Vitamin and Mineral Nutrition Laboratory (table 1).

A new laboratory, the Nutrient Composition Laboratory (NCL), was formed in 1975. This was accomplished by selecting one scientist and one staff person from each of the "original four HNRD" laboratories for the new operation. Kent Stewart (Protein Nutrition Laboratory) was appointed the first leader of this group. Although there had been activity on the composition of foods within the USDA since Atwater's time,



Gerald Combs, Sr., was appointed the new Nutrition National Program Leader within ARS.

the formation of this new laboratory was prompted by a request from the Director of the National Heart, Lung and Blood Institute (NHLBI) of NIH for accurate and extensive data on the fatty acid, cholesterol, and selected mineral content of foods, all of which were thought to be part of the etiology of chronic disease (13). At the same time, cooperative agreements were established between NHLBI and NCL, Consumer and Food Economics Institute (CFEI), and the School of Public Health at the University of Minnesota (Nutrition Coordinating Center) to provide “tools” for the investigation of potential relationships between vascular disease, diet, and nutrient intake. Thus with the re-emphasis of food composition research and tabulation, and scientific and financial collaboration with NIH, human nutrition research activity of the USDA was propelled into the new era of “diet and chronic disease.”

A change in the administration at the highest levels of ARS occurred in 1978 with the formation of the Science and Education Administration (SEA). All human nutrition research activities, including research on requirements and health, food composition activities, food surveys, and nutrition education, were moved from ARS into a parallel organization, Human Nutrition

Center, within SEA (table 1). World-renowned nutritionist D. Mark Hegsted was appointed Administrator of the new Center. He selected Jack Iacono as his associate for his knowledge of the “federal system,” as well as for his accomplishments as a scientist.

During this administration and with an infusion of funds for a room-size human calorimeter, associated instrumentation, and facility modifications, research on energy metabolism of humans began at Beltsville and restarted within USDA after a long hiatus from the days of Atwater. This activity was administratively located in the newly renamed Energy and Protein Nutrition Laboratory under the leadership of C.E. Bodwell. A few other minor administrative changes occurred at the same time (table 1). Administratively, SEA and the Human Nutrition Center existed for only a few years until the Reagan Administration. At that time, research programs at Beltsville were reincorporated into ARS, but the former CFEI (food composition tabulation, food surveys, and nutrition education) was formed into a new agency, Human Nutrition Information Service (HNIS). Also, the human nutrition research programs at Beltsville were renamed the Beltsville Human Nutrition Research Center (BHNRC). Gerald Combs, Sr., was appointed the new Nutrition National Program Leader within ARS, and several coordinating committees were formed that continue today and that foster coordination of nutrition research activities within USDA, as well as across all Federal agencies (14). In the early 1980s, a new collaborative program was begun with scientists at the National Cancer Institute (NCI), part of the NIH (table 1). This program had its origin with a committee of the National Academy of Sciences whose publication, *Diet, Nutrition, and Cancer*, reported the committee’s extensive findings (15). Mertz was a member of this committee, and through his vision a long and productive collaboration was established that

investigated numerous dietary components on markers for cancer inhibition and suspectability.

During the decade of the 1980s and early 1990s, administrative changes were minor. Combs retired; Jacqueline Dupont and Frankie Schwenk were named his replacements; Mertz retired; and Joseph Spence was appointed as BHNRC Director. Spence transferred from the State University of New York (SUNY) at Buffalo, where he was Professor of Biochemistry and Associate Dean for Research and Graduate Studies at the School of Medicine. He also had served as a Health Science Administrator at NHLBI.



Joseph Spence was appointed BHNRC Director.

In the mid-1990s, HNIS was abolished with administrative responsibility for its units transferring to ARS-BHNRC (for food consumption surveys and food composition data) and to the newly created USDA Center for Nutrition Policy and Promotion (CNPP) (for nutrition education). After 13 years of administrative separation, with these changes, all USDA food survey and food composition activities were together again within ARS.

Also during the 1990s, there were minor modifications of programs and unit names within BHNRC, as a result of the change in direction of research on diet and health-related issues (table 1). For example, a Carotenoids Research Unit was formed to bring together those scientists conducting metabolic research on this group of plant components. Because this group did not easily fit into BARC's organizational structure or into the accounting and reporting framework of ARS, soon it was established as a more traditional unit as the Phytonutrients Laboratory. Beverly Clevidence was appointed Research Leader, a similar position she had held with the Carotenoids Research Unit. Later in the decade, Clevidence became Research Leader of the Diet and Human Performance Laboratory, and Earl Harrison

was appointed Research Leader of the Phytonutrients Laboratory. Scientists with expertise in isotope labeling of plants (Steven Britz and Charles Caldwell) were transferred in 2000 from a plant physiology unit at BARC to this laboratory, which gave the group unique expertise in the development of labeled foods as well as the capability to follow the label through ingestion and metabolism. Also, National Program Leaders changed during the 1990s. Carla Fjeld succeeded Dupont and Schwenk; and Kathleen Ellwood, a former scientist at BHNRC, succeeded Fjeld (table 1).

Early in the 21st century, a small immunology program within the Animal Sciences Institute at BARC was transferred to BHNRC, which reformed the original Vitamins and Minerals Laboratory (now Nutrient Requirements and Functions Laboratory [NRFL]). Orville Levander, who was Research Leader at NRFL, returned to full-time research, and Joe Urban became Research Leader of the newly renamed Diet, Genomics and Immunology Laboratory. A series of retirements permitted the addition of scientists with appropriate expertise to expand the program of nutrition and immunology using pigs as a model for humans. However, the events of September 11, 2001, and the subsequent Iraq War

2003



Ribbon cutting for BHNRC buildings that included a large kitchen and dining facilities for ambulatory human studies, expanded calorimeter accommodations, and new laboratories.

2006



Allison Yates was appointed Director of BHNRC.

greatly limited any increased funding and further expansion of the program. Two additional scientists (Tom Wang and Jae Park) were transferred to this group from the Phytonutrients Laboratory when it was abolished in 2006. Nonetheless, a small but strong program focused on nutrition and immunity was developed.

Spence moved to the National Program Staff in 2002 and subsequently to the position of Deputy Administrator of ARS, where he exerted great influence to increase resources for the human nutrition research program within ARS. In 2008, he became Director of the Beltsville Area, which included BARC and BHNRC. However, BHNRC operated with a series of acting directors for several years, which in retrospect was quite detrimental to the program, especially during a period of scarce budget increases and less than favorable political environment for human nutrition research.

Finally, Allison Yates was appointed Director of BHNRC in 2006. Yates brought extensive experience in human nutrition policy and research. She had been Director of the Food and Nutrition Board, Institute of Medicine (IOM), National Academies for a decade, specifically during the expansion of Recommended Dietary Allowances (RDAs)

to Dietary Reference Intakes (DRIs). Prior to that, she was a member of several university faculties where she instituted new programs on nutrition research, dietetics, and health sciences. In mid-2011, Yates joined Spence as Associate Area Director, which once again left BHNRC without permanent leadership.

Mary (Molly) Kretsch and David Klurfeld were appointed National Program Leaders for Human Nutrition after Spence moved to the position of Deputy Administrator (table 1). Kretsch followed Spence as Deputy Administrator when Spence was appointed Area Director, and John Finley was appointed National Program Leader to fill her position.

The largest physical change during this period was the construction and occupancy of two new research buildings for BHNRC in 2003. These long-awaited new facilities provide about 40,000 net square feet of space that includes large kitchen and dining facilities for ambulatory human studies, expanded calorimeter accommodations, and new laboratories for those experiments dealing with nutrition and metabolic research. Food composition activities and food survey work also are currently located on the BARC campus but in separate buildings.

1962



Mary Marshall was one of the scientists intimately involved in metabolic research and food composition.

Much like Gortner 40 years earlier, Yates reorganized the research programs at BHNRC to provide emphasis on those nutrition- and health-related issues that are prominent in the U.S. population and to begin the long rebuilding process. As of 2011, the program consists of Ellen Harris as Acting Director, about 40 scientists, a host of post-doctorates, and support staff organized into 6 groups or laboratories. These include Diet, Genomics, and Immunology Laboratory; Food Components and Health Laboratory; Food Intake and Energy Regulation Laboratory; Food Composition and Methods Development Laboratory; Nutrient Data Laboratory; and Food Surveys Research Group. In addition, there are two small support groups: Human Studies Facility, which provides dietary, menu, and meal assistance in the conduct of human studies; and an Administrative support group that is part of the Director's Office.

Although there have been many administrative changes within ARS and the Beltsville human nutrition research program over the past half-century, the scientists have remained highly focused and have continued to design and conduct creative studies. The data from these relevant investigations have helped to advance the frontiers of human nutrition research and thus have contributed greatly to expand that knowledge base. Also, the numerous technical support individuals, post-doctorates, visiting scientists (domestic and foreign), and students have been critical to the success of a complex Federal research organization such as BHNRC. Highlights of these research findings are discussed in the following section.

Early Research Accomplishments

In an earlier chapter, Megan Elias focused on the many “home economics” contributions of scientists within the agency

during its early history (3). However, there also were efforts in metabolic research and food composition during that time. A significant accomplishment was the development of a strain of rats for the specific purpose of investigating non-insulin-dependent diabetes mellitus (16). The parent strain originated in 1942 through the cross of an albino Osborne-Mendell strain with rats of a hooded strain from Pennsylvania State University. Mary Marshall, one of the scientists intimately involved with the project, named the new strain “BHE” in honor of the Bureau of Home Economics (M. Marshall, personal communication). Extensive records were kept and summarized on life span, response to different diets, and tissue histology (17,18). Research on the metabolic response to dietary alterations of these animals continued through the 1970s when the colony was relocated to a contractor (19,20). A sub-strain was later developed, BHE/cdb, that had less animal-to-animal variability relative to age-related abnormal glucose tolerance and glomerulosclerosis, and fewer complications of obesity and other kidney diseases (16). Although not commercially available, the BHE strain has been supplied by the NIH Division of Research Resources, and the sub-strain by former BHNRC scientist Carolyn Berdanier through the University of Georgia.

In the mid-1950s, a group of scientists were presented with a USDA Distinguished Service Award for “Establishing vitamin A requirements of young adults, demonstrating variation in the bioavailability of carotenes from different foods and improvement of the vitamin A bioassay.” This award was based on research by Lelia Booher, Elizabeth Callison, and their colleagues, who conducted human studies on vitamin A requirements and laboratory experiments with foods to assess concentrations and bioavailability (21,22).

About a decade later, a USDA Special Service Award was presented for “The development and use of microbial methods for determining the amino acid content of protein and food and determining their nutritive value.” During the 1940s, M.J. Horn and colleagues developed microbiological and/or colorimetric methods for the measurement of each of the essential amino acids in proteins and foods. These procedures were published in a series of scientific articles and summarized in a USDA publication that formed the basis of the award (23).

The early research of D.B. Jones, a colleague and coauthor of Horn’s, must be highlighted. Jones carefully isolated proteins from a large number of foods and subsequently determined their nitrogen content. It is these seminal data that established the average nitrogen content of proteins at 16 percent and from which the factor 6.25 was derived that is applied for the conversion of nitrogen to protein (24). Although Jones was administratively part of the Protein and Nutrition Division of the Bureau of Agriculture Chemistry and Engineering while he conducted this work (1920s-1930s), his group was transferred to the Bureau of Human Nutrition and Home Economics in 1943, which brought Jones and Horn together administratively. Jones and colleagues subsequently evaluated proteins of cereal grains for “their growth

promoting value,” precursor research to the protein efficiency work of Womack et al. 2 decades later (25,26).

Much of the early metabolic research with human subjects was conducted under contract or cooperative agreement with universities and State experiment stations, due in part to the lack of human studies facilities at Beltsville. Studies conducted in the mid-1950s established levels of linoleic acid in healthy infants and children, a topic that received attention through the latter part of the 20th century (27,28). During that time, a multi-center study was conducted involving female subjects to investigate the bioavailability of vitamin C from fruits, vegetables, and crystalline ascorbic acid (29). During the late 1950s and early 1960s, many studies were sponsored and conducted that established human amino acids requirements, evaluated the Food and Agriculture Organization of the United Nations (FAO) amino acid reference pattern, and demonstrated that wheat alone could nearly meet protein needs for humans (30-32). At the same time, studies were funded and conducted that demonstrated, for the first time, increasing linoleic acid content of a standardized diet (33) resulted in decreased concentrations of serum cholesterol (34,35). These experiments were the first of many that later would be conducted at BHNRC to demonstrate the health benefits of dietary unsaturated fatty acids.

Later sponsored human studies demonstrated that high amounts of dietary protein resulted in negative calcium balance (36). These studies were part of a program at the University of Wisconsin-Madison to examine the generally high protein consumption as part of the etiology of osteoporosis and hip fractures. This hypothesis was later questioned also by sponsored research in Yugoslavia that indicated that adequate nutrition was an important determinant in the accretion of

bone mass in young adults, but it had little effect on age-related bone mass later in life (37).

M. Isabelle Irwin and her small staff provided scientific oversight for grants and contracts during this period. However, as resources diminished for this activity, Irwin turned her attention to the review of literature for human nutritional requirements for specific essential nutrients. She and her collaborators published nine conspectuses in the *Journal of Nutrition* that summarized research for amino acids, protein, calcium, zinc, copper, iron, vitamin A, vitamin C, and folacin (38,39 as examples). The Nutrition Foundation published a book in 1980 with a foreword by Gortner that combined all nine of the conspectuses (40). Much of the information in these publications was incorporated into documentation for subsequent Recommended Dietary Allowances (RDAs) published by the National Academy of Sciences. Unfortunately, Irwin's productive career was cut short by a tragic auto accident near BARC as she was commuting to her office.

Protein Chemistry, Availability, Quality, and Health Effects

The relative importance of proteins in human nutrition at the time is evident with the establishment of the Protein Nutrition Laboratory (PNL) as part of the 1969 reorganization (table 1). However, there was considerable protein nutrition research at HNRD. Madelyn Womack, who had received her advanced training under W.C. Rose at the University of Illinois—in whose laboratory, threonine, the “last” essential amino acid had been discovered in 1935 and where human studies had been conducted on essential amino acid balances—and Mary Marshall, who was trained at Iowa State College (now Iowa State University), had conducted studies with rats on the



Madelyn Womack trained under W.C. Rose at the University of Illinois—in whose laboratory threonine, the “last” essential amino acid, had been discovered in 1935.

utilization of various food proteins and on the interaction of amino acids and proteins with other dietary components (41,42). These studies were extended to investigate protein quality and adult human protein requirements, albeit with new collaborators, C.E. Bodwell and D.A. Vaughan, who were part of the scientific expansion of HNRD (43,44). As food technology advanced to produce semipurified protein fractions from soybeans, collaboration was established between the soybean industry and BHNRC that demonstrated that the addition of soy protein to ground beef had little effect on protein, iron, or zinc status in a large group of men, women, and children (45). The results of this study provided the nutritional “safety” information and resulting impetus for the addition of soy proteins to many food products including ground beef for the Armed Forces.

As amino acid and protein requirements became established for humans, concern focused on laboratory methods for determining the availability of amino acids and digestibility of proteins in foods and diets. Procedures based on microbiological growth were developed in the mid-1950s (46) and evaluated again 30 years later, but with different microbes and/or for a limited number of amino acids (47,48).

Despite the advantages of microbes as “experimental models,” laboratory rats provided more relevant data for humans. As a result of numerous experiments, Womack and collaborators reported a “Modified PER” (Protein Efficiency Ratio) procedure for estimating bioavailability of individual essential amino acids (49). These concepts were developed into a “protein digestibility-corrected amino acid score” method, the digestibility component of which was subjected to an eight-laboratory collaborative study with results in highly acceptable precision and repeatability (50). Based on the results of this major cooperative study and those of many preceding experiments, the rat bioassay for protein digestibility obtained “official status” from the Association of Official Analytical Chemists (AOAC) shortly thereafter (AOAC 991.29—True protein digestibility of foods and food ingredients).

Several additional scientists recruited during the HNRD expansion were experienced in protein chemistry and metabolism (Gary Beecher, Irwin Hornstein, Sam Lipton, Phillip McClain, and Kent Stewart). Lipton, originally a member of the food composition group, conducted amino acid analyses (51) and later retired when this research was phased out. McClain focused on collagen structure and contributed significantly to the understanding of the structure of these unique proteins (52). He retired early for medical reasons. Hornstein relocated from the Meat Laboratory at Beltsville to PNL, where he investigated the structure of muscle proteins in collaboration with Bodwell and McClain (53,54). In around 1970 he transferred to the United States Agency for International Development (USAID). Stewart developed procedures for the isolation and characterization of trypsin inhibitors (55), while Beecher investigated the effects of exercise and high dietary protein levels on protein metabolism and on bone health of rats (56,57). Shortly after coming together at PNL, Stewart and Beecher developed

new instrumentation for the rapid analysis of samples in solution (58), which is the sample introduction component for several current sophisticated analytical instruments. Stewart transferred from PNL in 1975 to become research leader at the new Nutrient Composition Laboratory, and Beecher followed in 1982.

With the introduction of the energy program into PNL in the early 1980s (table 1), the waning of issues relative to protein nutrition in the U.S. populace, and the retirement or transfer of key scientists who had conducted research on the many aspects of protein nutrition, this program had become phased out by 1990. Simultaneous with this decade of change, the laboratory was renamed the Energy and Protein Nutrition Laboratory, and it was subsequently renamed again to more accurately describe the energy research being conducted by the group (see Energy Metabolism and Associated Research below).

Animal Models for Nutrition and Chronic Disease Research

While the BHE rat provided a model for the investigation of non-insulin-dependent diabetes mellitus, it was intentionally bred as a non-obese animal. However, as early as the 1970s, it was obvious that obesity, diabetes mellitus, hypertension, and associated diseases were occurring in the U.S. population simultaneously and for which there was a dearth of animal models. Although the Zucker (fa/fa) rat had been bred elsewhere in the early 1960s as an obese, and possibly hypertensive, model, it lacked other chronic disease characteristics, most notably diabetes (59,60). In the early 1980s, Carl Hansen at the NIH developed a spontaneous hypertensive, corpulent (fat) rat strain (SHR/N-cp) that exhibited metabolic and histopathologic characteristics similar to type II diabetes of humans. Subsequently, scientists at BHNRC, most notably Michaelis

and Sam Bhatena, and many other supporting associates, collaborated with Hansen to fully characterize the metabolic response to dietary alterations of this new animal model (61,62). Somewhat later, a substrain of these rats was developed to be salt sensitive (DSS/N-cp), and it thereby provided a model in which obesity, together with diet, hypertension, and its complications, could be studied (63). The untimely death of Michaelis, the retirement of Bhatena, and separation or retirement of other BHNRC collaborators marked the end of this scientifically far-reaching and productive joint endeavor.

Carbohydrates, Fibers, and Human Health

There was a concerted and long-term effort at HNRD and its predecessor organizations to investigate metabolic responses to various dietary carbohydrates, similar to that for proteins. Much of the early work focused on characterizing the response of the BHE rat to dietary alterations of carbohydrate type and amount (19). When new investigators arrived as part of the 1960s expansion, they also investigated specific aspects of this model's metabolism. Thus, insulin levels and enzyme activities in response to carbohydrate meals were characterized (64,65), and the increased requirement for biotin by this strain was identified (66). A unique finding for the BHE rat was that ingesting specific types of dietary carbohydrates early in its lifespan altered its metabolic pattern at maturity (67,68).

Carolyn Berdanier, Bela Szepesi, and Mei Ling Chang investigated metabolic responses of rats to "starve-refeed" protocols during the 1970s. When the "refeeding" diet contained only sucrose as the carbohydrate source, glycogenesis initially occurred but shortly (within 1 day) was replaced by extensive lipogenesis, manifested by fatty livers (69). The observed enzyme "overshoot" of that regimen was directed by the hormone

glucocorticoid, which was involved in the synthesis of specific RNA for pentose shunt enzymes (70-72). This was the first time that scientists had demonstrated the involvement of glucocorticoid in the regulation of pentose shunt enzymes at the DNA transcriptional level. This model became popular with other investigators who were interested in hormonal control of metabolic enzyme activity. Shortly thereafter, Szepesi and coworkers demonstrated that dietary polyunsaturated fatty acids and triglycerides inhibited hepatic glucose-6-phosphate dehydrogenase and malic enzyme, enzymes involved in the pentose shunt and gluconeogenesis, respectively (73,74). However, they failed to connect these observations to control at the DNA transcriptional or RNA translational level.

Research by David Trout and collaborators on dietary influences of gastric empty in the rat showed that when mixed diets were fed, the carbohydrate component left the stomach first (75). However, this effect could be slowed when xanthan gum was added to the diet and when the carbohydrate was glucose (76). In terms of meal-eaters vs. animals fed ad libitum, contents of stomachs of meal-fed animals emptied more rapidly than those of their "nibbler" partners (77). In general, water-soluble components of the meal tended to exit stomachs of rats faster than the more lipid-compatible nutrients.

One of June Kelsay's areas of research, after her returning with a Ph.D. from the University of Wisconsin-Madison, was to test the feasibility of parotid saliva as a non-invasive source of biological fluid, a research area outlined in a brochure on the HNRD program issued in 1971. Although Kelsay and her colleagues focused only on changes in dietary carbohydrates to induce changes in saliva content, they showed that concentrations of blood (serum) and saliva lactate and pyruvate responded similarly to a wide variety of ingested sugars and

carbohydrates (78). In addition, responses were not changed if the test dietary carbohydrates were ingested in the absence or presence of foods (79). In contrast, when saliva amylase and protein concentrations were followed with the same experimental protocol, large inter-individual variability resulted even though intra-individual deviations were relatively small (80). These experiments demonstrated the feasibility of saliva as a selected source of biological fluid components similar to serum. Kelsay's group next investigated the interaction of oral contraceptives with the type of carbohydrate (sucrose vs. starch) in the diet of women. In general, oral contraceptives, but not carbohydrate source, increased several markers for diabetes and vascular disease over the relatively short duration of the studies (81,82). Kelsay subsequently initiated long-running studies on metabolic effects of dietary fibers, and she also was a driving-force behind the "Beltsville One-Year Dietary Intake Study," both of which are discussed below.

Shortly after Reiser and his technical assistant, Judith Hallfrisch, arrived at Beltsville, the Select Committee on GRAS Substances (SCOGS) published a report that stated in part, "...Other than the contribution made to dental caries, there is no clear evidence in the available information on sucrose that demonstrates a hazard to the public when used at the levels that are now current and in the manner now practiced" (83). This stimulated a formal response by Reiser and Szepesi that contested the generality of the decision of SCOGS and highlighted specific areas of research in support of their position that sucrose consumption was part of the etiology of diabetes (84). This document set the stage and provided the stimulus for the direction of the balance of Reiser's research career. He and his colleagues examined the metabolic effects of sucrose and fructose ingestion (*vis-à-vis* high fructose corn sweeteners introduced in 1967) with both

rats and human subjects (85,86). The many studies conducted by these investigators were summarized in a journal article (87) and at least two books (88), and the results were discussed in the 10th edition of the Recommended Dietary Allowances (89). However, the most succinct summary was published in a letter to the editor by Hallfrisch and Reiser, the last paragraph of which stated, "Our research over the last 10 y in both animal and human studies has consistently shown that sucrose or fructose substitution for complex carbohydrate results in adverse changes in risk factors for heart disease and diabetes" (90). Reiser retired in 1990 and died in 2012.

Early in the 1970s, Denis Burkitt and Hugh Trowell of the United Kingdom generated interest in dietary fiber based on their association of unrefined foods and fiber intake with reduced disease processes in West Africa and England, respectively. Shortly thereafter, Kelsay initiated a long-term dietary fiber research program at Beltsville by first reviewing the literature (91) and then by conducting studies with humans, along with Kay Behall and collaborators at the University of Maryland at College Park (UMCP) who addressed some of the gaps of knowledge in the "fiber story." Generally, diets high in fiber (fruits and vegetables vs. their juices, which are low in fiber) resulted in decreased apparent digestibility of energy, nitrogen, and fat, and increased stool weights; but they gave variable results relative to mineral balances, which may have been caused by experiments of different durations (92,93). Digestibility of fiber fractions ranged from very high for hemicellulose, intermediate for cellulose, and low for lignin (94). Subsequently, Behall carried the "fiber banner" and began to investigate the effect of dietary soluble fibers on markers for diabetes and vascular disease. She first teamed with scientists at the Johns Hopkins University School of Medicine in Baltimore, MD, to investigate the effects of guar gum,

which indicated that this fiber was safe for subjects with non-insulin-dependent diabetes mellitus, attenuated their insulin response, and reduced hyperlipidemic effects in men (95,96). Next, dietary amylose and amylopectin were compared by an in-house team who demonstrated that amylose, but not amylopectin, normalized insulin response in hyperinsulinemic subjects and lowered fasting triglycerides (97). These data suggested that amylose had potential for diabetic management through dietary means. Behall and Howe went on to provide evidence that resistant starch, a small (~15%) component of amylose, as well as poorly digestible fiber, contributed some energy (2+kcal/g fiber) to human subjects (98). However, ingestion of either amylose or amylopectin had no significant effect on energy expenditures (99). These observations, demonstrated previously in ruminants, validated the biological importance of lower gastrointestinal tract microflora and their contribution to dietary energy in humans, especially when healthful diets containing fiber are consumed.

Hallfrisch, who had earlier received a Ph.D. at UMCP while at Beltsville, returned from a fellowship at the National Institute on Aging, part of the NIH, following the retirement of Reiser and was appointed research leader at the Carbohydrate Nutrition Laboratory (subsequently renamed Metabolism and Nutrient Interactions Laboratory). She teamed with Behall and Scholfield to study the metabolic effects of cereals and cereal grains, a program they pursued for the remainder of their research careers. In general, inclusion of amylose, soluble fiber from oats or barley, or incorporation of these grains into the diet all had beneficial effects on glycemic response and on cardiovascular risk factors in subjects who were at risk (100-103). Studies with whole-grain diets (wheat, rice, and barley) reduced blood pressure in mildly hypercholesterolemic men (104). However, Z-Trim®, a non-caloric fiber isolated from grains, was less

effective than native soluble fiber in terms of moderating glycemic response (105). Results of several of these studies, along with those of other investigators, were cited in the IOM-DRI report for macronutrients (106), all of which have contributed greatly to our understanding of the health benefits of cereal grains.

Lipids, Diet, and Vascular Disease

Limited research on dietary lipids had been conducted at HNRD or sponsored by the Division prior to the 1969 reorganization. However, when Iacono was appointed research leader, he brought interest and experience in lipid metabolism. He immediately conducted a small nutritional epidemiological study that showed a beneficial relationship between habitual diets and the lipids of platelets and erythrocytes of men living in Milan and Sicily, Italy, and Cincinnati, OH (107). Several additional events helped the lipid research program at BHNRC. These included several small studies with human subjects that showed encouraging results between diet and vascular disease risk factors, the appointment of Joseph Judd as research leader after Iacono became the National Program Leader for Nutrition, and expansion of the human studies facilities. Coupled with these activities was the appointment of Norberta Schoene, who immediately specialized in metabolism of platelets (108), and the transfer of two groups from the Dairy Products Laboratory (table 1): Aldo Ferretti and Vincent Flannagan, who were specialists in chemical separations and mass spectrometry, and Elliot Berlin and his group, who had expertise in physical chemistry. Ferretti and Flannagan developed sophisticated techniques for the measurement of prostaglandins in biological fluids (109), while Berlin's group focused on membrane fluidity and the influence of dietary lipids on this important biological parameter (110). Beverly Clevidence later

joined the team, and dietitians and staff perfected the techniques and details for conducting well-designed and highly controlled nutrition-related human studies (111).

Research in the late 1970s and early 1980s demonstrated that dietary polyunsaturated fatty acids reduced moderately elevated blood pressures in adult men who were fed diets having both normal and low amounts of fat. These investigations provided the strongest evidence at that time for moderating mild hypertension in adults by dietary means (112,113).

In controlled feeding studies with adult men, relationships were determined between modest changes in the amount of ingested dietary fat and essential fatty acid (linoleic acid) on blood pressure and eicosanoid metabolite (PGI_2 and PGF_{2a}) excretion. Prostaglandin excretion was positively correlated with systolic and diastolic blood pressures. Also, alterations in excretion of metabolites were related to variation in the amount of essential fatty acid consumed. Prostaglandins have well-established roles in blood pressure control, and these studies provided a possible explanation for the beneficial effects of polyunsaturated fat intake on blood pressure (113-115).

Controlled diet studies with healthy adult male volunteers demonstrated that modifications in the amount of dietary fat and fatty acids and other nutrients (e.g., dietary fiber) could modulate concentrations of plasma cholesterol, triglycerides, lipoproteins, and apolipoproteins. In a study with healthy adult men, it was determined that feeding low-fat diets with reduced cholesterol, as compared with high-fat diets with high cholesterol (typical U.S. diet), did not reduce plasma cholesterol unless there was a simultaneous increase in the intake of polyunsaturated fatty acids. In another study, changes in the type and amount of dietary fat combined with increased dietary

fiber intake were associated with major improvements in plasma lipid profiles of healthy adult men. Such dietary changes could be achieved with moderate effort and have the potential of decreases in major risk factors for cardiovascular disease (116-118).

In the mid-1990s, two major studies at BHNRC demonstrated that when compared with oleic acid, dietary *trans* fatty acids raised LDL-cholesterol to a concentration similar to that of the most hypercholesterolemic saturated fatty acids, lauric, myristic, and palmitic acids. Further, high *trans* fatty acid levels resulted in reductions of HDL-cholesterol. This research refuted a body of evidence that had led to acceptance by most scientists, regulatory agencies such as the Food and Drug Administration (FDA), and health professionals that dietary *trans* fatty acids at levels in the U.S. diet had no major health effect. As a result of this study, major reconsideration of the safety of partially hydrogenated fats was undertaken in the United States, Canada, and England.

Scientists at BHNRC demonstrated that margarine manufactured with and without partially hydrogenated vegetable oils was effective in improving plasma lipoprotein profiles compared with butter when fed to 46 normocholesterolemic men and women as part of a controlled diet typical of that consumed in the United States. Earlier work at BHNRC on dietary *trans* fatty acids formed during partial hydrogenation of vegetable oils led to questions regarding the advisability of continuing the consumption of margarine prepared in this manner. Furthermore, the cholesterol-raising effects of *trans* fatty acids were being widely interpreted in the lay press and in some influential scientific circles as indication that a return to use of butter with its high levels of saturated fatty acids might be desirable. This investigation provided strong evidence that this was not so. This study served to place the findings of the

earlier *trans* study in a practical perspective for public health recommendations in the United States (119-121). Later, a large study with human subjects (~100) was conducted to elucidate differential metabolic effects between naturally occurring and industrial-produced *trans* fatty acid isomers (122).

In two recent dietary studies at BHNRC, scientists have shown that the cholesterol-lowering effects of sterol esters are independent of both the fat level in the product supplemented with the sterols and of the type and amount of fat in the diet with which the sterol esters are consumed. The lowering of LDL cholesterol by sterol ester supplementation of foods offers one of the most effective dietary means of reducing this cardiovascular disease risk factor. Further, research at BHNRC showed that this is equally effective in typical American diets and diets moderately reduced in fat level and saturated fat (123,124).

Simultaneous with many of the human studies that investigated the effect of diet on plasma lipids and other cardiovascular disease markers, Schoene evaluated the response of platelets to dietary alterations. Her team was the first to demonstrate mechanistic release of arachidonic acid from platelets for conversion to a thrombotic eicosanoid (108). Using spontaneously hypertensive/stroke-prone rats as a model, this group showed that diets containing fish oils decreased the development of hypertension (125). This was important new evidence showing that n-3 fatty acids in fish oil were counteracting the overproduction of eicosanoids from arachidonic acid and thereby reducing the risk of chronic disease. Meta-analyses of clinical trials recently reported that dietary n-3 fatty acids lowered blood pressure in human subjects. Other dietary factors that have been shown by Schoene's group to be important in platelet health include adequate selenium and soy isoflavones (126). As part of these studies, apparent platelet volume has been proposed

as a new biomarker for early activation of these blood cells (127).

Scientists at both BHNRC and the National Cancer Institute (NCI) became interested in the effects of moderate alcohol consumption on lipid and hormone metabolism, those associated with hormone-sensitive cancers, such as breast cancer. In a controlled-diet study with premenopausal women, moderate alcohol consumption was found to be beneficial to plasma lipoprotein levels (128). However, similar experiments with both premenopausal and postmenopausal women showed possible harmful effects of moderate alcohol intake on those serum hormones associated with breast cancer (129,130). These observations provided a possible explanation for the epidemiological association found between alcohol consumption and incidence of breast cancer.

P.P. (Uni) Nair came to NI/BHNRC in the late 1970s with interest and expertise in the relationship of diet and colonic cancers. He was one of the "prime movers" in the development of a multi-center study to investigate this association (131). At Beltsville, he and his group pursued the purported association of fecapentaenes, potent mutagens in the stools of some individuals, with the incidence of colon cancers. An early case-control study demonstrated a lack of this association (132). Further studies on stool samples collected from a large number of subjects in the area showed that 50% of the mutagenic samples (*Salmonella* mutagenicity assay) contained elevated fecapentaenes (133). However, fractionation of the mutagenicity of these samples indicated that other components of stool were important in the etiology of colorectal cancer. This assumption was validated by genotoxicity studies of the individually isolated fecapentaenes from human stools (134). Subsequently, Nair and his group developed a procedure for the isolation of exfoliated colonic epithelial cells from stool samples

(135). Nair and the group with whom he later associated employed this procedure as a sensitive, noninvasive technique for the potential identification of markers of colorectal cancer (136).

Beltsville One-Year Dietary Intake Study

Several observations converged in the late 1970s and early 1980s that prompted the “Beltsville Year-long Diet Study” led by Kelsay and Mertz. These included decreased caloric intake reported by subjects in the 1977-78 Nationwide Food Consumption Survey (NFCS) compared with similar data from the 1965 NFCS even though body weights increased slightly over the same period, caloric intakes 300-400kcal below then current RDAs for several groups of women reported from Health and Examination Survey II (1976-80), and observations from several studies at BHNRC wherein caloric intake needed to be increased above subject-reported values so that body weights could be maintained throughout experiments (137). Thus, 29 “healthy” subjects, partitioned about equally among gender and age classification, were enrolled into a one-year-long study. Dietary food intake was recorded daily, and duplicate foods and beverages were collected for 1 week, 4 times throughout the study, as were samples for nutrient balance studies. With the exception of calcium and iron intakes for females, reported intakes of calories and 19 nutrients met or exceeded the 1980 RDAs (138). However, daily caloric intakes were nearly 13% lower during diet collection periods compared with the mean recorded for the entire year (139). In addition, there were significant reductions in reported intakes of all nutrients during the collection periods. This later observation calls into question the validity of the negative balances reported for several minerals (Cu, Mg, Mn, Zn) and other measurements that relied on duplicate diet collections. A follow-up study with

over 250 free-living, middle-aged human volunteers of both sexes indicated that energy intakes calculated from 7-day daily food records collected prior to the study did not maintain the subjects’ weights during the 45+-day study (140). On average, the underreporting of calorie intake via food records was 18%, based on weight maintenance. Subsequently, Mertz raised the question: “Food intake measurements: is there a ‘gold standard?’” which he answered with an unequivocal “no” based on the above observations and several other lines of evidence (141). As a result, dietary recall techniques that were used for all U.S. national food consumption surveys were re-examined, modified, and validated. Details of these studies have been summarized by Moshfegh (4). Kelsay retired in 1987.

Vitamins and Minerals Research, and Interactions With Food Components

Like several other areas of nutrition research, there already was longstanding activity in vitamins and minerals research at the Bureau prior to the 1969 reorganization. As noted previously, Booher and Callison were awarded the USDA Distinguished Service Award for their research on the establishment of vitamin A requirements of humans and bioavailability from foods (21,22). Sweeney and Marsh followed this work with investigations of the bioavailability of carotene isomers from foods and their conversion to vitamin A in rats (142). However, much earlier (1927), McLaughlin reported on the utilization of calcium from spinach by human subjects (143). In the early 1960s, Hathaway published a comprehensive summary of metabolic data on magnesium in human nutrition, which included estimates of requirements for several age groups (144). This compendium served as a major resource of scientific information for several subsequent RDA deliberations.

The increased funding for HNRD, the arrival of Gortner, and the reorganization of the division resulted in the hiring of several scientists with expertise in mineral nutrition. All of these scientists came with training in laboratories of then world-renowned mineral nutritionists: Leon Hopkins (Wm Hoekstra and Klaus Schwarz), Eugene Morris (Boyd O'Dell), Walter Mertz (Klaus Schwarz), Orville Levander (Carl Bauman and Wm Hoekstra), and James C. Smith, Jr. (Klaus Schwarz). The ability to attract scientists with such outstanding credentials is a testament to the foresight and tenacity of Gortner and Weir (and later Mertz) to build an outstanding mineral research organization.

Although Hopkins was hired as assistant to Gortner, he also conducted research and reported the essentiality of vanadium for chicks (145). Unfortunately, he left HNRD shortly after the 1972 reorganization (table 1). Morris bridged the 1969 reorganization by initially measuring the mineral contents of wheat and wheat products (in the food composition group), but he subsequently elucidated an important iron complex of wheat. He and Rex Ellis, an organic chemist who had transferred from the Dairy Products Laboratory, isolated and reported monoferric phytate as the major form of iron in wheat (146). They further demonstrated this form of iron as readily available when fed with meals to rats, dogs, or humans (146-148). At the same time, they observed that a soluble fraction of whole-wheat bran, from which phytate had been removed, was quite inhibitory to iron absorption (148). Further characterization of this fraction was not conducted. Morris retired in 1996.

When Mertz transferred to HNRD as Laboratory Chief of Vitamins and Minerals, he brought with him an active research program on chromium nutrition. At NIH and at Walter Reed General Hospital, he and his colleagues had shown that chromium III is an essential nutrient for humans and

that it is a component of a “factor” (glucose tolerance factor [GTF]) that potentiates the action of insulin in glucose uptake by tissues. He and his team at HNRD—led by E.W. Toepfer, who had been in charge of the food composition group and who had been trained by H.C. Sherman—evaluated a series of foods for chromium content in relation to biological activity (149). Subsequently, they isolated and partially purified a GTF from brewer’s yeast and further showed that it contained chromium III, nicotinic acid, and several amino acids, including histidine, which was thought to complex with chromium III as part of the factor (150).

Shortly after Mertz was appointed Director of NI, Toepfer retired, and the “chromium torch” was passed to newly hired Richard Anderson. Mertz, however, remained very active on the nutrition research front, served on numerous National Academies and international nutrition committees, was coauthor of three RDAs, and wrote scientific reviews vociferously, even after he retired in 1992 (12). One of the National Academies committees he served on was Diet, Nutrition and Cancer (15), which prompted a long-standing collaboration with Peter Greenwald and his colleagues at the Division of Cancer Prevention, National Cancer Institute, NIH (table 1). Most importantly, Mertz was an outstanding ambassador for Beltsville, had an open-door policy for scientists, technical staff, and visitors alike, and always enjoyed a good discussion about nutrition research. He received many awards and accolades for his outstanding research achievements and contributions to the field of nutrition. (See Professional Awards section.)

In the early 1970s, the levels of chromium in biological fluids was very much in question. Although the practical application of atomic absorption spectrometry for mineral determinations was a little more than a decade old and held promise for increased sensitivity over previous colorimetric and other methods, published

values for chromium in human biologics kept declining with instrumental and procedural improvements. Interlaboratory comparisons often varied by as much as two orders of magnitude and could not be reconciled. Barbara Guthrie, a visiting nutritionist at HNRD from the University of Otago, New Zealand, along with staff scientists Claude Veillon and Wayne Wolf, identified and corrected the analytical issue (background [smoke] interference) with atomic absorption spectrometry (151). They then reported lower normal biological values for chromium employing definitive isotope dilution techniques (152). These observations ushered in the application of Certified Reference Materials to establish accurate measurements in biological samples and ended the dramatic downward trend in biological chromium values due to analytical errors (153). While Wolf moved to the newly formed Nutrient Composition Laboratory, Veillon remained at the Vitamins and Minerals Laboratory, where he was instrumental in the preparation and analysis of a contaminant-free bovine serum as a Certified Reference Material for selected minerals in biological materials (154), and where he developed many new, state-of-the-art techniques for the measurement of important elements and their isotopes in biological systems (155). Many of these procedures allowed cutting-edge metabolic studies to be conducted on trace elements at Beltsville and other research centers. Veillon retired in 2003.

Anderson and his team characterized several aspects of the metabolism of chromium in humans. These included dramatic increase in serum levels by providing 200 μ g CrCl₃ as a dietary supplement (156), nonlinear absorption of dietary chromium as the intake of the trace element was raised (157), increased urinary excretion of chromium when high-sugar diets were fed (158), reduced excretion with exercise training (159), normalization of abnormally high or low blood glucose

levels during a glucose tolerance test when additional dietary chromium was provided (160), and alleviation of hypoglycemia with supplementation (161). The latter observations were extended to Type II diabetics, who benefited substantially from chromium supplementation (162). Recently, heterogeneous response of diabetics to additional chromium has been attributed in large part to variability in baseline insulin sensitivity (163).

This group also determined that it is difficult to reach a safe and adequate intake of chromium (50-200 μ g/da) in well-balanced diets of normal foods, suggesting that supplements are required (164). Although tri-chloride and picolinate are common forms of chromium as a supplement, both are limited in their bioavailability. A histidine complex of chromium was developed that is substantially more bioavailable than other forms and is stable over time (165). U.S. and international patents have been granted for this formulation, which has accelerated its commercial availability as a supplement. The toxicity of chromium supplements was re-examined by feeding rats two forms of this trace element that were equivalent to several thousand times the recommended upper limit for human beings without adverse affects (163).

A survey of foods and spices that evaluated insulin potentiating factor in vitro as well as chromium content indicated that several of these dietary components increased insulin activity but had low to nominal concentrations of chromium (167). Cinnamon was further investigated, and tea was later studied (168). Human studies by Anderson and his collaborators involving subjects who had Type II diabetes, metabolic syndrome, or insulin resistance indicated that cinnamon supplementation benefits many of the markers associated with these maladies (169). Fractionation of both cinnamon and teas suggested that the

active, non-chromium, insulin-enhancing component(s) may be a series of complex polyphenols (168,169). In collaboration with other scientists of the newly reorganized Diet, Genomics, and Immunology Laboratory, a recent study indicated that a green tea extract along with a high-fructose diet fed to rats regulated gene expression in the glucose uptake and insulin-signaling pathway (170). These results provide a new vision in terms of understanding the mechanism of the complex insulin-mediated glucose uptake process.

Orville Levander transferred from the FDA in 1969 as part of the HNRD reorganization. He brought with him experience in selenium nutrition as well as its interaction with other heavy metals. Levander and his team demonstrated selenium to be a highly effective catalyst for the reduction of cytochrome c by glutathione (171) with the resultant oxidation of sulfur and selenium, and their potential carcinogenic affects. However, this group was most interested in the role of selenium in human nutrition per se. In collaboration with scientists at the University of California at Berkeley, they conducted the first short-term depletion/repletion study with human beings that demonstrated rapid biochemical changes when low amounts of selenium were fed (172). The results of these experiments provided the first estimates of selenium requirements for adult men. These subjects were fed liquid formula diets and housed in a metabolic ward. As part of the Beltsville Year-long Diet Study, estimated intakes to maintain selenium balance for healthy, free-living men and women were 80 and 60 micrograms per day, respectively (173). The first study to employ a stable isotope of selenium with human subjects determined that pregnancy required additional selenium (174). While it may be easy to make a statement relative to the outcome of this human study, considerable effort went into the labeling of the chickens and the resulting tissues that were used as

food sources of ⁷⁶Se for this study (175). The results of all of these investigations provided corroborative data for the 1989 RDA for selenium (176). With sponsorship by NCI and collaboration with scientists from several universities, a study was conducted in South Dakota (a seleniferous soil area of the United States) to examine the health of individuals, primarily ranchers, exposed to higher-than-normal dietary intakes of selenium (177). Although intakes were considerably higher in this area than average for the United States, there was no evidence of selenosis in these individuals. These observations were used by the U.S. Environmental Protection Agency to set a toxicological level for selenium as part of clean up of superfund waste sites.

Levander and his group also developed an animal model for determining the bioavailability of selenium in foods (178). Platelet levels of glutathione peroxidase were found to be a useful index of selenium status. Subsequently, these procedures were applied in a human study in Finland (a country that had low soil levels of selenium) to examine the bioavailability of selenium in inorganic and food sources (179). Ultimately, these procedures were employed by scientists in Finland to monitor increases in food selenium levels and bioavailability through application of selenium-containing fertilizers to such crops as wheat and rye.

During the remainder of his active career, Levander turned his attention to the interaction of several nutrients, food components, and disease vectors. In collaboration with scientists at the University of Miami, FL, studies showed that fish oils, their concentrates, or flaxseed oil protected vitamin E-deficient rats against malarial infection (180). Subsequently, a long-term collaboration with Melinda Beck and her group at University of North Carolina, Chapel Hill, was established that investigated dietary alterations on the virulence of viruses. Firstly, this team

demonstrated that heart damage caused by a myocarditic strain of coxsackie virus was markedly increased in mice deficient in either selenium or vitamin E (181). Subsequently, a benign strain of the virus also was shown to cause cardiopathology when introduced to mice on the same dietary regimen (182). These observations prompted studies that demonstrated that nutritionally compromised hosts were fertile grounds for genetic changes of the virus (183). Additional studies with influenza virus showed that lung damage was markedly increased in mice deficient in selenium (184). Again, investigations demonstrated a substantial change in the genomic structure of the virus when the host was nutritionally stressed. In collaboration with scientists at the University of Buenos Aires, Argentina, studies showed that heart muscle from selenium-deficient mice responded less forcefully to in vitro stimulation than similar muscle from well-nourished control animals (185). Recently, Levander and collaborators at BHNRC demonstrated that copper deficiency of mice also increases the virulence of coxsackie viruses (186). Taken in total, these studies re-emphasize the importance of proper nutrition in any efforts to stave off viral infections.

As were many scientists, Levander was involved in many other projects. A project that should be highlighted is research on the development of heterocyclic amines as a result of cooking meats by different methods and the subsequent metabolism of these compounds by human beings (187,188). This study was one of many funded through the cooperative agreement between BHNRC and NCI. Heterocyclic amines are thought to be quite carcinogenic and even today are often raised in the popular press. After a long and outstanding career, Levander retired in the mid-2000s. He died in December 2011 of conditions related to Parkinson's disease.

In the early 1970s, sponsored studies by HNRD in K. Michael Hambidge's laboratory at the University of Colorado, School of Medicine identified zinc deficiency as high as 8% in a group of U.S. children who manifested growth and health issues (189). These observations were the basis of extensive funding from several sources for Hambidge and his group to further investigate dietary zinc-health relationships. When James C. Smith, Jr., came to NI in 1977, he brought with him expertise in zinc nutriture, a topic that was boldly announced on the "DR ZINC" license plates of his Triumph sports car. Smith had earlier collaborated with M.I. Irwin and J.A. Halsted on the conspectus, "Zinc Requirements of Man" (39). During his postdoctorate, he had worked with Klaus Schwarz to develop a metal-free barrier system (isolator) for laboratory animals for the identification of additional "essential" trace elements (190). Forrest Nielsen used such a system to identify nickel deficiency in chicks (191) during his short tenure at Beltsville, between affiliations with the U.S. Army Metabolic Research and Nutrition Laboratory in Denver, CO, and GFHNRL. Based on collaborations begun at the Veterans Administration Hospital, Washington, DC, Smith's group developed a simplified direct method for the measurement of zinc in plasma by atomic absorption spectroscopy that was sanctioned as the "Selected Method" by the American Association of Clinical Chemists (192).

Smith and his colleagues continued to pursue research on zinc nutrition at NI/BHNRC by determining concentrations of this element in hospital diets and in diets of a selected sub-population of women in the far southwest of the United States (193,194). This group also identified the heritable aspects of elevated plasma zinc levels of a family (195) and the interaction of zinc deficiency with bone formation (196) and dental caries (197). Subsequently, data relative to zinc requirements,

bioavailabilities, and recommended dietary allowances were summarized and published in preparation for the 1989 RDAs (198) and reviewed over a decade later (199).

As early as 1973, Smith and colleagues reported an interaction between zinc nutriture and the metabolism of vitamin A in germ-free animals (190). Although several animal studies were conducted in the interim that suggested zinc was involved in liver retinol binding proteins (200), it wasn't until the late 1980s and in collaboration with colleagues at Mahidol University that a population of children was identified in Thailand where this hypothesis could be tested in humans (201). These children were generally at risk for inadequate zinc and/or vitamin A nutriture. Supplementing this population with twice the RDA for both nutrients improved indices of both zinc and vitamin A status, improved dark adaptometry tests, and normalized conjunctival epithelium (202). A subsequent study with the same population and in collaboration with Tim Kramer, who had transferred from the Grand Forks Human Nutrition Research Center (GFHNRC), showed a trend toward increased proliferative response of T lymphocytes to tuberculin antigen in females but not males when supplemented with zinc and vitamin A (203). Although the precise biochemical mechanisms were not elucidated with these human studies, the beneficial health and well-being outcome for the children was undeniable. While this area of research was being conducted, Smith and his group also were pursuing an understanding of the metabolism of carotenoids as part of the BHNRC-NCI collaborative efforts. The results of these studies are described in the Phytonutrient section of this chapter.

Meira Fields came to BHNRC as a visiting scientist with interest in the interaction of copper nutriture and general carbohydrate metabolism (204). She immediately began collaborations with Reiser and Smith and

soon found that dietary copper deficiency in rats was exacerbated with sucrose as the sole carbohydrate in the diet compared with starch (205). Additional studies identified fructose as the key dietary component that interacted with low copper levels to elicit dramatic biochemical and pathological changes (206). In general, copper deficiency reduced blood ceruloplasmin activity, hepatic copper, and ATP levels, but increased plasma cholesterol and triglycerides. Additionally, dietary sucrose or fructose in conjunction with low copper caused dramatic liver and heart hypertrophy, reduced hematocrit, hemoglobin, albumin levels, as well as superoxide dismutase (SOD) and glutathione peroxidase activities, but increased glucose response to glycemic stress and liver iron concentrations (206,207). During a 2-month experiment, about one-third of the animals died that were fed copper-deficient diets in combination with either fructose or sucrose, whereas only a few succumbed to a combination of low copper and starch nutriture. The primary cause of death was extensive heart pathologies (208). The team (Fields, Reiser, Smith, et al.) went on to demonstrate that dietary fructose greatly inhibited copper absorption, but not copper distribution, when animals were administered ⁶⁷Cu intraperitoneally (209-211). They suggested that the effect of fructose might be as simple as chelation of available dietary copper (212).

Fields and her collaborators further characterized the adverse effects of high-fructose–low-copper diets by showing that male rats, but not females nor castrated males, were susceptible (213) and that the fructose effect could be titrated in a dose-response manner (214). Additional treatments such as high dietary levels of vitamin E or coenzyme Q10 and administration of clofibrate did little to ameliorate the effect, whereas giving garlic oil extract or deferoxamine, an iron chelator, abolished the pathological

effects of the dietary regimen (215-219). Further studies with dietary iron indicated relatively low levels (17ppm diet) coupled with high fructose and deficient copper abolished heart lesions but induced pancreas atrophy (220). Additionally, 20% ethanol in drinking water in combination with low dietary copper and starch gave outcomes similar to low copper with high fructose (221), and the source of dietary protein was ineffective in alleviating the problem (222), with the exception of dried skim milk, which ameliorated the severity of the outcome (223). Further evaluation of hyperlipidemia in this model showed that copper deficiency along with high dietary fructose was responsible for elevated blood cholesterol, and a combination of low dietary copper, high fructose, and high fat resulted in increased concentrations of blood triglycerides (224). A single experiment with dietary zinc deficiency in rats was unable to demonstrate a dietary “fructose effect” (225).

Limited studies with pigs indicated that copper deficiency greatly reduced all of the typical biological markers for copper status, similar to rats, and that high dietary fructose nearly doubled heart sizes and substantially increased liver weights compared with glucose-fed or adequately nourished copper groups (226). Similar to rat studies, when dried skim milk was introduced as the source of protein into the rations of pigs, the effects of copper deficiency were unaltered by the type of dietary carbohydrate (fructose, glucose, and starch) (223). An additional study showed that dietary sucrose, compared with cornstarch and in combination with casein as the protein source, did not exacerbate copper deficiency in weanling pigs (227). Even though heart sizes were dramatically increased by copper deficiency in all of the studies with pigs, none of the animals succumbed to the dietary regimens. Nonetheless, collagen crosslinking, but not total collagen, of the myocardium and bicuspid valve was decreased in copper-

deficient groups (228), suggesting that a mechanism by which heart failure had occurred in rats. The authors of one of the studies with pigs made a bold statement in the abstract and conclusion of the paper, “Thus, these data fail to support the hypothesis that the Cu X CHO interaction observed in rats represents a health risk for humans.” (The authors assumed that pigs represented a cardiovascular model for humans.) Fields, Reiser, and Smith were not authors, but Mark Failla, one of the coauthors, was then a scientist at BHNRC (227). What is particularly bold about this statement is that several years earlier, a human study at BHNRC that examined this interaction had been terminated early because of several heart incidents in the subjects (212).

The human study (212) was designed to investigate the dietary carbohydrate and copper status interaction that had been observed in rats. Typical American diets for the period were provided except that copper intake was decreased to ~1 mg/da, zinc intake increased to nearly 20 mg/da, and diets provided 20% energy either as fructose or as cornstarch. Four individuals experienced myocardial incidents. They consisted of a diagnosed infarction by a subject consuming low copper and cornstarch for 4 weeks, two incidences of tachycardia, and a heart block occasion by persons who were currently or who had been on the low copper and fructose regimen. Immediately after the fourth and most serious incident, the study was terminated, and all subjects were repleted with dietary copper. All subjects were followed for an extended period of time, and additional adverse health incidents were not observed. Although there was a remote possibility that these myocardial occurrences were due to chance (<0.05%), when taken together with limited other observations, these data strongly point to the role of adequate dietary copper and complex carbohydrates in the maintenance of heart health (212). In the

long history of human studies at HNRD/NI/BHNRC, this is the only study that was prematurely terminated. Fields retired in 2001.

Robert Reynolds came to BHNRC in the late 1970s. He immediately began investigations of vitamin B6 metabolism during pregnancy and lactation of both rats and women (229-231). Unlike in rats, in which vitamin B6 levels dropped dramatically during pregnancy and early lactation regardless of dietary levels, the concentration of this vitamin in women was maintained throughout these same periods. At the same time, concerns were raised that indicated that dietary supplementation of vitamin B6 by lactating women depressed circulating levels of prolactin that cut short production of milk. Reynolds and his group debunked this myth with a carefully designed human study (230). However, Reynolds' ultimate interest was in metabolism during climbing at high altitudes and under other stressful conditions. He trained and was a member of a Mount Everest climb in 1989. He also convinced other members of the climbing team to be subjects of an experiment that investigated dietary preferences and changes in body composition during the climb (232,233). These results showed that high-altitude climbers preferred high-fat foods, unlike previous reports of high carbohydrate consumption, and that muscle mass was preserved at the expense of body fat. Reynolds moved to academia in the early 1990s, when his interests in metabolism at high altitudes and the mission of BHNRC conflicted.

Mark Failla arrived at BHNRC in the mid-1980s and was instrumental in establishing cell culture technology as another model for investigating several aspects of nutrition. The Caco-2 cell line, an immortalized line of heterogeneous human epithelial colorectal adenocarcinoma cells, developed by the Sloan-Kettering Institute for Cancer

Research primarily for drug studies, had become popular for investigating nutrient absorption and bioavailability in vitro. Failla and collaborators established this line at BHNRC and applied it to absorption aspects of iron and zinc (234,235). In addition, they developed cultures systems for several hepatic cell types, various blood cells, and splenic cell subsets (236-238). Unfortunately, Failla returned to academia in the early 1990s.

Energy Metabolism and Associated Research

As outlined above, the energy metabolism program for humans was re-established at NI/BHNRC in the early 1980s. C.E. Bodwell, then Chief of the Protein Nutrition Laboratory, was given responsibility for the program, and the activity was housed in that laboratory. Considering that this was a new program for which all instrumentation had to be constructed, much discussion ensued about the type of system to build. Would it be a combination direct-indirect calorimeter, similar to Atwater's system in Connecticut many years earlier (239), an indirect system like the large animal (bovine) units already in Beltsville; or would it be something else, such as the "water-circulating bodysuit" demonstrated by Paul Webb, a contractor of the NASA Space Program? A combination direct-indirect system was agreed upon, constructed, and installed in modified laboratory space on the third floor of Building 308 in Beltsville (240). This was conveniently located adjacent to the kitchens and dining facilities of the newly expanded human studies facilities. A few years later, a second indirect system was added. These systems provided the gold-standard in which human studies could be conducted and against which adaptations of equipment and the development of field procedures could be evaluated. Considering the massiveness of Atwater's calorimeters and the new ones, advances in this technology is exemplified by

the development of the hand-held indirect calorimeter recently described by BHNRC retirees and former scientists (241).

From the late 1970s to the early 1990s, there were substantial scientific personnel changes within PNL, a laboratory that had absorbed the Dairy Foods Laboratory and later was named the Energy and Protein Nutrition Laboratory (EPNL). A number of scientists retired (Alford, Lakshmanan, Lipton, McClain, McDonough, Vaughan, Womack, and Wong) or transferred (Beecher, Hitchens, Hornstein, and Stewart), thereby making way for the addition of new investigators with expertise in disciplines associated with energy metabolism (Marable, Conway, Miles, Seale, Rumpler, and Baer). Some of these investigators were at BHNRC for various periods of time (Marable, Miles, and Seale), one retired (Conway), and two remain active (Baer and Rumpler). Also during this period, there was a change of laboratory leadership due to the unexpected and untimely death of Bodwell and the transfer of Paul Moe from the large animal energy group at Beltsville to EPNL as research leader.

The direct-indirect human calorimeter system installed at EPNL was only the second in the United States at the time and, like any new instrument, was validated for accuracy (240) and repeatability of actual energy expenditures (242). Also, response times between the direct gradient layer calorimeter and the indirect system were dissimilar, so a series of algorithms were developed to compensate for the delayed response of the direct calorimeter (243). As part of the later studies, it was demonstrated that heat emission during sleep was greater than energy expenditure, a process that was reversed during arousal and that provided insight into heat regulation of the body. A series of studies were conducted to obtain estimates of variance for energy expenditure due to such events as day-to-day variation,

circadian cycle, menstrual cycle of women, body composition, and physical activity (244 as example). Such estimates were previously unavailable and were required for the design of future energy studies with humans.

Subsequently, several studies investigated interactions of dietary alterations and metabolic states with energy expenditure. A series of experiments elucidated the effect of moderately reduced energy intake and weight reduction on energy expenditure. Reduced energy expenditure was accounted for by a decreased thermic response due to the consumption of meals with lower calories and a reduction in body mass as a result of weight loss (244). However, when similar results were reported on a body weight basis, there were no changes in energy expenditure or in energy requirements (245). These studies also demonstrated that the low metabolic rate often reported by obese individuals is not a function of moderate restriction of calories but possibly that of such factors as reduced activity and inheritance and/or pathology.

Based on a series of experiments, a theory was developed that suggested that the rate and extent of fat oxidation served as an integrating mechanism for relating energy demand to energy availability (246). Research with alteration of dietary fiber indicated that this component reduced the energy value of the diet by about 8 MJ/g fiber added to the diet, which was greater than the energy contributed by the fiber (247). Work with moderate alcohol consumption over long periods of time with a large number of subjects demonstrated that the human body adapted to alcohol and used it as an energy source as efficiently as other dietary components (248). These were new and controversial data, because epidemiological data and earlier short-term human studies had all reported that high levels of alcohol intake contributed very little energy.

Collaboration with a Japanese tea firm stimulated research with oolong tea. Studies on energy metabolism demonstrated that energy expenditure was proportional to caffeine consumption, but that fat oxidation rates were higher with tea than with caffeine alone (249). These results provided a basis for the anecdotal observations that long-term tea consumption contributes to somewhat lower body weight.

In a uniquely designed study using free-choice cafeteria-style meals but with additional supplements, it was shown that high carbohydrate intake, but not high fat or high protein intake, suppressed voluntary food and energy intake for a few weeks (250). Unfortunately, the metabolism of the subjects adapted and the high carbohydrate effect was lost after 2 months.

The burgeoning obesity epidemic in the United States and the need for accurate field measures of energy intake and energy expenditure moved the calorimetry discipline at BHNRC into the arena of methods development. Doubly labeled water (DLW) with stable isotopes $^2\text{H}_2^{18}\text{O}$ had been used to measure energy expenditure in small animals as early as 1955—a method Schoeller, working with human subjects, accidentally rediscovered in the early 1980s (251). The need to understand energy metabolism in detail in human subjects, political pressure to increase production of labeled water in the late 1970s, thereby decreasing its cost, and advances in mass spectrometry instrumentation provided the opportunity to use this technique extensively. A paper by Seale, Miles, and Bodwell reporting methods for the calculation of energy expenditure employing DLW with one subject was published in 1989 (252). Thereafter followed a series of publications that compared DLW results with direct and indirect calorimetry data (253), that validated the technique over 7 days (254), and that compared energy expenditure among DLW, indirect

calorimetry, and dietary records calculations (255). The validation of the DLW technique as a field method permitted it to be used to evaluate and improve physical activity questionnaires (256,257) and to apply it as a new tool to estimate calorie intake errors from food frequency questionnaires (258). The DLW technique also was used as the basis for modifications of the USDA Automated Multiple-Pass Method, the dietary intake component of the National Health and Nutrition Examination Survey (259). Moe retired in 1997.

Although Joan Conway contributed greatly to the validation of the human calorimeters at BHNRC, she also had other research interests. One of these was measurement of and understanding body composition. In the mid-1980s, she teamed with Karl Norris—of the Instrumentation Laboratory at Beltsville and inventor of non-invasive near infrared spectroscopy for assessment of quality of agricultural products—to develop a system for the estimation of body composition (260). Results from this system compared favorably with stable-isotope dilution, skinfold, and ultrasound measurements, but the system was not produced commercially, perhaps because a patent was never sought for the concept and the instrument. Subsequently, she determined that anthropometric measurements used to predict body fat distribution in Caucasian subjects were somewhat different for African-American women (261,262). A review of ethnicity and energy stores suggested that physiological measurements were more appropriate than ethnic background in terms of characterizing the location of energy stores within the body (263). Collaboration with scientists in the Growth Biology Laboratory at BARC investigated the application of new instrumentation (dual-energy x-ray absorptiometry) for the assessment of body composition in humans for similar measurements in pigs and chickens (264,265). Results from these and other studies suggested that substantial

procedural and instrumentation refinement were required before comparable results from traditional methods could be obtained.

Another of Conway's research interests was assessment of physical activity/energy expenditure, particularly field measurements. Comparison of eight different physical activity questionnaires indicated that results could be used to obtain reasonable group means, but that data on individual energy expenditure were less than optimal (266). A decade later, using results from doubly labeled water for comparison, 7-day physical activity records, but not 7-day recalls, provided acceptable estimates of energy expenditure (256). However, energy expenditure of individuals (men) whose occupations involved significant intermittent moderate activity was the most difficult to assess with physical activity questionnaires (267). Conway retired in 2007.

Phytonutrient Metabolism and Associated Programs

The terms "phytonutrient" and "phytochemical" crept into the lexicon of nutritionists as part of the increased consumption of dietary supplements during the 1970s and 1980s, particularly those botanically derived. The passage of the Dietary Supplement, Health and Education Act (1994) thrust the consuming public in the position of "test subjects" for dietary supplements, i.e., the FDA could no longer require health safety data *prior to* the marketing of a supplement. Over time, these terms referred to compounds in plant foods, other than essential nutrients for which there are DRIs, but which have potential for health promotion. The program began at NI/BHNRC in the early 1980s, when scientists at NCI became interested in nutrients and phytonutrients that might be able to modulate markers for cancer. The first cooperative agreement with NCI was written

very broadly, including investigations of β -carotene. The β -carotene effort was multi-faceted with research oriented toward metabolism by humans and food analysis (6). James C. Smith, Jr. was asked by Mertz to direct the metabolic research program, primarily because of the provitamin A activity of this carotene. Historically, this was the reactivation of a small program that Sweeney had conducted with laboratory animals prior to his retirement a decade earlier (142).

One of the early issues with β -carotene and other absorbed carotenoids was accurate and precise measurement in serum and plasma. Due to their ease of oxidation and the early-stage development of high-performance liquid chromatography (HPLC) systems, particularly column construction and packing materials, considerable efforts were required to develop reliable and reproducible analyses. Smith collaborated with John (Jack) Bieri, an emeritus and retired vitamin E nutritionist from NIH, to develop a system with then current instrumentation for the measurement of all prominent carotenoids in plasma (268). Neal Craft, a member of Smith's team, refined this system to reduce losses of carotenoids during analysis, which improved both accuracy and precision (269). Shortly thereafter, Craft transferred to the National Bureau of Standards (later renamed National Institute of Standards and Technology [NIST]), where he characterized HPLC columns for carotenoid separations and contributed to the development of the first Certified Reference Material for β -carotene and other carotenoids in plasma. These were major advances that greatly improved the reliable measurement of these phytonutrients in plasma (serum) and foods. Subsequently, methods were developed for the measurement of carotenoids and their metabolites in both serum and human milk in collaboration between Smith's group and investigators at the Food Composition Laboratory (270,271).

This newly developed methodology was employed to show the relatively short storage stability of carotenoids in low-temperature frozen plasma (269), and the lack of a plasma response when men ingested a relatively high-fat meal with low levels of carotenoids (272). Subsequently, the first ever human study was conducted that followed plasma concentrations of 7 carotenoids for 11 days after the ingestion of pure β -carotene or a single meal of high-carotenoid foods (273). Results from this study showed that maximum plasma concentrations of β -carotene occurred 24-48 hours after ingestion of the pure compound or carrots, a relatively long lag period. Several additional observations were also made that included huge inter-individual variability of β -carotene response (an early observation of responders and non-responders), greater bioavailability of β -carotene from the pure form than from carrots, and lack of plasma response of those carotenoids in broccoli (lutein and β -carotene) and tomato juice (lycopene) at the low levels provided by the diet. During this period, the oxidation of LDL-cholesterol as a major contributor to cardiovascular disease was gaining popularity, so a report of the distribution of carotenoids among plasma lipoproteins, as potential antioxidants, was very timely (274). These early experiments were the foundation upon which the phytonutrient research program at BHNRC was built and continues today (2011).

Smith, Clevidence, and their collaborators expanded investigations by studying the metabolism of other prominent food carotenoids. Lutein, although not commercially available but potentially important in eye health, was isolated from extracts of marigold petals (275) and shown to be absorbed over a time course similar to β -carotene (276). This was the first report of absorption kinetics of purified lutein in humans. Lycopene, a carotenoid found in only a few red-colored foods and thought to

mitigate specific cancers, was demonstrated to have saturatable absorption kinetics at modest intakes (277). However, phytoene and phytofluene, minor carotenoids of tomatoes, were extremely bioavailable. Additional human studies on carotenoid bioavailability were correlated with plasma antioxidant activity (278), and oxidation products of both lutein and lycopene were isolated from plasma, further substantiating the potential antioxidative role of these phytonutrients (276). Results of these human studies were cited in the IOM-DRI Report on Dietary Antioxidants and Related Compounds (279).

At this time, a question arose as to whether cellular cleavage of β -carotene into retinol was primarily central or eccentric. Smith and research associate Alexandrine During developed sensitive procedures for monitoring the central cleavage enzyme, 15-15' dioxygenase (280), which were then employed to demonstrate its activity in a clone of Caco-2 cells, in small intestinal mucosa preparations from man, and in human liver for the first time (281). Results from these and additional studies showed that this enzyme is both copper and iron dependent (282). Calculations based on enzyme activities of normal human tissues indicated a capacity for central β -carotene cleavage of about 12 mg/day, one-fifth by the small intestine and the balance by the liver. This capacity is well within the range of the average intake of β -carotene reported from recent national surveys (~2 mg/day), and highly supportive of central cleavage as the primary conversion of this carotenoid to retinol. Smith retired in 2000.

Earl Harrison arrived at BHNRC in the late 1990s from the Medical College of Pennsylvania in Philadelphia with expertise and interest in vitamin A metabolism. He quickly teamed with During and employed cell culture techniques to investigate intestinal absorption and metabolism of carotenoids (283). This small team went

on to demonstrate that carotenoid uptake into intestinal and other cells is a carrier-mediated process that involves scavenger receptor SRBI (284). With the closing of the Phytonutrients Laboratory in 2006, Harrison and Daring transferred to academia.

In the late 20th century, flavonoids became a popular category of phytonutrients due to their health-related promotion (based on in vitro and epidemiologic studies) and their abundance in many foods. Anthocyanins, a subclass of flavonoids, were chosen by Janet Novotny and her group to study due to their purported association with several health benefits and dearth of metabolic data. Human studies with several foods (red cabbage, purple carrots, and strawberries) containing these components demonstrated that absorption was linear at low and moderate consumption but showed saturation at high intake levels (285,286). In nature anthocyanins have sugars and other compounds attached to them; however, these studies showed that removal of acyl groups enhanced absorption (287, 288). Advances in laboratory instrumentation led to identification and quantification of new anthocyanins and new food sources of these phytonutrients (289).

By the mid-1990s, interest was growing among many nutritionists in stable-isotope labeling of organic components of foods and following them through harvest, food preparation, digestion, and metabolism. Mineral nutritionists had been using these techniques with specific labeled elements for several years (174). A group of scientists at BARC coalesced at around this time with expertise spanning plant physiology to human metabolism and with unique abilities to label large amounts of plants, characterize the labeled compounds, and conduct human studies (290). At the time, this was one of the few groups in the world with this capability. Validation studies followed β -carotene and lutein from

^{13}C -labeled kale into these components of plasma as well as into retinol with relatively high appearance of label at peak plasma concentrations (0.7% of dose for β -carotene and retinol, 3.6% for lutein) (291). Simultaneous with these experiments, analytical procedures were developed that increased sensitivity and employed advanced instrumentation (292). The combined plant labeling and advanced analytical techniques permitted a detailed study of vitamin K absorption and kinetics in humans (293). This study showed peak ^{13}C -phyloquinone plasma concentrations at 6-10 hours after ingestion of labeled kale with a mean maximum concentration of 2.1 nmol/l (6 subjects). Results of modeling studies demonstrated an average bioavailability of phyloquinone from kale of 4.7% and plasma and tissue half times of 8.8 and 215 hours, respectively. In addition, one subject of this small study showed minimal absorption of labeled phyloquinone, suggesting a responder/nonresponder phenomenon similar to that of β -carotene absorption. Recently, conditions were developed whereby anthocyanins were labeled with ^{13}C in young red cabbage hydroponically grown in the presence of $^{13}\text{CO}_2$ (294). A total of 36 anthocyanins were labeled, of which 11 were reported for the first time.

Tea, especially green tea, has been purported to be a healthful food (beverage). With the increasing interest in flavonoids in the 1990s, Beverly Warden, a visiting scientist from Florida International University, conducted a human study that demonstrated small but significant absorption and excretion of primary flavonoids from black tea (295). Subsequent experiments by Judd, Clevidence, Baer, et al. demonstrated that high consumption of black tea (5 cups/day) lowered plasma cholesterol by 7% or more (296). However, consumption of oolong tea, either taken alone or fortified with additional catechins or other polyphenols, failed to modify glucose

metabolism in healthy adult volunteers (297). Nonetheless, taken together with the beneficial energy outcome, these observations generally added credence to the healthful contribution of tea as a beverage. Judd retired in the mid-2000s.

Jae Park arrived at BHNRC in the late 1990s and selected phenolic acids and their naturally occurring derivatives to investigate relative to biological activity. Several of these types of compounds (N-coumaroyldopamine [caffedymine] and N-caffeoyldopamine), identified in such foods as cocoa, were found to inhibit platelet activation through suppression of p-selectin, a platelet activation marker (298,299). Recently, Park has shown that additional compounds of similar structure, serotomide and safflomide, and found in specific groups of foods, blocked receptors on cells that are similar to receptors of the central nervous system of humans (300). These results support the concept that foods have biological effects other than solely providing nutrients and energy. Park transferred to the Diet, Genomics, and Immunology Laboratory in 2006 when the Phytonutrients Laboratory was closed.

Tom Wang came to BHNRC in 1999 with considerable experience in cellular and receptor biology. He investigated the molecular action of phytochemicals on regulation of human sex hormone receptors, specifically estrogen and androgen receptors, which are keys in the modulation of breast and prostate cancer, respectively. Wang and his collaborators were the first to identify concentration-dependent modulation of human prostate cancer cells by genistein employing DNA microarray analysis (301). Genistein is a prominent isoflavone of soybeans and soy-based foods, and these results suggest potential benefit of such foods. Using cell culture models, Wang and his team demonstrated that genistein exerted biological effects on androgen-responsive genes through inhibition of

both androgen and estrogen receptor mediated pathways (302). This was the first demonstration of the alteration of androgen-responsive genes by a phytonutrient through multiple pathways. Wang joined the Diet, Genomics and Immunology Laboratory when the Phytonutrients Laboratory was closed in 2006.

Modeling

Advances in computer technology have allowed sophisticated mathematical equations and other complex problems to be solved relatively quickly. These advances have led the way for mathematical modeling to be applied to biological systems, which has focused high-cost research with animal models or human subjects on those areas where there is a dearth of data required for accurate modeling. Janet Novotny, with expertise in modeling, came to BHNRC as a postdoctorate in 1993 and was hired as a research scientist in 1996. In collaboration with Andrew Clifford and his colleagues at the University of California-Davis, Novotny developed the first model of β -carotene metabolism to predict its conversion to vitamin A in vivo (303). The results of these studies, which indicated that conversion of β -carotene to vitamin A was substantially lower than originally estimated, were used by organizations worldwide to adjust recommended intakes of these nutrients. Subsequently, Novotny assisted Phyllis Bowen's group at the University of Illinois-Chicago on modeling lycopene metabolism as part of an NCI Phase I clinical trial, which demonstrated that lycopene absorption becomes saturated at increasing levels of intake (304). Results from these studies were incorporated into a European Food Safety Authority report that established intakes of lycopene of 0.5 mg/kg body weight/day as posing no health risk. Collaborative studies with other groups have resulted in modeling of α -linolenic acid and α -tocopherol metabolism (305,306),

as well as molybdenum kinetics (307). Modeling data from energy metabolic studies at BHNRC indicated that small decreases in organ mass as a result of dieting fully accounted for the reduction in resting energy expenditure during weight loss (308). A decrease in visceral organ size of only 300 g was sufficient to account for the reduction in energy expenditure. Through these studies and others, Novotny and her collaborations have established BHNRC as a leader in nutritional pharmacokinetic modeling over a relatively short period of time.

Diet, Genomics, Immunology, and Related Programs

As noted above, a new dimension was added to the research program of BHNRC with the transfer of Joe Urban and the framework of an immunology research program from the Livestock and Poultry Sciences Institute at BARC in late 2000 (table 1). The focus of this program is to investigate selected nutrients and phytochemicals/phytonutrients on function of the immune system. Pigs are used as models because of the similarity of their metabolism to that of humans. Harry Dawson came to this program in 2001 with training in vitamin metabolism at A.C. Ross's laboratory at Pennsylvania State University. A major contribution by Dawson has been the development of the Porcine Immunology and Nutrition Database that spans immunologically related genes that have been classified under many categories of activity. One of the purposes of this activity is to compare similarities of these genes between pigs and humans. Dawson and collaborators have begun to investigate the role of foods in the control of the many immunological and inflammatory processes (309-311).

Allen Smith, a virologist trained at Rutgers University, was hired into the research program shortly before the addition of

immunology emphasis. He has expanded on the program initiated by Levander by investigating nutritional states of mice that increase susceptibility to bacterial and viral infections (312-314). Recently, he has characterized a common food contaminant, *Salmonella*, investigated requirements for growth, and reported conditions for optimal virulence in mice (315-317).

Gloria Solano-Aguilar came to the program in 2001 and has led the project related to the effects of different probiotic bacteria on immune and intestinal function. Swine have been standardized as a model for the validation of these effects. Also, a specific and functional gene marker (*tuf*) has been identified for strain B12 of Bifidobacterium, which will serve as a tool to follow this common probiotic among the many bacteria/microflora of the gastrointestinal tract and its effect on immune response and other intestinal functions (318).

Schoene currently is associated with the Diet, Genomics and Immunology Laboratory, where she is investigating a variety of nutrients and food components on cell function in culture. Zinc was found to be an important nutrient in the control of cell cycle function in normal human bronchial epithelial cells, HepG2 liver cells, and human hepatoblastoma cells (319-322). Extracts rich in anthocyanins, polyphenols from cinnamon, or phytoalexin glyceollins from soybeans altered cellular growth and function in HT29 colon cancer cells, hematologic tumor cells, and human prostate cancer cells LNCaP, respectively (170,323,324). Recently, in collaboration with scientists at UMCP, resveratrol was shown to modulate growth and increase zinc concentrations in normal human prostate cells in culture (325).

Although the nutrition- and metabolic-related programs of BHNRC are much smaller than those of HNRD shortly after the 1969 reorganization, they are highly focused

on the interaction of diet and markers for chronic disease. In addition, the Center is staffed by scientific experts and equipped with tools to investigate these difficult and complex interactions. Its location in one of the world's largest and most diversified agricultural research facilities, as well as being near a major agricultural university (UMCP) and several large medical complexes, provides ideal opportunities for the scientific interaction required to solve complex diet and health issues.

International Activities

Nearly all BHNRC scientists have presented data, chaired sessions, and led discussions at international scientific meetings, and some have participated in international collaborations. A few have been invited to be part of special international collaborations.

FAO/WHO (Food and Agriculture Organization/ World Health Organization). In the late 1990s, Joan Conway took a sabbatical leave with FAO, where she was part of the Secretariat that organized and conducted a review of "Vitamin and Mineral Requirements in Human Nutrition" as part of an FAO/WHO activity. A consultation with experts was held in Bangkok, Thailand, in 1998. A report of the consultation was issued in 2002, and a final WHO publication followed in 2004 (326).

PL 480 Projects. Current U.S. international food assistance programs began after World War II (326). One of the programs outlined in Title II of Public Law 480 of 1954 (Food for Peace Program) and administered by the U.S. Agency for International Development (USAID) continually reviews nutrient adequacy of foods provided for this program. One such review conducted in early 1996 concluded that new and improved products were needed for this program. As part of this initiative, a task force of ARS scientists was assembled to formulate a revised set

of nutrient specifications that would allow flexibility in meeting nutritional needs with least cost blends of available commodities. Judd, Moe, and Smith were members of this task group along with Robert Jacob, Virginia Holsinger, and Peter Reeds from other ARS laboratories. A summary of the discussions and recommendations was prepared for USAID, entitled "Report of USDA ARS Task Group on Nutrient Standards for Grain Blends— February 7, 1997." Other BHNRC scientists (Beecher and Reynolds) also were called upon for advice as part of other similar meetings to evaluate and improve nutritional quality of foods destined for the Food for Peace Program.

Awards

The following is a partial listing of awards given to scientists of BHNRC and its predecessors by professional societies, USDA, and other government agencies.

- 1942 Ruth Leverton, Borden Award, American Home Economics Association
- 1947 Millicent Hathaway, Borden Award, American Home Economics Association
- 1953 Ruth Leverton, Borden Award, American Home Economics Association
- 1961 Ruth Leverton, Honorary Doctor of Science, University of Nebraska
- 1964 Hazel Stiebeling, Fellow of American Institute of Nutrition, Charter Member
- 1969 Walter Mertz, Research and Development Award, U.S. Army
- 1971 Walter Mertz, Osborne and Mendel Award, American Institute of Nutrition
- 1971 Walter Mertz, Superior Service Award, U.S. Department of Agriculture
- 1972 Ruth Leverton, Distinguished Service Award, U.S. Department of Agriculture
- 1973 Lelia Booher, Fellow of American Institute of Nutrition, Charter Member
- 1973 Ruth Leverton, Conrad Elvehjem Award for Public Service in Nutrition, American Institute of Nutrition
- 1974 Willis Gortner, Fellow of Institute of Food Technologists
- 1975 Mildred Adams, Fellow of American Institute of Nutrition
- 1976 Callie Mae Coons, Fellow of American Institute of Nutrition
- 1977 Ruth Leverton, Fellow of American Institute of Nutrition
- 1977 Ruth Leverton, Federal Women's Award
- 1977 Ruth Leverton, Medallion Award, American Dietetic Association
- 1979 James C. Smith, Jr., Klaus Schwarz Medal, International Association of Bioinorganic Scientists
- 1982 Walter Mertz, Lederle Award, American Institute of Nutrition
- 1982 Madelyn Womack, Fellow of American Institute of Nutrition
- 1984 Louise Stanley, induction into the National Agriculture Hall of Fame
- 1986 Orville Levander, Osborne and Mendel Award, American Institute of Nutrition
- 1986 Walter Mertz, Certificate of Merit Service to Agriculture of Gamma Sigma Delta, University of Maryland Chapter
- 1987 Walter Mertz, International Award for Modern Nutrition of the World Health Organization, the United Nations
- 1987 Walter Mertz, Distinguished Service Award, U.S. Department of Agriculture
- 1989 Walter Mertz, Fellow of American Institute of Nutrition
- 1995 Orville Levander, Klaus Schwarz Medal, International Association of Bioinorganic Scientists
- 1995 Walter Mertz, induction into the ARS Science Hall of Fame
- 1998 James Iacono, Fellow of American Institute of Nutrition
- Joseph Spence, Award for Sustained Accomplishment, U.S. Department of Agriculture
- 2001 James C. Smith, Jr., Fellow of American Society for Nutrition
- 2004 Joseph Spence, Presidential Rank Meritorious Executive Award, U.S. Department of Agriculture
- 2006 Orville Levander, Fellow of American Society for Nutrition
- 2010 Marilyn Polansky, USDA Employee with Most Years of Full-Time Federal Service. *(She retired in 2011 after 56 years with USDA.)*

Acknowledgments

Many people have helped in the assembly of this historical document, to whom I am grateful. I especially want to acknowledge the efforts of J.C. Smith, Jr. for his forbearance in reviewing, editing, and commenting on the manuscript. The unpublished notes by H.J. Souders entitled "Agricultural Research Service, USDA Highlights of Contributions of Food and Nutrition Research," which detailed this activity from the late 1800s to 1976, as well as the personal records of Mrs. Mary Marshal, were extremely helpful. Comments by Dr. Robert Doherty also are greatly appreciated.

Disclaimer

The publications cited here are not intended to be a complete list for scientists at BHNRC and its predecessor organizations; rather, they are intended to be representative of the research discussed in the chapter. Publication lists for each scientist are available at NIH's National Library of Medicine (www.ncbi.nlm.nih.gov/pubmed/) and USDA's National Agricultural Library (www.nal.usda.gov).

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CHAPTER 5

History of Food Composition Activities at the U.S. Department of Agriculture

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Abbreviations

AH8	Agriculture Handbook No. 8	HPLC	high performance liquid chromatography
AMS	Agricultural Marketing Service, USDA	HPLC-MS	high performance liquid chromatography-mass spectrometry
AOAC	Association of Official Analytical Chemists (originally Association of Official Agricultural Chemists, now AOAC International)	ICP	inductively couple plasma
ARS	Agricultural Research Service, USDA	ICP-MS	inductively coupled plasma-mass spectrometry
BARC	Beltsville Agricultural Research Center	INFOODS	International Network of Food Data Systems
BHE	Bureau of Home Economics	IOM	Institute of Medicine of the National Academies
BHNRC	Beltsville Human Nutrition Research Center	IUNS	International Union of Nutritional Scientists
CFEI	Consumer and Food Economics Institute	LRC	Lipid Research Clinics
CFERD	Consumer and Food Economics Research Division	MIT	Massachusetts Institute of Technology
CRMs	Certified Reference Materials	MRFIT	Multiple Risk Factor Intervention Trial
ERS	Economic Research Service, USDA	MS	mass spectrometry
EuroFir	European Food Information Resource	NBS	National Bureau of Standards
FALCC	Food Analysis Laboratory Coordination Center	NCI	National Cancer Institute
FAO	Food and Agricultural Organization of the United Nations	NCL	Nutrient Composition Laboratory
FCL	Food Composition Laboratory	NDBS	Nutrient Data Bank System
FCMDL	Food Composition and Methods Development Laboratory	NDL	Nutrient Data Laboratory
FGIS	Federal Grain Inspection Service, USDA	NDRB	Nutrient Data Research Branch
GC-MS	gas chromatography-mass spectrometry	NDRG	Nutrient Data Research Group
Hispanic		NFNAP	National Food and Nutrient Analysis Program
HANES	Hispanic Health and Nutrition Examination Survey	NHANES	National Health and Nutrition Examination Survey
HNHE	Human Nutrition and Home Economics	NHLBI	National Heart, Lung and Blood Institute
HNIS	Human Nutrition Information Service, USDA	NIH	National Institutes of Health
HNRD	Human Nutrition Research Division	NIR	near-infrared spectroscopy
		NIST	National Institute of Standards and Technology
		NLEA	National Nutrient Labeling and Education Act
		NNDB	National Nutrient Data Bank
		NNDC	National Nutrient Data Bank Conference
		ODS	Office of Dietary Supplements, NIH
		PDA	personal digital assistant
		SR	Standard Reference
		SRM	Standard Reference Material
		UMCP	University of Maryland-College Park
		UNDP	United Nations Development Program
		UNU	United Nations University
		USDA	United States Department of Agriculture
		USFDA	United States Food and Drug Administration
		UV	ultraviolet
		VT	Virginia Polytechnic Institute and State University

Table 1. Organizations and related events of food composition activities in

Date	Detail of events
1894	U.S. Congress appropriated \$10,000 to be used for investigations leading to reports of “the nutritive value” of various foods and more “wholesome and edible rations” that are “more economical” than those commonly consumed. W.O. Atwater was named special agent in charge of nutrition investigations. Activity was administratively placed in USDA Office of Experiment Stations. Atwater began to develop a network of about 30 collaborators (most were at State Experiment Stations and 1890s Colleges) to initiate studies on measurements of food composition and on assessing food intakes. He began work on 1895 publication (table 2), which outlined priorities for research and methodologies for future studies, but also reported food composition data and metabolic results.
1897	Congress increased annual appropriations to \$15,000 for “nutritional studies.”
1901	Appropriations increased to \$20,000 per year.
1904	Atwater suffered career-ending stroke; he died in 1907.
1905	C.F. Langworthy, Atwater’s assistant, was placed in charge of Nutrition Investigations.
1906	Headquarters of Human Nutrition Investigations and calorimetry studies were moved to USDA at Washington, DC.
1915	States Relations Service of USDA was formed that incorporated the Office of Experiment Stations, a newly created Extension Service, and a separate Office of Home Economics headed by Langworthy. The latter office absorbed Human Nutrition Investigations and administered several other home economics-related programs.
1923	Bureau of Home Economics (BHE) was established with Louise Stanley as Chief and with three initial divisions: Food and Nutrition (Stanley, Acting Head), Textiles and Clothing (Ruth O’Brien, Head), and Family Economics (Hildegarde Kneeland, Head)—within which food composition compilations were conducted. Additional home economics-related divisions were organized later.
1930	Hazel Stiebeling was appointed Head of Division of Family Economics (and food composition activities).
1941	BHE divisions requiring laboratory space moved to Beltsville Agricultural Research Center (BARC). Non-laboratory-requiring activities, including food composition work, remained in Washington, DC.
1942	Agricultural Research Administration was established. Stiebeling was appointed Assistant Chief of BHE.
1943	BHE merged with Protein and Amino Acid Investigations, part of Division of Protein and Nutrition Research at Beltsville, to form Bureau of Human Nutrition and Home Economics (BHNHE). Stanley stepped down as Chief, Henry C. Sherman was appointed as new Chief, and Stiebeling was appointed as Assistant Chief. Five divisions were organized: Food and Nutrition, Family Economics (including food composition activities), Textiles and Clothing, Housing and Household Equipment, and Information.

Date	Detail of events
1944	Stiebeling was appointed Chief of BHNHE and Ruth O'Brien as Assistant Chief.
1945	Callie Mae Coons was appointed Assistant Chief of BHNHE.
1948	Twenty-fifth anniversary of the Bureau was celebrated.
1953	Agricultural Research Administration was renamed Agricultural Research Service (ARS).
1954	BHNHE activities were divided into two branches: (1) Human Nutrition Research (Food and Nutrition Division, and Food Composition and Diet Appraisal Research from Family Economics Division, with Coons as Chief) and (2) Home Economics Research (remaining divisions and sections of BHNHE, with O'Brien as Chief). Stiebeling was Director of BHNHE.
1955	Bureau of Home Economics Research was formed with Stiebeling as Director. Three branches were established: Human Nutrition Research (Coons, Chief), Clothing and Housing Research (O'Brien, Chief), and Household Economics Research, including food composition activities (Gertrude Weiss, Chief).
1957	Institute of Home Economics was formed with Stiebeling as Director. Three branches organized in 1955 were renamed divisions with leadership changes (Esther Batchelder, Chief of Clothing and Housing, and Faith Clark, Chief of Household Economics, including food composition activities).
1961	Nutrition and Consumer-Use Research was formed to more accurately reflect nature and scope of ongoing research programs. Stiebeling was named Deputy Administrator, Ruth Leverton Assistant Administrator. Three divisions continued: Human Nutrition Research (Coons, Director), Clothing and Housing Research (Batchelder, Director), and Consumer and Food Economics Research with food composition activities (CFERD), renamed from Household Economics Research (Clark, Chief).
1962	Stiebeling retired, and Coons was appointed Assistant to the Administrator as Chief Nutrition Specialist.
1963	Nutrition and Consumer Use Research merged with ARS Utilization Research (regional utilization laboratories) with one Deputy Administrator (Fred Senti, Deputy Administrator, and Leverton as Assistant Deputy Administrator for nutrition-related activities).
	This resulted in a total of seven research divisions: Human Nutrition Research (HNRD) (C. Edith Weir, Acting Director), Clothing and Housing Research (Batchelder, Director), CFERD (Clark, Director), and the four regional utilization laboratories as divisions (Albany, CA, New Orleans, LA, Peoria, IL, and Wyndmoor, PA).
	HNRD laboratories: Experimental Nutrition, Human Metabolism, Food Quality and Use, and Food Composition, which developed new analytical methods and analyzed foods for nutritive value (E.W. Toepfer, Chief).

Table 1. Organizations and related events of food composition activities in

Date	Detail of events
1963	<p>CFERD branches: Family Economics Branch, Food Consumption Branch, Survey Statistics Staff, and Food and Diet Appraisal Branch, which had food composition compilation activities (Bernice Watt, Leader).</p> <p>CFERD relocated from Washington, DC, to Hyattsville, MD.</p>
1963	<p>Report to Congress “Proposed Program for Expanded Research in Food and Nutrition” in part called for expansion of “Beltsville Center,” doubling of scientists, and five-fold increase in funding over 3 years.</p>
1964	<p>Willis Gortner was appointed director of HNRD.</p>
1969	<p>HNRD was reorganized and its programs redirected to emphasize research on human requirements of nutrients and on nutritive value of foods. Research on “food science” was discontinued, and research on food preparation, quality, and acceptability (Food Quality and Use) was transferred to CFERD. Food Composition Laboratory was abolished with scientists moved to four new laboratories. (Gortner, Director, Weir, Associate Director, and Leon L. Hopkins, Assistant to Director.) Research programs were divided among four laboratories: Carbohydrate Nutrition, Lipid Nutrition, Protein Nutrition, and Vitamin and Mineral Nutrition. Each laboratory had at least two investigations units—food composition and nutrient requirements.</p> <p>CFERD was renamed Consumer and Food Economics Institute (CFEI); food composition compilation activities were put under Nutrient Data Research Center.</p>
1970	<p>Clark retired; Robert Rizek was appointed Director, CFEI.</p>
1972	<p>Major reorganization of ARS to regionalize administration of research programs (four regions): Northeast, North Central, South, and West.</p> <p>A National Program Staff was established to coordinate nationwide research programs. Gortner was appointed first National Program Staff Scientist for Nutrition and Family Living.</p> <p>HNRD was renamed Nutrition Institute (NI); Walter Mertz was appointed Director.</p> <p>Dairy Products Laboratory, Washington, DC, was transferred to Eastern Regional Research Center, Philadelphia, PA. Several sections of the Laboratory were transferred to NI, and several scientists transferred to Nutrient Data Research Center at CFEI.</p> <p>Scientists with expertise in plant physiology and in plant isotope labeling techniques transferred to PL from other BARC laboratories.</p>
1974	<p>Bernice Watt retired.</p>
1975	<p>Nutrient Composition Laboratory (NCL) was formed in response to National Heart, Lung and Blood Institute, NIH (NHLBI) request for accurate and extensive data on fatty acid, cholesterol, and selected mineral content of foods. Kent Stewart was appointed Chief of the newly formed group.</p>

the U. S. Department of Agriculture¹—*Continued*

Date	Detail of events
1977	<p>Frank Hepburn was appointed Leader of Nutrient Data Research Group (food composition compilation activities).</p> <p>James (Jack) Iacono was appointed National Program Staff Scientist for Nutrition and Family Living.</p>
1978	<p>Science and Education Administration (SEA), USDA, was formed under the new Democratic Administration. All human nutrition research activities moved from ARS to a parallel organization, Human Nutrition Center (HNC), within SEA. D. Mark Hegsted was appointed Administrator, James (Jack) Iacono as Associate Administrator. Research programs were coordinated from Administrator's Office.</p> <p>CFEI was renamed Consumer Nutrition Center (CNC).</p>
1981	<p>SEA was abolished under the new Republican Administration.</p> <p>CNC was transferred into a new agency, Human Nutrition Information Service (HNIS), and was administratively placed under the Assistant Secretary for Food and Nutrition Service, separating it from the Assistant Secretary responsible for ARS. Food and Nutrition Information Center of National Agricultural Library also was administratively transferred to HNIS.</p> <p>Two Divisions from the "old" CNC were formed: Consumer Nutrition Division and Nutrition Monitoring Division (NMD). Food Consumption Research Branch (food consumption surveys) and Nutrient Data Research Branch (food composition data) were organized within NMD with Rizek as Director.</p> <p>The Human Nutrition Research Centers were integrated into ARS's regional organization. NI renamed Beltsville Human Nutrition Research Center (BHNRC).</p> <p>Gerald F. Combs, Sr., was appointed Nutrition National Program Leader to coordinate human nutrition research activities within USDA and across all Federal agencies.</p>
1982	<p>Gary Beecher was appointed Chief of NCL.</p>
1983	<p>Isabel Wolf was appointed Administrator of HNIS.</p>
1985	<p>Suzanne Harris was appointed Administrator of HNIS.</p>
1987	<p>Laura Sims was appointed Administrator of HNIS.</p> <p>Ruth Matthews was appointed Chief, Nutrient Data Research Branch (food composition compilation activities)</p>
1990	<p>Sue Ann Ritchko was appointed Administrator of HNIS.</p>
1991	<p>Jacqueline L. Dupont was appointed Nutrition National Program Leader.</p>

Table 1. Organizations and related events of food composition activities in

Date	Detail of events
1993	<p>Ellen Harris was appointed Director of HNIS Nutrition Monitoring Division.</p> <p>Mertz retired; Joseph Spence was appointed Director of BHNRC.</p> <p>W.O. Atwater Centennial Celebration Symposium was held “to commemorate 100 years of human nutrition research in the U.S. Department of Agriculture and to honor the memory of its initiator and mover, Wilbur O. Atwater.” Proceedings were published as a supplement to <i>The Journal of Nutrition</i> 1994;124(9S):1707S-1890S.</p>
1994	<p>HNIS activities were transferred to ARS (after HNIS was abolished). Food consumption survey and food composition data activities were administratively moved into BHNRC as Food Surveys Research Group and Nutrient Data Laboratory, respectively. Nutrition education component (Pyramid, etc.) of HNIS moved to USDA Center for Nutrition Policy and Promotion, Alexandria, VA. Metabolism-related laboratories of BHNRC were renamed with minor reorganization—Diet & Human Performance, Metabolism & Nutrient Interactions, and Nutrient Requirements & Functions (NRFL). Food Composition Laboratory (FCL) retained its mission, renamed from NCL.</p>
1995	<p>Joanne Holden was appointed Research Leader of Nutrient Data Laboratory.</p> <p>Food Surveys Research Group and Nutrient Data Laboratory moved from Hyattsville to Riverdale, MD; occupied building jointly with several Animal and Plant Health Inspection Service (APHIS) units.</p>
1997	<p>James Harnly was appointed Research Leader of FCL.</p>
1998	<p>Carla Fjeld was appointed Nutrition National Program Leader.</p>
1999	<p>Food Surveys Research Group and Nutrient Data Laboratory moved from Riverdale, MD, to Building 005, BARC.</p> <p>Kathleen Ellwood was appointed Nutrition National Program Leader.</p>
2002	<p>Spence was appointed Acting Nutrition National Program Leader.</p>
2004	<p>Spence was appointed Deputy Administrator for Nutrition, Food Safety and Quality.</p> <p>Mary “Molly” Kretsch and David Klurfeld were appointed Nutrition National Program Leaders.</p>
2006	<p>Allison Yates was appointed Director of BHNRC.</p>
2007	<p>Reorganization of metabolism units of BHNRC. Changes were driven by budget constraints and personnel retirements. Six laboratories/groups—Food Surveys Research Group; Nutrient Data Laboratory; Food Composition and Methods Laboratory (renamed from FCL); Food Intake and Energy Regulation Laboratory; Food Components and Health Laboratory; and Diet, Genomics and Immunology Laboratory.</p>

the U. S. Department of Agriculture¹—*Continued*

Date	Detail of events
2008	Spence was appointed Director of Beltsville Area, which included BARC as well as BHNRC.
2009	Kretsch was appointed Deputy Administrator for Nutrition, Food Safety and Quality. John Finley was appointed Nutrition National Program Leader.
2011	Allison Yates was appointed Associate Director of Beltsville Area.

¹Historical information compiled from Elias (5), Swan (216), and Souders (217), as well as from the library of “Director’s Notes” maintained by Jacob Exler.

Table 2. Compilations of food composition data and related information released

Year	Description
1895	Methods and Results of Investigations on the Chemistry and Economy of Food. USDA Office of Experiment Stations Bulletin No. 21. A comprehensive bulletin by W.O. Atwater that not only reported energy and proximate values for selected foods but also discussed the results of human calorimetry studies, general metabolism, and food consumption surveys. Origin of 4, 9, 4 kcal/g for carbohydrate, fat, and protein, respectively.
1896	Chemical Composition of American Food Materials. USDA Office of Experiment Stations Bulletin No. 28. Updated 1899, 1906 ³ .
1926	Proximate Composition of Beef. USDA Circular No. 38.
1928	Proximate Composition of Fresh Fruits. USDA Circular No. 50.
1929	Vitamins in Food Materials. USDA Circular No. 84.
1931	Proximate Composition of Fresh Vegetables. USDA Circular No. 146. Factors for Converting Percentages of Nitrogen in Foods and Feeds Into Percentages of Protein. USDA Circular No. 183. Revised 1941 ³ .
1937	Vitamin Content of Foods: A Summary of the Chemistry of Vitamins Units of Measurement, Quantitative Aspects in Human Nutrition and Occurrence in Foods. USDA Miscellaneous Publication No. 275.
1939	The Vitamin B1 Content of Foods in Terms of Crystalline Thiamin. USDA Technical Bulletin No. 707.
1940	Proximate Composition of American Food Materials. USDA Circular No. 549.
1941	The Vitamin A Values of 128 Foods as Determined by the Rat-growth Method. USDA Technical Bulletin No. 802.
1945	Tables of Food Composition in Terms of Eleven Nutrients. USDA Miscellaneous Publication No. 572.
1950	Composition of Foods: Raw, Processed, Prepared. USDA Handbook No. 8.
1951	Folic Acid Content of Foods. USDA Handbook No. 29.
1955	Energy Value of Foods. Basis and Derivation. USDA Handbook No. 74. Revised 1973 ³ .
1956	Pantothenic Acid in Foods. USDA Handbook No. 97. Food Yields Summarized by Different Stages of Preparation. USDA Handbook No. 102. Revised 1975 ³ .
1957	Amino Acid Content of Foods. USDA Home Economics Research Report No. 4. Reviewed and reprinted 1963.

Released by USDA 1895-2011¹

Year	Description
1959	Fatty Acids in Food Fats. USDA Home Economics Research Report No. 7.
1960	Nutritive Value of Foods. USDA Home and Garden Bulletin No. 72. Revised 1976, 1990, 2002 ³ .
1961	Vitamin B12—Microbiological Assay Methods and Distribution in Selected Foods. USDA Home Economics Research Report No. 13.
1963	Composition of Foods: Raw, Processed, Prepared. USDA Handbook No. 8. Revised.
1965	Vitamin E Content of Foods and Feeds for Human and Animal Consumption. University of Wyoming Bulletin No. 435. Research sponsored by HNRD ² .
	Proximate Composition of Beef from Carcass to Cooked Meat: Method of Derivation and Tables of Values. USDA Home Economics Research Report No. 31.
1966	Procedures for Calculating Nutritive Values of Home-Prepared Foods: as Used in Agriculture Handbook No. 8. Revised 1963. USDA, ARS Bulletin No. 62-13.
1969	Average Weight of a Measured Cup of Various Foods. USDA, ARS Bulletin No. 61-6. Pantothenic Acid, Vitamin B6 and Vitamin B12 in Foods. USDA Home Economics Research Report No. 36.
1975	Nutritive Value of American Foods in Common Units. USDA Handbook No. 456.
1976- 1992	Composition of Foods: Raw, Processed, Prepared. Agriculture Handbook (AH) No. 8. Revised. Updated in loose-leaf notebook format. First release: AH 8-1 Dairy and Egg Products; final release: AH 8-18 Baked Products. A total of 21 sections prepared and released.
1980	The Sodium Content of Your Food. USDA Home and Garden Bulletin No. 233.
1980- 1994	A series of provisional tables that included early tabulations of specific nutrients and food components, e.g., Nutrient Content of Bakery Foods, Selenium Content of Foods, Vitamin D Content of Foods, and Vitamin K Content of Foods. Most of these data have been incorporated into the USDA National Nutrient Database for Standard Reference (see below). Some of these tables are available on the USDA Nutrient Data Laboratory Web site (see below).
1980- 2011	USDA National Nutrient Database for Standard Reference (SR) 3. Electronic version of Agriculture Handbook No. 8, data updated and released each year; latest release SR-26 (2013).
1983	Iron Content of Food. USDA Home Economics Research Report No. 45.
1985	Key Foods. Revised 1998, 2003, 2005 ³ . Listing of “key foods” consumed in the United States based on data from the most recent food consumption survey.

Table 2. Compilations of food composition data and related information released by USDA 1895-2011¹—Continued

Year	Description
1987	Sugar Content of Selected Foods: Individual and Total. USDA Home Economics Research Report No. 48. Revised 1990 ³ .
1990-1992	Supplements to Agriculture Handbook No. 8. Revised. Loose-leaf version. Updates released as individual foods (sheets) that replaced existing notebook entries.
1993	USDA-NCC (NCI) ² Carotenoid Database for U.S. Foods. Updated 1998 ³ .
1995	Selected Foods Containing Trans Fatty Acids ³ .
1998	USDA-Iowa State University Database on the Isoflavone Content of Foods. Updated 2000, 2008 as Release 2.0 ³ .
2003	USDA Database for the Flavonoid Content of Foods. Updated 2011 as Release 3 ³ . USDA Table of Nutrient Retention Factors, Release 5. Updated 2007 as Release 6 ³ .
2004	USDA Database for the Choline Content of Common Foods. Updated 2008 as Release 2 ³ . USDA Database for the Proanthocyanin Content of Selected Foods ³ . USDA National Fluoride Database of Selected Beverages and Foods. Updated 2005 as Release 2 ³ .
2006	USDA Database for the Added Sugars Content of Selected Foods, Release 1 ³ .
2007	Oxygen Radical Absorbance Capacity (ORAC) of Selected Foods. Updated 2010 as Release 2 ³ . USDA Nutrient Data Set for Fresh Pork (Derived from SR), Release 1.0. Updated 2009 as Release 2.0 ³ .
2009	Dietary Supplement Ingredient Database, Release 1 ³ . Oxalic Acid Content of Selected Vegetables (originally published as part of Agriculture Handbook 8-11, 1984). USDA Nutrient Data Set for Retail Beef Cuts, Release 1.0. Updated 2011 as Release 2.0 ³ .

¹Adapted from USDA Compiling Food Composition Data for Over 115 Years [Internet]. Beltsville, MD: USDA, ARS, Nutrient Data Laboratory; [cited 2009 Jun 30]. Available at www.ars.usda.gov/Aboutus/docs.htm?docid=9418&pf=1&cg_id=0. Some information abstracted from selected publications (1,49,217).

²Abbreviations: HNRD—Human Nutrition Research Division; NCC—Nutrition Coordinating Center, School of Public Health, University of Minnesota, Minneapolis; NCI—National Cancer Institute, National Institutes of Health.

³Documents available at <http://www.ars.usda.gov/nutrientdata>.



Dr. W.O. Atwater recognized the need for food composition data.

Introduction

Today, information on the nutritive value and health promotion of foods supports the quantitative study of nutrition and is widely used in many fields, including epidemiological research, clinical practice, health policy and promotion, and food manufacture (1). W.O. Atwater recognized the need for food composition data as part of his early studies. As a result, formal and integrated food composition activities in the United States had their origins in Atwater's and his colleagues' laboratories in Connecticut (table 1). As early as 1892, Atwater and C.D. Woods reported energy and proximate values for selected American foods (2). These data were documented in detail by Atwater in an 1895 publication (table 2). Atwater and Woods published the first *comprehensive* food composition table for U.S. foods in 1896 (table 2). Prior to this publication, the composition of U.S. foods was based on European products that had been analyzed in laboratories in Germany (3). The 1896 tables were subsequently updated (1899, 1906) with data from Atwater's laboratory, as well as from other research groups, and served as the food composition tables for the United States for two decades. Over the next 20 years, there was a hiatus of food composition data

tabulations except for those data reported by H.C. Sherman in his textbook *Chemistry of Food and Nutrition* and its updates and revisions (4).

Early Accomplishments

Beginning in the mid-1920s, scientists in the newly created Bureau of Home Economics (BHE), Family Economics Division (5) published a series of circulars, handbooks, and pamphlets that updated and expanded the Atwater tables (tables 1, 2). Many of these updates followed the discovery of new, essential nutrients and methods for their assay in foods and biological materials. Although some data were generated in BHE laboratories, a large amount of information came from State Experiment Stations and Land Grant Institutions, as well as other national and international laboratories. In 1925 Louise Stanley, Chief of BHE, chaired a Committee on Vitamin Content of Food in Relation to Human Nutrition convened by the Association of Land Grant Colleges. Subsequently, she personally contacted each of the State Experiment Station Directors to inquire about the vitamin research at their location (5). Undoubtedly, these efforts were responsible for the tabulation and publication of the first table on vitamin content of U.S. foods as early as 1929 (table 2).

In the 1930s, A.L. Winton and K.B. Winton published an extensive four-volume series on the "Structure and Composition of Foods" (6-9). These works were stimulated by the passage of laws to suppress food fraud and were organized by food class, including spices and a few botanicals, emphasizing the relationship of structure to then-known chemical composition. This husband-and-wife team, who were associated with the Connecticut Experiment Station and later with USDA (not BHE), produced a voluminous amount of critical morphological

and chemical information on common foods and spices of the era.

At about the same time, D.B. Jones conducted seminal research by carefully isolating proteins from a large number of foods and feeds and subsequently determined their nitrogen content. It is these data that established the average nitrogen content of proteins as 16% and from which the factor 6.25 was derived that is applied for the conversion of nitrogen to protein content (table 2). Although Jones was administratively part of the Protein and Nutrition Division of the Bureau of Agriculture Chemistry and Engineering at Beltsville while he conducted this work, his group was merged with BHE in 1943, creating the Bureau of Human Nutrition and Home Economics (table 1).

Heretofore, U.S. food composition tables reported limited groups of nutrients, i.e., proximates, vitamins, etc. In 1945 a comprehensive table on the composition of foods was published, which included new data for three minerals and five vitamins, as well as proximate composition (table 2). This table was collated and released in collaboration with the National Research Council and was intended for nationwide use. It served as the predecessor to the well-regarded and widely used USDA Handbook No. 8, *Composition of Foods: Raw, Processed, Prepared*, published in 1950, which also reported the same number of nutrients but for 750 foods (table 2). This popular handbook was updated and published in 1963 with the addition of data for three more minerals (sodium, potassium, and magnesium), cholesterol, fatty acids, and information for about 1,200 foods. The Agriculture Handbook 8 (AH8) served as the reference source of U.S. food composition for several decades until all of the sections of the loose-leaf version were updated and published in 1992 (table 2). A very popular abbreviated version of AH8 is the USDA Home and Gardens Bulletin No. 72, first

published in 1960 and updated several times, most recently in 2002.

As the fledgling laboratories of the Food and Nutrition Division of BHE developed and grew, a large amount of food composition data was generated and published in conjunction with food data compilers (table 1). As an example, L.E. Booher, the first full-time head of the Food and Nutrition Division, and E.R. Hartzler published the first vitamin B1 table based on methods they had developed using crystalline thiamin as a standard (table 2). Subsequently, Booher and R.L. Marsh reported the vitamin A values of over 100 foods based on the rat-growth method. This work was part of the extensive vitamin A research conducted by Booher, E.C. Callison, and colleagues, and for which they received the USDA Distinguished Service Award. The analyses of newly discovered vitamins in foods continued to the extent that a Food Composition Laboratory was organized in about 1963 within the Human Nutrition Research Branch (table 1) (10). During this period, E.G. Zook, E.W. Toepfer, and their colleagues reported the levels of folic acid, pantothenic acid, and vitamin B6 in foods, and H. Lichtenstein et al. published the vitamin B12 content of selected foods based on a new microbiological assay (table 2). Marilyn Polansky, who retired in 2011, was part of this group. Just prior to her retirement, Polansky was cited as the USDA employee with the most years of full-time Federal service (56 years) and was still working full-time at the Department. H.T. Slover and colleagues reported the first separation of tocopherols on newly developed gas-liquid chromatography instrumentation (11). The data generated by this procedure were later added to the USDA food tables. Soon after, J.P. Sweeney and A.C. Marsh separated the various stereoisomers of α - and β -carotene on laboratory-assembled "high-pressure" liquid chromatography systems (12). Similar

1958



Georgian Adams was one of the scientists responsible for reactivating food composition research in the Beltsville Human Nutrition Research Center (BHNRC).

1963



Bernice Watt helped update the original Agriculture Handbook 8 for the 1963 revision.

instrumentation was commercialized and became very popular a few years later.

Even though there was considerable in-house expertise and capability in USDA for nutrient analysis of foods, contracts and cooperative agreements were issued for specific data. For example, *Folic Acid Content of Foods*, published in 1951 (table 2), was a cooperative effort with scientists at the Texas Agriculture Experiment Station. Similarly, the generation of vitamin E data for the 1965 table was supported by a contract with scientists at the University of Wyoming, and much of the data for *Proximate Composition of Beef From Carcass to Cooked Meat: Method of Derivation and Tables of Values*, published in 1965 (table 2), was generated through a contract with meat scientists at the University of Wisconsin.

Administratively, the compilation of food composition data was an activity of organizations associated with Family Economics or Consumer and Food Economics (table 1). This group was also the first to develop such calculations as the nutritive value of the food supply (13) based on food production and disappearance statistics. This work evolved into food consumption surveys and similar

summaries. Only briefly during the 20th century were food composition activities combined with human nutrition research activities, e.g., 1954-1961 and 1994 to the present, when the group was transferred to the Beltsville Human Nutrition Research Center (BHNRC). Regardless of the organization or physical location, scientists who were compiling food composition data continued their work throughout the decades. C. Chatfield and G. Adams, the two scientists responsible for reactivating food composition research in the Department after Atwater, compiled the early proximate composition data. B.K. Watt, A.L. Merrill, M.L. Orr, W.T. Wu, and R.K. Pecot compiled the original Agriculture Handbook 8; and Watt and Merrill, assisted by Pecot, Orr, C.F. Adams, and D.F. Miller, updated the work for the 1963 revision (table 2). Orr and Watt also compiled the first table on the amino acid content of foods, a compilation for 18 amino acids of over 300 foods. They followed this with a table of phenylalanine and tyrosine values of fruits and vegetables, specifically designed for use in planning diets for phenylketonurics (14). Merrill and Watt summarized the energy values for foods, and Pecot and Watt assembled the data for the first edition of *Food Yields Summarized by Different Stages of Preparation*, USDA Handbook

1970



Dr. Robert Rizek was appointed Director of the Consumer and Food Economics Institute (CFEI) in late 1970. He helped initiate the concept of a USDA Nutrient Data Bank.

No. 102, published in 1956 (table 2). R.H. Matthews and Y.J. Garrison coauthored an update of the work in 1975. While Chatfield, Adams, and Watt were recognized for their publication *Historically Important Contributions of Women in the Nutrition Society* (15), several others contributed to each of the handbooks and circulars. The list of publications during this early period emphasizes the numerous accomplishments attained with relatively few scientists and staff.

Compilation of Food Composition Data 1963-2011

The administrative merger of nutrition, consumer, and industrial use research at the level of ARS in 1963 (table 1) had little effect on the Consumer and Food Economics Research Division (CFERD), as it had been reorganized and renamed in 1961 (from Household Economics Research Division). Dr. Faith Clark continued as Division Director, and B.K. Watt was in charge of Food Composition within the Diet and Appraisal Branch of the Division (table 2). That same year, CFERD activity moved from offices in Washington, DC, to a new building in Hyattsville, MD—a privately owned, leased building.

The reorganization of the Human Nutrition Research Division (HNRD) in Beltsville in 1969, however, had more impact on food composition activities at the Consumer and Food Economics Institute (CFEI) (newly renamed) (table 2). This reorganization abolished the Food Composition Laboratory at HNRD, a group that had generated considerable data, and integrated this research activity into the human nutrition metabolic units. Not only was this group active in measuring vitamin concentrations of foods as noted above, but a large collaborative project on the nutritive value of selected wheat and wheat products had been completed just prior to reorganization.

A series of publications reported the results of this endeavor (16-25). Soon thereafter, Feeley et al. summarized the nutrient content of dairy products (26-28), Levander and colleagues reported on the selenium content of foods (29,30), and Toepfer et al. measured chromium in foods in relation to biological activity (31). Subsequently, collaborations and contracts were expanded at CFEI in an effort to generate food composition data that were being requested by scientists in a wide variety of disciplines.

Dr. Robert Rizek was appointed Director of CFEI in late 1970 upon the retirement of Clark earlier that year (table 1). Murphy, Watt, and Rizek initiated the concept of a USDA Nutrient Data Bank with cooperation from other government agencies and the food industry (32). The U.S. Food and Drug Administration (USFDA) had been conducting their “Total Diet Study” since 1961. It generated important data for some nutrients as well as for toxicants and contaminants, and in foods that were purchased at retail stores (33). In addition, the food industry was increasing analyses of its products as the role of diet in health was being recognized. At that time, the USDA Nutrient Data Bank was viewed as the potential reference source of data for the voluntary food-labeling initiative that would

be part of USFDA. However, proprietary issues with food industry-generated data prevented this partnership. A form was developed that unified submission of data to CFEI and that was distributed to food analysis laboratories for their use. These early visions and decisions led to the current USDA National Nutrient Data Bank and the many products that are generated from it.

During 1973-1974, J.E. Kinsella, a lipids specialist in food science and nutrition at Cornell University, elected to do his sabbatical at CFEI. While there he developed a comprehensive and collaborative program, in conjunction with CFEI scientists, to generate new data on the fatty acid and lipid content of foods. The results of these efforts were published in many journal articles, and the data were added to the newly developed Nutrient Data Bank (34-36). In retrospect, many of these data were those that program administrators at the National Heart, Lung and Blood Institute (NHLBI) of the National Institutes of Health were calling for to support the nutritional epidemiology programs that recently had been initiated. (See section on Nutrient Composition Laboratory.) Such diet and health investigations required current and complete composition data for retail foods, which quickly increased the workload and responsibilities of the scientists working in the Food Composition Group.

In 1975, the final printed total compilation of USDA Handbook No. 456, authored by C.F. Adams, was published. It reported the nutritive values of American foods in household units, i.e., cups, ounces, pounds, rather than in scientific weights and measures (table 2). This was a very popular handbook, and the aspect of common measures or units has been incorporated into the search characteristic of the current USDA electronic database system (www.ars.usda.gov/nutrientdata). Concurrently, foods' zinc values were summarized and

released as a publication (37). Also, newly available data on the cholesterol content of foods were reported (38).

To circumvent some of the publication delays in the release of new data, a loose-leaf notebook format for AH8 was proposed with all data for a single food presented on one page. This format facilitated the updating of data in that only affected foods (pages) were required to be reprinted rather than the entire booklet. The first sections in this format, 8-1 Dairy and Egg Products and 8-2 Spices and Herbs, were published in early 1977. Twenty-one sections along with several supplements were published over the next 15 years (table 2).

The first computer system arrived at CFEI in 1976. It consisted of a mainframe with key punch cards and data tapes as input/output media and employed the programming language COBOL. The integration of this new electronic management of information in the Nutrient Data Bank System (NDBS) was announced and described by R.R. Butrum and S.E. Gebhardt (39). In fact, the 1963 version of AH8 was released not only in printed version but also as the first 80-column card set intended for computer use (J. Holden, personal communication). Additional "computerized" versions of food composition information included USDA Handbook No. 456 and an update of AH8 that reflected recent changes in food enrichment standards (40). The next "computerized" version of AH8 (1980) integrated the first few sections of the revised AH8 in loose-leaf format, and was named the *USDA Nutrient Database for Standard Reference* (SR) (table 2). In the absence of electronic transmission, these data were available primarily as magnetic tapes. SR, the primary food composition data product, has been updated since 1980 and released yearly since 1996. SR is available on the Nutrient Data Laboratory's Web site, www.ars.usda.gov/nutrientdata.

As computer technology advanced, changes also were made in the Nutrient Data Bank System; the programming language was changed to PL1 in 1985. To make SR more accessible, a telephone Dial-up Bulletin Board was in place from the late 1980s through the mid-1990s. During the early 1990s, Loretta Hoover, Professor of Nutrition at University of Missouri-Columbia, was on sabbatical at CFEI specifically to evaluate the data bank system and to make recommendations for its improvement. In 1996, for the first time, SR was made available on the Internet for searching and downloading. A year later, the NDBS was converted to Oracle platform and upgraded with customized database management software. About this time, personal computers were replacing terminals linked to mainframe systems, and handheld computing devices were appearing in the marketplace. Software for the Palm-OS PDA (personal digital assistant) was developed in 2002 to allow mobile access to SR. The next year, software to search SR was developed for Windows PC and was made available. All of these changes have greatly increased the availability and ease with which professionals and the public can access food composition information and data electronically.

Not only had a computer been integrated into the management of food composition data at CFEI in the mid-1970s, but computers also were being used to assess nutrient intake, determine nutritional status, plan menus, and so forth. Although there were only a few locations, primarily academia, using computers at that time, these activities placed an extreme demand on food composition information, so much so that the National Invitational Conference on the Development of Nutrient Data Bases, sponsored by the American Academy of Pediatrics, was held at the University of Washington, Seattle, in the spring of 1976 (41). This conference was “designed to share

information, resources and software, but specifically designed to present our [health care community] nutrient information needs to the United States Department of Agriculture [CFEI].” Rizek and Butrum represented CFEI among the 33 invited registrants at the meeting. This meeting represented the First National Nutrient Data Bank Conference. Faculty at the Department of Nutrition and Food Science of Utah State University hosted the second Data Bank Conference in the spring of 1977 (42). Thus began the annual meetings of the National Nutrient Data Bank Conference (NNDC), the most recent of which, the 35th, was held in Washington, DC, in 2011 as a satellite to the Experimental Biology meeting. Since 1998, the meeting has been held in alternate years as a satellite to this large scientific conference, and in 2008, the meeting became North American with its site in Ottawa, Ontario, Canada.

At the request of the organizers of the second NNDC, USDA sponsored, hosted, and largely planned the third conference in 1978, which was the first open meeting (43). It was becoming obvious that as a result of automation, USDA’s food composition data were being used in many new and different ways, and that not only more and better data were needed, but also more education was required about the data’s applications and limitations. By 1980, USDA had joined with volunteers from industry, academia, and other government agencies to ensure that this conference would continue annually to provide a forum for this essential exchange of information. Today, the conference is incorporated, with its own Internet domain www.nutrientdataconf.org and a series of well-coordinated committees who execute and publish the details of each meeting (D. Haytowitz, personal communication).

In 1977, Frank Hepburn was appointed leader of the Nutrient Data Research Group (NDRG), taking the position long held by



Frank Hepburn was appointed Leader of the Nutrient Data Research Group (NDRG), taking the position long held by Bernice Watt, who had retired.

Watt, who had retired earlier (table 1). Watt had quietly compiled and published an extensive amount of food composition data in collaboration with coworkers as noted above. Like Atwater, she left as her legacy the first comprehensive food composition table (AH8) of her era for the United States. Attracted from the American Institute of Baking as it was moving from Chicago, IL, to Manhattan, KS, Hepburn had been a collaborator with USDA scientists on earlier projects. During the 1970s, some contract employees working under a cooperative agreement with the University of Maryland at College Park (UMCP) later became full-time Federal employees at NDRG, e.g., I. Marge Hoke and Jacob Exler. Other familiar scientists who were associated with NDRG during this era included Ritva Butrum, Rena Cutrufelli, Susan Gebhardt, David Haytowitz, Elaine Lanza, Ruth Matthews, Marie McCarthy, Elizabeth Murphy, Louise Orr, Betty Perloff, James Reeves, Martha Richardson, and Jean Stewart. Also, Barbara Anderson, Linda Posati, and John Weihrauch transferred from the Dairy Products Laboratory in Washington, DC, when the lab was moved to Philadelphia, PA (table 1); and Anne Marsh transferred from the Nutrition Institute in Beltsville at about the same time.

Early in the next decade, a series of provisional tables were initiated to report available data for selected nutrients or other components in foods (table 2). Often, these nutrients were some of the most recently identified as essential (selenium, for example) or were gaining scientific prominence as a health-related food component. The available data for sodium and sugar contents of foods, although falling into the latter category, were published as full reports (table 2). Also during this period, the iron content of foods was updated by using data from recent analyses (table 2). This activity was the origin of “critical analysis of food composition data” (discussed below). The number of retail foods increased, and the number of nutrients and food components of interest to health scientists also grew simultaneously. Therefore, priorities were required to determine which foods should receive critical resources for sampling, analysis, and updating. Thus, the concept of “Key Foods” was developed and first reported in 1985 (table 2). Key foods have been identified as those food items that contribute up to 75% of any one nutrient to the dietary intake of the U.S. population (44). This list has been updated frequently based on the findings in the most recent food consumption survey.

In the early 1980s, major administrative changes took place as human nutrition research within ARS was reorganized (table 1). All of the activities under the Consumer Nutrition Center (formerly CFEI) were transferred to a new agency, Human Nutrition Information Service (HNIS), and distributed in two divisions: Nutrition Monitoring and Nutrition Education. Food composition research was the responsibility of a branch within the Nutrition Monitoring Division: Nutrient Data Research Branch (NDRB). This new agency, HNIS, was placed under the Assistant Secretary for Food and Nutrition Service, a different Assistant Secretary from the person to whom ARS

1987



Ruth Matthews was appointed Chief of the Nutrient Data Research Branch shortly after the retirement of Frank Hepburn.

1993



Ellen Harris became Director of the Nutrition Monitoring Division, replacing Robert Rizek.

and its human nutrition research activities reported. This administrative separation was eased somewhat by the appointment of Isabel Wolf, Suzanne Harris, and Laura Sims as early HNIS administrators, who were scientists, and by the appointment of Gerald Combs, Sr., as Nutrition National Program Leader for human nutrition research activities, whose responsibilities encompassed and coordinated the efforts within several USDA and Federal agencies (45).

Revisions and updates of the loose-leaf and digital formats of AH8 were the primary focus during this HNIS era. These activities required considerable amounts of new and reliable food composition data that were supplied through numerous contracts with university and commercial laboratories. NDRB scientists also collaborated with commodity groups to assist in the production of reliable data that were integrated into AH8 updates, e.g., beef, pork, and eggs. Food companies also were encouraged to contribute data they were generating for nutrient labels. Although the close working partnership with industry that was envisioned in the 1970s may not have been realized, several AH8 sections benefited substantially from data submitted by food companies.

Another priority of activities during this period was providing data for food surveys. HNIS had individual food intake surveys in the field continually from 1985 through 1991. During this time, NDRB provided databases for all of them, as well as for the Nationwide Household Food Survey, Hispanic HANES, and NHANES III, phase 1. These nutrient databases were publicly released as versions of the USDA Survey Nutrient Database. Generating these databases relied heavily on estimating nutrients in “mixed dishes.” Some of the contracts outlined above included studies to test reliability of recipe calculation methods.

With the many food composition database products and the varied formats (loose-leaf AH8, computer files, etc.) produced by HNIS scientists and staff during this period, a major activity was educating users and sharing details of each of the databases. Much of this endeavor was vested in the National Nutrient Data Bank Conference, where NDRB personnel served on steering, program, and communications committees, organized sessions for new users, provided updates about nutrient data products and activities for attendees, and arranged for speakers who could provide needed insights about issues related to food composition data. In addition, the doors of scientists



Joanne Holden was appointed Research Leader of the Nutrient Data Laboratory.

and staff were always open to national and international visitors, as food composition information became an important component of human health worldwide (see Food Composition International Activities).

Ruth Matthews was appointed chief of the NDRB in 1987 shortly after the retirement of Hepburn (table 1). Matthews had been a scientist in the branch for many years, had contributed greatly to the compilation of data, and was familiar with all aspects of its operation. In 1990, Sue Ann Ritchko was appointed administrator of HNIS. Three years later, Ellen Harris became Director of the Nutrition Monitoring Division, replacing Rizek, who stepped down primarily because of the low response during the 1987-1988 National Food Consumption Survey (46). Shortly thereafter (1994), all HNIS activities were transferred to ARS. The nutrition education component was ultimately moved to the USDA Center for Nutrition Policy and Promotion (CNPP). Food composition data and food consumption survey activities were integrated into the Beltsville Human Nutrition Research Center (BHNRC) as individual units (table 1). Thus, all food composition and food consumption activities were combined again with human nutrition research activities following a 13-year administrative separation.

Joanne Holden was appointed Research Leader of the Nutrient Data Laboratory (food composition tabulation activities in BHNRC [NDL]) in 1995 (table 1). She had extensive experience with nutrition research and food composition work, having been a member of several laboratories of BHNRC, most recently the Food Composition Laboratory. Also, NDL moved from Hyattsville to Riverdale, MD, the same year. Four years later, the laboratory moved again to Building 005 on the Beltsville Agricultural Research Center (BARC) campus, where it remains today (table 1). Since the transfer of food data compilation activities back to ARS, updating and maintaining SR has been the primary focus of the laboratory as the official source of food composition information for the United States. Also, NDL scientists have developed several smaller databases that report the levels of nutrients, food components, and biological activities believed to impact health (table 2). These databases follow scientific evidence of the importance of food components to health and the ability to measure them in foods. Most recently, a database on the ingredients of dietary supplements has been released (table 2), which was prompted by data in reports from the National Center for Health Statistics that as early as 1974, nearly one-quarter of U.S. adults took dietary supplements daily (47). This trend has risen substantially over the last three decades, which accounts for a significant level of intake for as many as 20 nutrients (48). All of these databases have been possible through extensive collaboration with governmental agencies, the food industry, and scientists in academia (see below). Today (2011) the scientific staff of NDL includes, in addition to Holden, Seema Bhagwat, Jacob Exler, David Haytowitz, Susan Gebhardt, Linda Lemar, Melissa Nickle, Kristine Patterson, Pamela Pehrsson, Bethany Showell, Robin Thomas, and Denise Trainer.



Kent Stewart was one of the scientists who made up the initial staff of the Nutrient Composition Laboratory and was its first Laboratory Chief.

Nutrient Composition Laboratory 1975-2010

Six years after the Food Composition Laboratory of HNRD was abolished (table 1), a new laboratory was formed as a result of negotiations between Willis Gortner, Director of HNRD, and Robert Levy, Director, NHLBI (table 1) (49). NHLBI had funded two large nutritional epidemiology projects—Multiple Risk Factor Intervention Trial (MRFIT) and Lipid Research Clinics (LRC)—and requested the continuation of state-of-the-art methodology for accurate food composition data from within a governmental agency rather than relying on individual grants and contracts, the traditional primary external funding mechanism of NIH. In addition, NHLBI was beginning to focus on individual dietary fatty acids as potential risk factors in vascular disease. NHLBI scientists were familiar with the methodology research of Hal Slover, a scientist at the Lipid Nutrition Laboratory who was world-renowned for accurate measurement of fatty acids and tocopherols (50,51). Thus began a 30-year collaboration between USDA and NHLBI (49). At the same time, NHLBI established collaborations with CFEI and the School of Public Health at the University of Minnesota (Nutrition Coordinating Center) to provide tools for the evaluation of potential relationships between diet, nutrient intake, and vascular diseases.

The staff of the Nutrient Composition Laboratory (NCL) was initially formed by the “contribution” of one scientist and one support person from each of the four metabolic laboratories of HNRD. Kent Stewart, designated Laboratory Chief, Hal Slover, and Wayne Wolf formed the initial scientific core of the laboratory. Jose Gutierrez, a microbiologist, was the fourth scientist asked to join NCL, but he opted for retirement instead. Soon thereafter, Doris Baker from USDA’s Agricultural Marketing Division and Betty Li from Virginia Polytechnic Institute and State University (VT) joined the laboratory to begin method development and analyses for food fiber and carbohydrates, respectively. James Harnly, with a newly earned Ph.D. from UMCP, joined Wolf to enhance mineral analysis research capability. Also, Elaine Lanza from CFEI and Raymond (Rick) Thompson, Jr., from Michigan State University joined Slover to form a large lipids research and analysis group. Ritva Butrum and Mary Moss transferred from CFEI to lead food sampling. When Butrum transferred to the National Cancer Institute (NCI) at NIH, Joanne Holden joined Moss. Joseph (Joe) Vanderslice, who retired from the Department of Chemistry at UMCP after a sabbatical at NCL, also joined NCL to pursue research in vitamin analysis. The laboratory occupied the available space in several buildings on the BARC campus until newly renovated space was made available in Building 161 in the early 1980s. The flexible innovations built into the laboratory furniture and accommodations during remodeling allowed the group to remain in this building 30 years later.

There was discussion related to the mission of this new laboratory. While some (Rizek and NHLBI administrators) considered it a government analytical laboratory for foods, others (Stewart and ARS administrators) proposed a strong research component. The result was a laboratory with a research mission, because of its administrative

location within the research arm of USDA, but also with a mission to apply recently developed methodologies and techniques in the acquisition of food composition data. In retrospect, this dual mission has been very fruitful in terms of testing applications of new methodologies on foods and also in the engagement of scientists in the entire scheme of food composition activities—from representative food sampling and the many aspects of analysis to evaluation, tabulation, and publication of data.

After transferring to BHE in 1961, Slover developed substantial expertise in the separation and measurement of tocopherols, tocotrienols, and fatty acids in foods and biological samples employing newly developed gas liquid chromatography (11, 18, 50-55). At the Nutrient Composition Laboratory, Slover and colleagues advanced technology for the measurement of fatty acids, tocopherols, and sterols by the application of capillary gas chromatography columns that increased resolution and required smaller sample sizes (56-58). As early as 1981, this group developed a system for the estimation of trans fatty acids in foods with these new techniques (59). It is interesting to note that during this era, Slover and many other analysts advanced the boundaries for column technology. In order to accomplish this goal, he had a complete system for “drawing” glass and quartz capillary columns in his laboratory, a technique that was akin to the art of glass blowing and a talent that was essential for the advancement of the application of gas chromatography to food analysis. Slover reviewed both packed and capillary column technology for gas chromatography and its analytical potential in 1983 (60). He and his group applied these newly developed methods to the analyses of a wide variety of foods, including fast foods (61) and margarines (62), as well as cooked and raw beef (63) and pork (64) that were part of large collaborative studies with the meat industry and several USDA agencies.

(See discussion below.) Slover retired in the early 1990s. Thompson continued to develop techniques for cholesterol and sterol analyses (65). He retired in the late 1990s. Although research on methodology for fatty acids and other lipid components of foods was discontinued at NCL, the technology had been transferred to many laboratories including commercial analytical groups. This was in response to the Nutrition Labeling and Education Act of 1990 that required similar data on food labels, as well as to general consumer interest in fatty acids and cholesterol levels in foods in relation to health.

Wolf, a specialist in inorganic nutrient analysis, developed new methodologies for these food components, especially for recently identified essential trace elements (chromium, selenium), by coupling gas chromatography with atomic absorption spectrometry (66, 67). Subsequently, selenomethionine was identified as a health-related active form of dietary selenium, for which Wolf’s group developed highly sensitive and accurate methods (68, 69). This group also was active in the generation of data on inorganic nutrient content of mixed diets (70, 71) and meat-based foods (72-75). As part of Wolf’s interest in the application of Certified Reference Materials (see discussion below), he recognized the need to improve analytical methods for niacin in foods. This led to the addition of chromatographic sample cleanup to “standard niacin analysis” (76) and a new validated procedure for the measurement of niacin in infant formula (77). Recently, isotope dilution technology has been coupled with liquid chromatography for the determination of this vitamin (78).

Stewart brought with him to NCL the new analytical technology he and Gary Beecher had developed when they worked together at the Protein Nutrition Laboratory (79). He teamed with Vanderslice, a physical chemist, to mathematically describe the

1982



Gary Beecher was appointed Chief of the Nutrient Composition Laboratory.

flow of solutions in the small bore tubing (~0.25mm internal diameter) that was employed in these instruments (80,81). He also reviewed the history of this technology in the United States (82). However, Stewart's primary emphasis was promotion of analytical concepts and techniques for the improved analysis of foods and diets. Some of these concepts involved critical review of data, which he and others first applied to *Iron Content of Food* released in 1983 (see discussion below) (table 2). He often discussed the many issues in the measurement of nutrients and other health-related components of foods and encouraged a wide range of scientists to apply their knowledge in the search of resolutions (83). Also born from this environment was the concept of an international scientific journal devoted exclusively to all aspects of food composition research. Although there were several journals that published food composition-related papers (*Analytical Chemistry*, *Journal of Agriculture and Food Chemistry*, and *Journal of Food Science*, for example), there was no one journal that included publications on all aspects of this unique research. After many meetings and much planning with Academic Press and United Nations University, the first issue of the *Journal of Food Composition and Analysis* was published in 1987 with Stewart as Editor and several papers authored by scientists at NCL. Today, this is the only peer-reviewed, international journal that reports all aspects of food composition and related research. Elsevier currently publishes this journal, and Katherine Phillips at VT serves as Editor. Stewart moved to VT in 1982, where he and Phillips developed the currently active Food Analysis Laboratory Coordination Center (FALCC).

Gary Beecher was appointed Laboratory Chief of NCL in 1982 following Stewart's move to VT (table 1). In terms of research program, Beecher took his lead from information in the then recently published *Diet, Nutrition and Cancer* (84) and the

interest among NCI scientists in β -carotene as a possible food component that might decrease cancer risk. While β -carotene and other provitamin A-active carotenoids were known, their activities were combined and reported as a single vitamin A value in food composition tables, thereby negating the ability to evaluate individual components. In addition, there were other abundant carotenoids in many plant foods—lutein, lycopene, and zeaxanthin—that did not have provitamin A activity and were not measured, but they were suspected of being absorbed from the diet and metabolized by humans and thus having an effect on health. With the expertise of Fred Khachik, a research associate, the carotenoid analysis program at BHNRC was reactivated (12), and HPLC procedures were developed for the separation and measurement of the many carotenoids in fruits and vegetables (85-88). Many of the analytical issues experienced with the analysis of carotenoids in plasma, i.e., instability, oxidation, etc, (10) were also observed with foods, which complicated this research. The large number of carotenoids in the plant kingdom, the many possible derivatives, and the lack of commercially available standards often required a lengthy isolation and characterization process for foods. This was necessary so that the precise structure and their derivatives

could be understood (89). These analytical procedures were subsequently employed to measure carotenoids in several foods (90,91). The data resulting from this activity and published information on the content of individual carotenoids of foods were combined into the first database for these food components (92, table 2). It was the availability and application of this database that permitted J.M. Seddon et al. to draw an association between increased intake of carotenoids, specifically lutein and zeaxanthin, and decreased risk of advanced age-related macular degeneration (93). As Beecher moved his research program to focus on flavonoids, Khachik transferred to UMCP, where he continued investigation of carotenoids. Beecher returned to full-time research in 1996.

Baker, who had expertise in cereal grains, transferred to NCL from a USDA Agricultural Marketing Service (AMS) laboratory on the BARC campus in 1976 as the Federal Grain Inspection Service (FGIS) was being formed from AMS. The probability was quite high that she would be transferred to a laboratory in the center of the country as FGIS began to fulfill its mission and research activity was being diminished.

The mid-1970s marked an awakening in the fiber content in foods and its potential impact on human health. However, the only routine analytic technique then available measured “crude fiber,” the insoluble residue that remains after severe treatment with sulfuric acid. A new “neutral detergent fiber” method had been proposed for foods for which Baker developed routine procedures for cereals and cereal products (94,95). She also collaborated with a former AMS colleague, Karl Norris, a scientist at the Instrumentation Laboratory at BARC who was developing many practical agricultural applications for near-infrared spectroscopy (NIR), a technique he had invented earlier. Together they developed

a procedure for the estimation of dietary fiber and other nutrients in foods (96). From these agricultural applications, NIR technology has found its niche in quality control in the food industry as well as in the manufacture of many consumer products. Baker retired in the mid-1980s. Lanza continued this research with the comparison of data from traditional analytical methods in a nationwide sampling of ground beef and fruit juices (74,97). Lanza transferred to NCI in the late 1980s.

Betty Li, an organic chemist and a transfer from VT, developed procedures for the quantification of individual sugars and starch in foods employing gas-liquid chromatography instrumentation (98). Heretofore, the “carbohydrate” content of foods was calculated by subtracting the percentage of moisture, protein, fat, and ash from 100. Thus, the research efforts of Baker and Li were an attempt to begin to quantify, by direct measurement using modern instrumentation, specific components of the “carbohydrate” or nitrogen-free extract (6) fraction of foods. Li applied these new techniques to the measurement of sugars in several foods, most notably breakfast cereals (99,100), fruit juices (101), and yogurts (102), as well as starch in fast-food fried chicken (103). The publications listing concentrations of sugars in ready-to-eat breakfast cereals by brand names for the first time caused a substantial reaction by the industry, which is still an issue today for consumers who wish to limit their consumption of foods with high sugar content.

Subsequent to Baker’s retirement, Li took on the task of developing new and modified methods for the measurement of dietary fibers and similar components of foods. There was already at least one “official” AOAC (Association of Official Analytical Chemists) method for measuring dietary fiber. However, that method had many steps, employed several enzymes, and required

pH adjustments rendering it extremely cumbersome. At this time, dieticians and nutritionists were demanding data on the fiber content of foods. Concurrently, a small group of international analysts had coalesced (L. Prosky, N.G. Asp, J.W. DeVries, I. Furda, R. Mongeau, O. Theander, D.A.T. Southgate, and H.N. Englyst) to address these dietary fiber analysis issues. From the outset, there was a philosophical difference between the European and the North American scientists over the definition of components of the fiber fraction of foods and their analysis. This difference was never resolved, and as a result, methods based on both definitions were developed. Li was accepted into this group as she addressed the simplification of the AOAC method, by removing an enzyme and its incubation step (104), and modified the procedure to measure both soluble and insoluble fiber (105). Soon she identified specific classes of foods, i.e., legumes, fruits and vegetables, for which steps could be removed without altering results (106,107), and additional modifications were made to improve speed and safety (108,109). Ultimately, a general, simplified procedure was developed that was less costly and less labor intensive, but that gave acceptable results for many different foods and from several laboratories (110). These steps were combined with earlier methods to form a single procedure so that sugars, starch, and total dietary fiber could be determined in a mixed food sample (111). A non-enzymatic gravimetric method for foods containing less than 2% starch was collaboratively studied and eventually approved as AOAC method 993.21. Li participated in numerous collaborative studies conducted by analysts in New Zealand, England, Sweden, Japan, and the United States. She also was a participant in the collaborative analytical fiber group to develop official methods that are currently employed for the determination of fiber values listed on food labels. A comparison between data using an official method and Li's simplified procedure for many

different types of foods indicates the extreme challenge in the determination of food components that lack molecular species identification, e.g., dietary fiber (112). Li retired in 2004.

The collection, processing, and preparation of representative food samples prior to analysis were goals of NCL from its beginning. Moss and Holden were instrumental in assuring that samples from the large beef and pork studies were appropriately selected from purveyors, shipped properly, reduced to representative retail cuts, and cooked according to common practice (72,73). Moss transferred to the food industry in the mid-1980s. However, Holden continued to provide expertise on representative sampling of retail foods in the United States based on population density and brand-name market share (74,103). Holden also was a major contributor to the application and refinement of the critical evaluation system for food composition data while at the Nutrient Composition Laboratory, and was the driving force for the incorporation of many of its principles into the National Nutrient Databank (NNDDB) system after she became Research Leader of the Nutrient Data Laboratory. (See Critical Evaluation of Food Composition Data below.)

Joe Vanderslice developed analytical procedures for several water-soluble vitamins. He and his group first applied high performance liquid chromatography (HPLC) to the separation and quantification of the prominent forms of vitamin B6 (113). The inability to acquire HPLC columns employed for the original measurements required an extensive search for new columns and reinvestigation of vitamin B6 separations (114). These procedures were subsequently applied to the quantification of this vitamin in several foods, animal tissues, and plasma (115-118). Vanderslice's group applied similar techniques to the separation and measurement of the various forms of thiamin (119).

The desire of scientists at NCI to conduct a large human study at BHNRC that investigated the effect of vitamin C from foods on several biological markers prompted Vanderslice to develop HPLC techniques for the measurement of all forms of this vitamin in foods (120). Because of the sensitivity of vitamin C to oxidation, robotic directed procedures were developed to extract and prepare samples for HPLC measurement (121). These procedures were then applied to the analysis of foods for the human study (122); the resulting data provided the basis for discussions of the variability of vitamin C in foods (123). At the same time, the question arose as to the amount of oxidized vitamin C in human plasma, which was addressed with many of these same techniques and found to be negligible (124).

L. Faye Russell, a scientist with Agriculture Canada, arranged to complete her doctorate at UMCP, but she conducted her research with Vanderslice's group. Her research consisted of a review of the current methods for the measurement of riboflavin in foods and tissues (125), and then development of new extraction and HPLC techniques for the quantification of this vitamin (126). She also developed a statistically based sampling plan for the measurement of riboflavin in fast-food hamburgers (127).

Vanderslice and his group began to evaluate procedures for the measurement of folates and folic acid in foods (128). However, the development of separations of these vitamins and their validation was left to Pawlosky, Beecher, and Doherty (see below). Vanderslice retired in 1994.

James Harnly joined NCL in 1979. Research for his Ph.D. with Tom O'Haver at UMCP developed components for multi-element atomic absorption spectrometers. Atomic absorption spectroscopy for elemental analysis, then only about 15 years old, had excellent sensitivity. However, the original

design employed a lamp that emitted a sharp, narrow wavelength of the spectrum unique for a single element. To measure a different element, the lamp needed to be changed and the monochromator reset to the appropriate wavelength. O'Haver and many of his students pursued the research and development required for the transition to an atomic absorption instrument that could measure several elements simultaneously. Harnly continued this line of research at NCL in collaboration with O'Haver and several students, as well as with several scientists around the world. One of those students, Nancy Miller-Ihli, later joined NCL as a scientist. Many aspects of each of the components of the new instrument were evaluated and further developed (129-136). Some advances were made only after technological developments in such components as monochromators and solid-state detectors (137). Nonetheless, this technology was never commercialized even though Perkin Elmer, the preeminent analytical instrument company for atomic absorption instrumentation at the time, showed interest. Several events doomed the new instrumentation including corporate decisions to promote inductively coupled plasma (ICP) analysis instrumentation because of higher profits and the reorganization of Perkin Elmer, which closed its outstanding German research and development facility. Although a few retired Perkin Elmer scientists continue to work on the development of multi-element atomic absorption spectrometry, it is doubtful it will become a widely accepted commercial instrument, especially given the current overwhelming market penetration of ICP and ICP-mass spectrometry (ICP-MS).

In 1997, Harnly was appointed Research Leader of the Food Composition Laboratory (FCL), renamed from Nutrient Composition Laboratory (table 1). Soon he focused on methodologies for the measurement of organic components of foods and dietary supplements. His group first developed



James (Jim) Harnly was appointed Research Leader of the Food Composition Laboratory.

procedures for assessing allicin, a sulfur-containing, purported health-related component of garlic (138), followed by gas chromatography mass spectrometry (GC-MS) methods for free amino acids in garlic and broccoli (139,140). Subsequently, he developed a new approach for the evaluation of the many organic compounds of plant foods and supplements. Employing the separation power of HPLC coupled with ultraviolet-visible and mass spectrometry detection, Harnly's group developed standard procedures for the routine generation of "fingerprint profiles" of foods and supplements (141,142). By applying new statistical techniques (analysis of variance-principle component analysis) to the data, sources of variation were readily identified (143,144). While this is a work in progress, it demonstrates the feasibility of a new approach (plant metabolomics) to the characterization of plant compounds that may be important in human health.

When Beecher returned to full-time research in 1996, he reviewed the many components of plant foods that have the potential to promote human health (145) and selected flavonoids as the next class of compounds for analytical methodology research. Flavonoids, a broad class of polyphenols with several subclasses, are

prominent in most plant foods and many botanical supplements. They are the primary organic constituents in teas, which received considerable health-related attention in the early 1990s. Although there were analytical procedures for individual foods or classes of flavonoids, a universal system of measurement was lacking (146). An HPLC system was developed with ultraviolet-visible detection that separated the major food flavonoids as their aglycones (147). Also, a sample preparation scheme was developed that removed sugars attached to flavonoids but yet allowed accurate quantification of the polyphenols (148). These procedures were subsequently applied to the measurement of flavonoids in a large number of plant food samples of the National Food and Nutrient Analysis Program (NFNAP) (see discussion below) (149). These data and other published results were integrated into a database on the flavonoid content of foods (150, table 2).

During the late 20th century, Finnish scientists promoted lignans, another group of phytonutrients that have hormone-like biological activities. These compounds are found primarily in flax- and rye-based foods and dietary supplements in the United States. Two new lignans were isolated and characterized from flaxseed meal (151), and the available data on the lignan content of foods were summarized (152).

Also during this period, the Department of Defense became interested in the health of its female soldiers, upon urging by Congress, and made available resources through a grants program. Early studies indicated that isoflavones, a subclass of flavonoids and prominent in soy-based foods, had estrogen-like biological activities. Together with Pat Murphy at Iowa State University, who had considerable experience in the analysis of these compounds in soy and soy foods, Beecher and Holden submitted a proposal that was funded. Appropriate retail and institutional foods were sampled and

analyzed (153), and a database derived from these and published values was assembled and released in 1998 (table 2). This database has been updated several times because of continued research and health interest in these compounds and continuing analysis of new foods.

As a result of Beecher's experience studying carotenoids and foods in general, he was invited to be a member of two Institute of Medicine (IOM) panels: Dietary Reference Intakes for Vitamin C, Vitamin E, Selenium and Carotenoids; and Establishment of the Basis for Daily Values for Food Labeling in U.S. and Canada. Beecher retired in 2001.

Nancy Miller-Ihli, who had conducted her Ph.D. research with Harnly, joined NCL in 1984. She focused her research on sample preparation for mineral analysis of foods. Whereas the standard procedure had been to oxidize carbonaceous material by ashing either in a furnace or digestion with strong acids prior to analysis, either procedure was long and labor intensive and, in the case of furnace ashing, often resulted in the loss of some elements through vaporization. Miller-Ihli sought to avoid this long sample preparation step and used the graphite furnace of the atomic absorption spectrometer as the "ashing" furnace, as well as the source of elemental vaporization for ultimate analysis. The problem was transfer of a very small, representative sample of solid food or other material into the furnace of the instrument. This was overcome by grinding samples to a specific small particle size and then maintaining them in homogeneous slurry with ultrasonic mixing while a small aliquot was taken for introduction into the furnace (154). Perkin Elmer acquired rights to the prototype instrument and its patent, and produced it as an attachment for their instrumentation. An international collaborative study with more than a dozen laboratories validated the technology and also highlighted technical areas for improvement of performance

(155). Subsequently, the slurry sampler and furnace were interfaced to ICP-MS and, using sensitive isotope dilution analysis, slurry conditions were optimized taking into consideration such factors as sample density, particle size, slurry mixing, and analyte extraction into the slurry (156).

Miller-Ihli also developed highly accurate instrumental methods for the measurement of trace elements in foods, water, and commodities and subsequently demonstrated their application with a series of analyses. An ICP-atomic emission and an atomic absorption procedure were developed for foods (157) and employed in the analysis of trace elements in fruits (158). Subsequently, ICP-MS methods were substantially modified to improve accuracy and precision (159). That procedure, as well as ICP-atomic emission, was used to assess the trace element composition of municipal waters in the United States (160). Miller-Ihli also was called on for advice in the measurement of lead in sugars. She developed a graphite furnace atomic absorption procedure that was relatively fast and gave accurate and precise values (161,162). Miller-Ihli retired in 2004.

Robert Pawlosky joined the Food Composition Laboratory in the late 1990s. He came from the University of Minnesota and NIH with considerable mass spectrometry (MS) experience. He took the position previously held by Aldo Ferretti, whose program had been transferred from BHNRC's Lipid Nutrition Laboratory to FCL although he retired before physically moving to Building 161. Fortunately, his associate Vince Flanagan, an MS expert dating back to the 1960s, waited several years before retiring. The Pawlosky-Flanagan team first developed a sensitive HPLC-MS procedure for the measurement of deuterium-labeled β -carotene in biological samples from humans (163). Subsequently, they developed a method for the measurement of both endogenous and ^{13}C -labeled β -carotene,

lutein, and vitamin A in human plasma (164). Beverly Clevidence, Janet Novotny, and the BHNRC human studies group employed these procedures to investigate the metabolism of carotenoids (165). Next, Pawlosky turned his attention to folates in foods and biological samples. At the request of Christine Pfeiffer at the Centers for Disease Control and Prevention, Atlanta, GA, a stable isotope dilution procedure was developed for the analysis of 5-methyltetrahydrofolic acid in serum (166). This was followed by the development and validation of a similar method for folic acid in fortified foods (167) and analysis of both folic acid and 5-methyltetrahydrofolic acid in fortified citrus juices (168). These procedures were then applied to the validation of HPLC methods for the measurement of folates in foods (169,170). Pawlosky returned to NIH in 2002, and Flanagan retired shortly thereafter.

Rebecca Robbins, an organic chemist, joined FCL in 2001. She focused on methodology for analysis of phenolic acids in plant foods, which she reviewed (171). Subsequently, Robbins developed HPLC procedures for accurate measurement of these components (172). She left FCL for the snack food division of Mars, Inc., in New Jersey in 2004.

As of the time of writing (2011), as a result of retirements and transfers of several scientists as well as budget constraints, the laboratory has five scientists. The laboratory was renamed Food Composition and Methods Development Laboratory (FCMDL) in 2007. Harnly is the Research Leader and focuses on analytical fingerprinting and profiling. Wolf continued his efforts in the development of analytical procedures for organic species of selenium and selected water-soluble vitamins. He also worked with scientists at the National Institute of Standards and Technology (NIST) and other organizations to facilitate availability and

application of Certified Reference Materials in food and biological analyses. These materials are critical to the area of analytical quality assurance and the laboratory qualification process. Wolf retired in March 2011.

Three new scientists joined the laboratory during this decade. Wm. Craig Byrdwell currently is focusing his efforts on the development of sensitive methods for the analysis of various forms of vitamin D in foods (173). This is in support of a large effort to update data on the vitamin D content of foods (174) as a committee of IOM re-examined recommendations for vitamin D intake (175).

Pei Chen is collaborating with Harnly on the chromatographic fingerprinting and profiling of foods and dietary supplements (176). He also has developed sensitive analytical procedures for the determination of water-soluble vitamins in multi-vitamin dietary supplements (177,178).

Devanand Luthria has investigated the important steps of sample preparation as part of analyses of foods and supplements (179,180). He has developed chromatographic procedures for the determination of total phenolics and phenolic acids and applied these methods to the analysis of foods (181,182).

In the tradition of the origin of the Nutrient Composition Laboratory over 30 years earlier, this small group of scientists continue to develop new measurement concepts and apply modern analytical technology to the assessment of nutrients and health-related components in foods and dietary supplements. It is the only laboratory in the United States with this specific mission.

Overarching Programs That Improved Food Composition Information

Throughout the history of food composition activities in the United States, there have been many encompassing programs, in addition to the specific efforts of USDA scientists that have contributed to the extent and quality of food composition data. A few of these programs are highlighted below.

Collaborations—Interagency Federal Government. Collaborations with health-related agencies began in the 1970s when diet was recognized as a potential component of chronic disease (49). Thus, Levy and NHLBI were the impetus to reactivate a formal Nutrient Composition Laboratory at the Nutrition Institute that carried with it financial support for many years. At the same time, resources were provided by NHLBI for the tabulation and reporting of food composition data. Shortly thereafter, Walter Mertz, Director of BHNRC, and Peter Greenwald at NCI developed cooperative research efforts that included support for the measurement and tabulation of several nutrients and components of foods associated with reduced cancer risk. At about the same time, the USFDA helped initiate the concept of the USDA Nutrient Databank and contributed data on many samples from its Total Diet Study (33).

In the mid-1990s, primarily through the efforts of Abby Ershow at NHLBI and Joanne Holden and others at NDL, a large collaborative program was initiated to update nutrient data in the USDA National Nutrient Databank. This program, the National Food and Nutrient Analysis Program (NFNAP), generated the support of 17 Institutes and Offices of NIH as well as USFDA and USDA. The objectives of NFNAP included the acquisition of nationally representative samples of those foods that were the major contributors of nutrients in the American diet. Thus, the “Key Foods” list was updated prior to each food sampling

cycle by combining the most recent food consumption data and existing nutrient data (table 2). The “Key Foods” list helped to set priorities for food sampling and analyses under NFNAP. Although earlier food sampling was based on U.S. population distribution and, where applicable, on product brand-name market share (103), statistically based research was expanded, and a nationwide multi-stage, probability-based sampling plan was developed for the acquisition of representative samples of foods from across the country (183). A procedure was developed in conjunction with USDA procurement personnel to identify analytical laboratories based on accuracy in performance of analysis as well as cost. An agreement was established with the FALCC laboratory at VT to comminute, aliquot, store, and distribute food samples (184). This laboratory also had a high level of expertise in analytical quality control and was selected to serve as the quality control group for NFNAP (185). A report of the first decade of the program indicated substantial differences in selected nutrient values of some foods compared with Databank data, which validated the contribution of the program to assure reliable, current food composition information (186).

More recently, collaboration with the Office of Dietary Supplements, NIH (ODS) was established to develop an analytically based dietary supplement ingredient database. With nearly one-half of American adults using a dietary supplement at the turn of the 20th century and the availability of only a “supplements label” database, ODS sought the expertise of scientists at both FCMDL and NDL for the development of a database of values based on independent analyses (187). The project began with a survey of adult multivitamin-mineral supplements for which data have been released (table 2). Long-range goals of the program are to include values for all dietary supplements in the database (188).

Collaboration with scientists at other USDA human nutrition research centers also has been critical to the expansion and success of food composition activities. Ron Prior and his colleagues at the Arkansas Children's Nutrition Center generated data from NFNAP samples on proanthocyanidin content and for antioxidant activities, both of which contributed greatly to respective databases (table 2). Also, Sarah Booth and her team of experts in vitamin K measurements and metabolism at the Jean Mayer USDA Human Nutrition Research Center on Aging at Tufts University analyzed NFNAP samples, and the resulting data (189-191) were integrated into the USDA National Nutrient Databank system. There were many less extensive interactions with scientists at other centers that also contributed to the advancement of technology and success of both analytical and data tabulation activities.

Extensive collaboration with the National Bureau of Standards/National Institute of Standards and Technology is discussed below as part of the activity involving the development of Certified Reference Materials for foods.

Collaborations—Academia and State Experiment Stations. Atwater laid the groundwork for collaborations with scientists at State experiment stations, colleges, and universities (table 1). These scientists were called on for their expertise in many areas to assist in the conduct of food composition projects throughout USDA's history. Continuing into the 1970s and 1980s, collaborations with scientists at many universities—such as University of Georgia, University of Idaho, University of Illinois, and Oregon State University—were established to generate food composition data. Ruth Matthews often coordinated these collaborations at national scientific meetings (192). Two recent collaborations that resulted in extensive data include Ron Eitenmiller's group at the University of Georgia who generated data on folates,

tocopherol, and tocotrienol content of foods (193), and Steve Ziesel's team at the University of North Carolina at Chapel Hill, which is one of the few laboratories in the world capable of measuring the various forms of choline in foods. Data from the latter group have been released as a database (table 2).

Collaborations—Food Industry. As indicated earlier, the importance of diet in the prevention of chronic disease was well recognized by the mid-1970s. Consequently, the food industry became interested in the nutrient levels of foods it was producing and concerned that those data were accurately represented in the Databank. The meat industry is one of the food purveyors that have worked closely with USDA's food composition scientists over the years. As early as 1975, representatives at the National Livestock and Meat Board collaborated with food composition scientists and other scientists at the Meat Laboratory at BARC to plan a large beef study with the purpose of generating new data on the nutrient content of raw and cooked retail cuts. Samples from this study were among the first analyses conducted by scientists at the newly formed Nutrient Composition Laboratory. Soon, a large collaborative pork study was conducted to update data on the composition of pork cuts. As fat, especially animal fat, in the diet became more important from a health perspective, the meat industry continued to decrease the fat of its products. There was an effort to establish mathematical relationships between the amount of external fat and nutrient content of retail cuts. This research often involved academic scientists, particularly at Texas A&M University and the University of Wisconsin, and usually resulted in the updating of food composition handbooks, i.e., Revised AH-13 Beef Products and AH-10 Pork Products and related databases. Today, external fat is essentially zero on most retail cuts of meat, which is reflected in the nutrient

composition data of these products. The fat content of ground beef also has decreased dramatically. In the recent past, products with 17% total fat were considered “extra lean.” As of this writing, ground beef may be as low as 3% fat, with the most common levels in the 5-20% range. Recently, a “Ground Beef Calculator” was developed as part of SR software, again in collaboration with industry and academic scientists, which adjusts the nutrient content based on levels of fat ranging from 5% to 30% (194). Ground pork also is becoming popular, but the levels of fat/lean are less structured than those for ground beef. A similar calculator system may be needed for this product (195).

Many food companies and other food industry organizations have been involved in collaborations to improve and update food composition information. These include such groups as the Egg Nutrition Institute, which brought attention to the lowered cholesterol levels of eggs in the late 1980s (49) and again in 2011. During the 1980s, the National Chicken (formerly Broiler) Council and the National Turkey Federation participated in several projects to update food composition data for their products. Several other collaborators included food companies (Mars, Inc., and Ocean Spray Cranberries, Inc., for example) whose products contain proanthocyanidins and whose sponsored research demonstrated health benefits from consumption of their products containing these polyphenols. All of these collaborations have been very beneficial in the maintenance of data in the USDA food composition handbooks and Databank.

Critical Evaluation of Food Composition Data. New data on the iron content of beef and pork from the large 1970s studies discussed above, and based on instrumental and validated methods, indicated that values were considerably lower than those reported in the revised USDA Agriculture

Handbook No. 8 (table 2) (49). An historical investigation revealed that the existing iron values had been calculated from the protein content of muscle rather than the measurement of iron levels per se (75). A similar situation occurred in the calculation of iron content of corn syrup, which had been based on iron levels of blackstrap molasses and resulted in inflated values for corn syrup (49). Based on these experiences, scientists involved with the generation and collation of food composition data at Beltsville and Hyattsville thought that the values should have a quality indicator associated with them.

The research team identified three categories of information that most impacted the quality of analytical data. These included (1) sample handling and appropriateness of analytical method, (2) documentation of analytical method, and (3) quality control. Later, these categories were expanded to five and included (1) number of samples, (2) analytical method, (3) sample handling, (4) sampling plan, and (5) analytical quality control. An expert system prototype was developed to include specific questions or criteria within each of the five categories. Answers to these questions/criteria were given a numerical rating, and an overall quality value was calculated—a “confidence code.” The first data evaluation system, employing three categories, was applied to the newly published data for the *Iron Content of Food* released in 1983 (table 2). The system was subsequently modified and expanded for the evaluation of selenium (196,197) and copper (198) contents of foods. The data evaluation system was further modified when it was applied to the individual carotenoid content of foods, the first organic class of nutrients to receive such scrutiny (92). Application of the system to data for new food components (isoflavones, flavonoids, and proanthocyanidins) resulted in further modifications of the rating scale and proved that it was a valuable tool for systematic

evaluation of the quality of analytical data for foods (table 2).

A major advancement was attained when the principles of the data evaluation system were applied to assess the quality of data in the National Nutrient Databank and to set priorities for new work. The quality of the existing data was summarized by food and the resulting information used to rank key foods according to their priority for future sampling and analyses. Principles of this automated data quality evaluation system were first used to design the approach for the sampling and analysis of foods for the NFNAP project. For new analytical data to be entered into the NNDB, the documentation for datasets must be reviewed by NDL scientists and the above data evaluation criteria must be met before the data can be accepted (199). This system also generates a confidence code for each nutrient/food combination, similar to that described above, which is an integral part of the “Key Foods” rating system.

The application of this system represents one of the first efforts to standardize and harmonize the evaluation of analytical data quality across the international food composition network. The European Food Information Resource (EuroFir), a consortium of governments and institutions in 26 countries of the European Union, has adapted the principles of the USDA system for the evaluation of published literature on contents of bioactive substances in foods (200). They also are developing a similar system for the assessment of nutrients in foods. Several other countries have adapted the data evaluation system and applied it to specific sets of published works (49).

Analytical Paradigm Shift and Certified Reference Materials. During the latter quarter of the 20th century, there was a major paradigm shift in the assessment of the quality of analytical measurements. Wolf was a major contributor to this endeavor

and remains active in this area (49). Until this time, measurements depended upon a procedure-based approach that relied on exactly following a carefully defined process that had been validated to give a desired precision, such as an AOAC International Official Method of Analysis. The paradigm shift added the component of accuracy by demonstrating acceptable results from a known standard material (Certified Reference Material). Thus, analyses moved from a “procedure-based” to a “performance-based” analytical paradigm (49).

This paradigm shift for food’s analysis had its basis in the international metrology community, primarily in the coming together of the many countries into the European Union, and in the rich history of the development of standards for metals in alloys and steels by the National Bureau of Standards (NBS), later renamed the National Institute of Standards and Technology (NIST). The accuracy component of the analysis is based on results from Certified Reference Materials (CRMs), which are stable, homogeneous materials of matrices similar to “real foods” and with carefully assigned analytical values for selected nutrients and components. The development of the first food CRMs was the result of collaborations between scientists involved with the analysis of foods and NBS scientists who had experience in the execution of highly accurate analyses to produce reference materials. The first CRMs with certified values for a few inorganic nutrients and that had matrices with some relevance to foods were bovine liver (SRM 1577) and orchard leaves (SRM 1571). Soon, a “total mixed diet” representing food intakes based on the most recent food consumption survey was assembled with the help of personnel at the BHNRC diet study kitchen. This diet was certified for several inorganic and organic nutrients (201). However, various foods present many different matrices, i.e., high carbohydrate, high fat, high protein, and innumerable combinations, for which

Wolf and Andrews developed an approach for the definition and identification of appropriate CRMs (202). From these meager beginnings, the available CRMs include many that have matrices similar to foods and have certified as well as informational values for nutrients and other health-related components (203). Also, many more CRMs are available from metrology units of other countries, particularly England and the European Union. In addition, several commodity organizations such as the American Association of Cereal Chemists have reference “check sample” programs with accuracy components imbedded in them.

The second component of this paradigm shift has been a large educational program on the integration of CRMs with official methods as well as routine analyses (49). A new international symposium series was initiated in 1983—the International Symposium on Biological and Environmental Reference Materials—in which Wolf was extensively involved. The goals of this ongoing symposium are the promotion of appropriate application of CRMs and the identification of needs for new certified materials. A decade later and in response to new food labeling legislation (National Nutrient Labeling and Education Act, 1990 [NLEA]), AOAC International published an extensive volume that identified suitable analytical methods for NLEA and, for the first time, recommended appropriate CRMs and procedures for each validated method (204). As a consequence of these events, a Technical Division on Reference Materials was established within AOAC International to provide continual guidance and education on the availability and application of CRMs with official methods. Wolf has been significantly involved with activities of this division.

The value of incorporation of CRMs into analytical procedures has been demonstrated in the NFNAP program. This

program generated over 7,000 food samples that required analyses of more than 100 nutrients and dietary components by a host of government, university, and contract laboratories. Evaluation of the performance of laboratories based on analyses of CRMs indicated that most data were within acceptable limits (205). Those nutrients or food components that lacked molecular definition (dietary fiber) or required complex separations for measurement (carotenoids, tocopherols, and fatty acids) provided the greatest challenge in terms of accurate quantification. Nonetheless, the data generated as part of the NFNAP program are the most accurate and the highest quality data in the USDA Nutrient Databank.

International Food Composition Activities.

By the mid-20th century, the Food and Agriculture Organization (FAO) of the United Nations and only a few countries, including the United States, had produced tables of the composition of foods (206). Moving forward, the development of tables for new areas of the world was often sponsored by the country itself, regional nutrition organizations, or FAO (207). Data often were borrowed from existing tables, such as Agricultural Handbook No. 8 or the British tables recognized as “McCance and Widdowson” (208). However, international coordination and collaboration was lacking, except that representatives of individual countries would often visit those who were active in the field, e.g., Elsie Widdowson’s first meeting with USDA’s Charlotte Chatfield in 1936 (3).

This changed in the early 1980s when Nevin Scrimshaw, Director of Development Studies at United Nations University (UNU), the educational component of the United Nations, and also Professor of Nutrition at Massachusetts Institute of Technology (MIT), assembled a small group of international experts on food composition in Bellagio, Italy (207). The purpose of this meeting was to assess the status and

problems of food composition data and explore future possibilities and potential execution. The group recommended the formation of the International Network of Food Data Systems (INFOODS), and shortly thereafter, a secretariat was established at MIT, funded by several U.S. Government agencies, the food industry, and private foundations. Hepburn and Stewart represented the U.S. food composition activities at the Bellagio meeting. One of the first activities of INFOODS was sponsorship of an international meeting at Utah State University (March 1985) of scientists involved with various aspects of food composition data to assess the needs of the user community (209). Several publications followed, sponsored by INFOODS, that addressed issues important to compilation of food composition data (207). At a 1994 meeting in Tunis, Tunisia, FAO joined INFOODS and UNU to mobilize resources for improving the quality, quantity, and accessibility of food composition data in the developing world (210). Today, INFOODS also is part of the International Union of Nutritional Scientists (IUNS) and sponsors conferences, workshops, and training activities as well as supports the *Journal of Food Composition and Analysis* and other food-composition-related publications (211).

Another of the many results of the Bellagio meeting was the publication of *Food Composition Data: Production, Management, and Use* by Heather Greenfield and David Southgate in 1992 (212). This was an extensive update of an earlier publication by Southgate, but the first comprehensive discussion of all aspects of the generation and compilation of food composition data. Simultaneously with the preparation of this book, Southgate joined Clive West of Wageningen University, the Netherlands, to design and present the first International Graduate Course on Production and Use of Food Composition Data in Nutrition at Wageningen University (1992). The 10th session, a course that lasted 2 weeks, was

held at the university in October 2011. The course also has been offered at several sites around the world (213). Holden has been a lecturer and an integral part of this course from its early history, and Beecher has presented lectures in the course at several of the international sites. Shortly after *Food Composition Data: Production, Management and Use* was published, Greenfield organized the first International Food Data Conference in Sydney, Australia, as a satellite meeting to the 15th International Congress of Nutrition (214). Recently having its 9th session convened in Norwich, United Kingdom (2011), this conference affords the opportunity for scientists from around the world to present and discuss new findings on the general topic of food composition. From the vision of Nevin Scrimshaw, the spark of the Bellagio meeting only a quarter century ago, and with the help of electronic technology, food composition activities have become internationalized with free exchange of ideas, techniques, and often data.

Another activity that was part of the United Nations Development Program (UNDP) in China included exchange of scientists and engineers to transfer technology. In the mid-1980s, Guangya Wang at the Institute of Nutrition and Food Hygiene, Chinese Academy of Preventive Medicine, Beijing, China, was on sabbatical at NCL. At that time, Wang was responsible for food composition information in all of China. While at NCL, she learned current analytical procedures for several nutrients of foods. Shortly after returning to China, she invited Beecher and Vanderslice to China to present a 4-week-long course on nutrient analysis of foods. Wang had invited about 50 food analysts from all provinces and autonomous regions of China. Graduate students simultaneously translated English-language lectures into Mandarin. Although this may seem somewhat awkward, it was easy to discern from facial expressions when the participants did not comprehend the lecture material, which prompted the lecturer

to rephrase and expand on a concept for greater clarity. This activity established a long-term interaction between Wang and scientists at NCL.

Evaluation of Economic Benefits From Public Research

Recently, scientists at USDA Economic Research Service (ERS) critically assessed the benefits of public research within an economic framework (215). Their observations were based on three groups within ARS, and one of the groups evaluated was NDL. Although only actual products (SR and other food composition databases, publications, and presentations) generated by the scientists at NDL were evaluated by the ERS team, all of the experience and knowledge gained throughout the history of food composition activities at USDA, as outlined above, have greatly contributed to the quality, quantity, and stature of these products today. The ERS team outlined the uses and applications of food composition information, which are similar to those highlighted at the outset of this chapter. Relative to economic benefits of the products of NDL, improved public health was cited as the primary benefit (215). However, quantifying metrics were difficult to establish, because all of the information produced and published by NDL scientists is in the public domain. Many of the products likely have been incorporated into “secondary uses,” often without reference or credit for the original data, and sometimes into classified, confidential, or “politically volatile” environments. Nonetheless, there are no economical alternatives for a nationally based, census-driven, quality-oriented food measurement system within the United States. The ERS report concluded that generation and assembly of food composition information into user-friendly products is a highly effective use of public funds, for which there is an observable economic benefit. (215).

Awards

The following is a partial listing of awards given to USDA scientists working on food composition by professional societies, USDA, and other government agencies.

- 1947 David Breese Jones, Superior Service Award, U.S. Department of Agriculture
- 1951 Vitamin A Research Unit, Distinguished Service Award, U.S. Department of Agriculture
- 1952 Hazel Stiebeling, Distinguished Service Award, U.S. Department of Agriculture
- 1953 Food Composition Unit, Human Nutrition and Home Economics (HNHE), Superior Service Award, U.S. Department of Agriculture
- Millard Horn, Superior Service Award, U.S. Department of Agriculture
- Bernice Watt, Superior Service Award, U.S. Department of Agriculture
- 1957 Callie Mae Coons, Distinguished Service Award, U.S. Department of Agriculture
- 1958 Georgian Adams, Superior Service Award, U.S. Department of Agriculture
- Amino Acid Investigations, Superior Service Award, U.S. Department of Agriculture
- 1959 Hazel Stiebeling, Distinguished Federal Civilian Service Award
- 1965 C. Edith Weir, Superior Service Award, U.S. Department of Agriculture
- 1967 Georgian Adams, Fellow of American Institute of Nutrition
- 1969 Bernice Watt, Distinguished Achievement Award, Iowa State University
- 1972 Ruth Leverton, Distinguished Service Award, U.S. Department of Agriculture
- Bernice Watt, Borden Award, American Home Economics Association
- 1973 Lela Booher, Fellow of American Institute of Nutrition, Charter Member
- 1974 Bernice Watt, Distinguished Service Award, U.S. Department of Agriculture
- 1975 Mildred Adams, Fellow of American Institute of Nutrition
- 1980 Bernice Watt, Conrad Elvehjem Award for Public Service, American Institute of Nutrition
- 1988 Robert Rizek, Superior Service Award, U.S. Department of Agriculture
- 2001 Gary Beecher, Superior Service Award, U.S. Department of Agriculture
- 2003 Nutrient Data Laboratory, Superior Service Award, U.S. Department of Agriculture
- 2003 Rena Cutrufelli, Vincent de Jesus, David Haytowitz, Joanne Holden, Linda Lemar, and Robin Thomas, Honor Award, U.S. Department of Agriculture
- 2003 Wayne Wolf, Fellow of Association of Official Analytical Chemists International
- 2006 Gary Beecher, Fellow of American Society for Nutrition
- 2008 Joanne Holden, Larry Douglass, Dennis Buege, Karen Molyé, Jon Krainak, and Julie Howe, Regional Excellence in Technology Transfer, Federal Laboratory Consortium Mid-Atlantic Region
- 2009 Joanne Holden, Janet Roseland, Karen Andrews, Matthew Feinberg, Larry Douglass, Johanna Dwyer, and Florence Chang, Regional Excellence in Technology Transfer, Federal Laboratory Consortium Mid-Atlantic Region

Acknowledgments

I am extremely grateful to the many people who have helped in the assembly of this historical document. I especially want to acknowledge the efforts of J.C. Smith, Jr. for his forbearance in reviewing, editing, and commenting on the manuscript. Comments and additions by Robert Doherty, Jacob Exler, Sue Gebhardt, David Haytowitz, Joanne Holden, Betty Li, Betty Perlof, and Wayne Wolf are greatly appreciated. The impeccable library of “Directors’ Notes” from the directors and administrators of the Consumer and Food Economics Institute (CFEI) and the Human Nutrition Information Service (HNIS), maintained by Jacob Exler, provided a window into the past for the activities in these agencies. The unpublished notes by H.J. Souders entitled “Agricultural Research Service, USDA Highlights of Contributions of Food and Nutrition Research,” which detailed activity from the late 1800s to 1976, also were extremely helpful.

Disclaimer

The publications cited here are not intended to be a complete list for scientists who worked/are working in food composition; rather, they are intended to be representative of the topics discussed in this chapter. Publication lists for each scientist are available at NIH’s National Library of Medicine (www.ncbi.nlm.nih.gov/pubmed/) and USDA’s National Agricultural Library (www.nal.usda.gov).

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CHAPTER 6

History of Food Consumption Surveys Conducted by the U.S. Department of Agriculture

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Introduction

One mission of the U.S. Department of Agriculture (USDA) is to encourage the production and availability of a sufficient, safe, and nutritionally adequate supply of food for Americans. In support of this mission, USDA has conducted surveys to monitor food use and food consumption patterns in the U.S. population since the latter part of the 19th century. Early studies on food and nutrition that were begun during the 1890s aimed to help people in the working class to achieve good diets at low cost. As time went on, recognition of the need for nationally representative food and nutrient intake data resulted in the research and development of larger and more complex methodologies and surveys. The purposes and populations for which food consumption information is sought, techniques to select participants, nature of the country's food supplies, understanding of the nutritional composition of foods, what constituted a diet, biological research advancements, emerging computer technology, and statistical procedures are among the most recognized advancements of food consumption research and surveys at USDA (1).

This chapter describes the dietary survey work conducted by USDA beginning with

the work of W.O. Atwater and continuing through the current national food consumption survey, What We Eat in America, NHANES. This survey is conducted as a partnership between USDA's Agricultural Research Service (ARS) and the National Center for Health Statistics in the U.S. Department of Health and Human Services (DHHS), which addresses the requirements of the National Nutrition Monitoring and Related Research Act of 1990 (2,3).

Uses of the Data

Numerous public policy activities and evaluations rely on national dietary data to ensure the public's health, safety, and well-being. As shown in table 1, evaluations of diet quality and tracking changes in the diet over time have many Federal, State, and local applications, including policy formation and evaluation, program planning, and nutrition education. Users of the survey data include numerous USDA and DHHS agencies, as well as others such as the Environmental Protection Agency (EPA), the Federal Trade Commission, State agencies, county health departments, food and agricultural industries, and universities. The data are used to determine the food choices Americans make and to evaluate the content and adequacy

Table 1. Selected uses of data from nationwide food surveys in the United States

Assessment of dietary intakes

Provide detailed data on food and nutrient intakes and eating patterns of the population and population subgroups

Monitor the nutritional quality of diets and determine the size and nature of populations at risk of having diets too low or too high in certain nutrients

Identify factors and characteristics associated with diets

Correlate food and nutrient consumption and changes over time with biochemical indicators, health profile measures, and disease risk

Food policies, programs, regulations, and guidance

Determine appropriate levels of enrichment or fortification

Determine serving sizes for food labels

Monitor food security and diet quality

Identify populations and requirements for food/health/nutrition programs

Develop food plans that reflect current food consumption practices and meet nutritional and cost criteria

Evaluate the dietary and health effectiveness of food assistance programs

Establish dietary guidance/nutrient requirements, nutrition objectives for a healthy population

Estimate the demand for agricultural products and marketing facilities

Understand the effects of information on consumer food behavior

Food safety

Estimate exposure to pesticide residues, food additives, contaminants, and toxic substances in foods

Predict food items in which a food additive can safely be permitted in specified amounts

of their diets. As such, the data are used to evaluate diets in relationship to the recommendations set forth in the 2010 Dietary Guidelines for Americans (4) and ChooseMyPlate (5); the nutrition objectives of Healthy People 2020 (6); and the nutrient requirements established by the National Academy of Sciences' Dietary Reference Intakes (7). The data are also used to assess the nutritional impact of the USDA's food assistance programs; to estimate exposure to pesticide residues, as required by the Food Quality and Protection Act of 1996 (8), food additives, and arid contaminants; to develop food fortification, enrichment, and food labeling policies; and to assess the demand for agricultural products and marketing facilities.

Major Survey Periods

Food consumption surveys conducted by USDA are summarized in table 2. The surveys may be divided into five periods:

1. Early, small-scale studies conducted in the early 1900s.
2. Nationwide, but nonrepresentative, surveys conducted in 1935-36, 1942, and 1948.
3. Nationwide surveys of household use of food conducted in 1955, 1965-66, 1977-78, and 1987-88.
4. Nationwide surveys of dietary intakes by individuals conducted solely by USDA in 1965-66, 1977-78, 1985-86, 1987-88, 1989-91, 1994-96, and 1998. Additionally, intake surveys in 1989-91 and 1994-96 were coupled with a telephone follow-up survey designed to measure attitudes and knowledge about diet and health among Americans.
5. USDA nationwide food intake surveys integrated with the U.S. Department of Health and Human Services National Health and Nutrition Examination Survey (NHANES) to form What We Eat

in America, the dietary intake component of NHANES (What We Eat In America, NHANES) conducted jointly by USDA and DHHS in 2001-2002, 2003-2004, 2005-2006, 2007-2008, 2009-2010, and 2011-2012, and continuing with yearly collection and 2-year data release.

Early Small-Scale Studies

In 1894, Congress mandated that human nutrition investigations be conducted by the USDA Office of Experiment Stations. W.O. Atwater, the first director of the experiment stations, is credited with the first food consumption studies in the United States in the late 19th century. Atwater recognized the essential links between such studies and research on food composition, nutritional requirements, and dietary guidance: he pioneered studies in all of these areas. Atwater sought food consumption information that would help him develop recommendations on what a working man should eat and how families could spend their food money wisely (9-11).

By 1898, USDA investigators had made studies of food consumption by more than 300 families (1). In early studies, participants were simply whoever volunteered or, as the investigators put it, "willing families." Researchers used a food inventory record to collect data by determining the weight and cost of food used by the family from inventories of food on hand at the start and end of the survey period and from records of foods brought into the home during the period (12).

Because the complex food inventory procedure was found to be too intrusive, too time consuming, and too costly, it was replaced in the 1930s by the food list recall (or food list). The new technique required only an interview with the household respondent (usually the homemaker) who recalled, using the food list, the quantities of listed foods used by the household during the preceding week

and the amounts paid for purchased items. Although the list recall procedure was introduced with little preliminary study, response rates for the list recall were later shown to be much higher than for the food inventory record method (13).

Nationwide Nonrepresentative Surveys

During the Depression years of the 1930s, concern about the quality of American diets was high. USDA began periodic nationwide surveys of households in the 1930s using the food list recall method along with statistical sampling techniques that permitted the collection of data from large numbers of households in relatively short periods. Because the surveys conducted in the 1930s and 1940s preceded the advent of probability sampling in surveys, they were less than fully representative of the U.S. population (14). However, as the best benchmark data available at the time, they were important for various Federal uses. The comprehensive picture of household food consumption and dietary levels obtained in the Consumer Purchases Study of 1935-36 indicated that a third of the Nation's families had diets that were poor by nutritional standards in use at the time (15). On the basis of this finding, President Franklin D. Roosevelt stated that a third of the Nation was ill-fed (16). This reference is inscribed on the Franklin Delano Roosevelt Memorial adjacent to the Tidal Basin in Washington, DC.

The survey findings from the Consumer Purchases Study gave impetus to the enrichment of white flour and bread with iron and three B vitamins, establishment of the National School Lunch Program, and expansion of nutrition education and research. Also, USDA economists used results to project food consumption in the United States and develop food budgets to help families select good diets (17). USDA developed four nutritious food plans at different cost levels for families with varying

Table 2. Overview of USDA nationwide food surveys, 1936 to 2014

Survey	Population	Sample	Type of dietary data	Dietary method	Selected advances
1935-36 Consumer Purchases Study	Farm, village, and city households in five geographic regions	Husband and wife families, white and native born	Household food use	7-day list-recall; 7-day food inventory record	List recall imposed less respondent burden than food inventory record; later shown to have better response rates as well (12).
1942 Family Spending and Saving in Wartime	Cities, rural non-farm areas, and farms	Housekeeping families and single persons	Household food use	7-day list-recall	Recommended Dietary Allowances (RDA) issued in 1941 by the Food and Nutrition Board, National Academy of Sciences, provided basis for assessing calories and nutrient intakes in surveys.
1948 Food Consumption of Urban Families	Urban families nationwide in spring plus surveys in 4 cities	Housekeeping families of 2 or more persons	Household food use	7-day list-recall	Computers first used in data analysis (1).
1955 Food Consumption of Households	48 States plus a supplement of farm households	National, self-weighting probability sample of housekeeping households	Household food use	7-day list-recall	Self-weighting probability sample provided first nationally representative food use estimates.
1965-66 Household Food Consumption Survey	48 States	Two separate samples (basic and low income); selected household members were asked to provide intake information	Household food use Individual intake	7-day list-recall 24-hr dietary recall in spring only	First coverage of all 4 seasons. First data on food intakes by individuals allowed comparison of intakes with sex- and age-specific RDAs.

Survey	Population	Sample	Type of dietary data	Dietary method	Selected advances
1977-78 Nationwide Food Consumption Survey (NFCS)	48 States	Two separate samples (basic and low income); all household members were asked to provide intake information	Household food use Individual intake	7-day list-recall 3 consecutive days: 24-hr dietary recall and 2-day diet record	Dataset made widely available to public on magnetic data tape for first time. First nationwide survey to collect multiple days of dietary intake data.
1985-86 Continuing Survey of Food Intakes by Individuals (CSFII)	48 States	Two separate samples (basic and low income); women 19-50 yr. and their children 1-5 yr. in both years and men 19-50 yr. in 1985 only	Individual intake	Women and children: 6 nonconsecutive 24-hr dietary recalls; day 1 in person and remaining days by telephone. Men: day 1 only	Surveys timed more closely together to provide early indications of dietary changes. First use of telephone for second and subsequent days of data collection.
1987-88 NFCS	48 States	Two separate samples (basic and low income); all household members were asked to provide intake information	Household food use Individual intake	7-day list-recall 3 consecutive days: 24-hr dietary recall and 2-day diet record	Facilitation of list recall with laptop computer. Heavy respondent burden and poor response rate led to discontinuation of household component.
1989-91 CSFII	48 States	Two separate samples (basic and low income); all household members were asked to provide intake information	Individual intake	3 consecutive days: 24-hr dietary recall and 2-day diet record	First linkage of intakes with knowledge and attitude information provided by Diet and Health Knowledge Survey. First 3-year survey.

**Table 2. Overview of USDA nationwide food surveys, 1936 to 2014
—Continued**

Survey	Population	Sample	Type of dietary data	Dietary method	Selected advances
1989-91 Diet and Health Knowledge Survey (DHKS)	48 States	Main meal- planners/preparers with a completed day one intake in CSFII	Dietary knowl- edge, behavior, and attitudes	Telephone fol- low-up to CSFII	Initiated to improve un- derstanding of factors related to food choices; data linkage with CSFII.
1994-96 CSFII	50 States	Oversampling of the low-income population; only selected house- hold members were asked to provide intake information	Individual intake	2 nonconsecutive 24-hr dietary recalls; 3-step multiple pass paper and pencil method	First collection of nonconsecutive days of dietary data to improve representation of food intake. Multiple-pass method for 24-hr recall launched. Data released within a year of data collection and on CD-ROM for first time. Technical survey databases docu- menting nutrient values for each survey food pub- licly released for first time.
1994-96 DHKS	50 States	Adults 20 years and over with a completed day one intake in CSFII	Dietary knowl- edge, behavior, and attitudes	Telephone fol- low-up to CSFII	See 1989-1991 DHKS.
1998 Supple- mental Children's Survey to CSFII 1994-96, resulting in 1998 CSFII	50 States	Children 0-9 years	Individual intake	2 nonconsecutive 24-hr dietary recalls 3-step multiple pass paper and pencil method	Undertaken to provide increased sample size for estimation of exposure to pesticide residues when merged with CSFII 1994- 96.

Survey	Population	Sample	Type of dietary data	Dietary method	Selected advances
2001-2002 What We Eat in America (WWEIA), NHANES	50 States	Over sampling of individuals 12-19 years and 60+ years, African Americans, Mexican Americans, low-income, and pregnant females	Individual intake	One 24-hr recall in 2001, 2 non-consecutive 24-hr dietary recalls in 2002 5-step AMPM first used in 2002	<p>Survey integration of USDA's CSFII and HHS NHANES forming first joint USDA-DHHS nationwide dietary survey.</p> <p>Launch of continuous yearly dietary data collection</p> <p>Validated recall methodology (5-step AMPM) first used in national dietary survey (63).</p> <p>Dietary Reference Intakes issued by the Food and Nutrition Board, National Academies in 1997, establishes a set of reference values for nutrients for use in assessing intakes of population groups and replacing the Recommended Dietary Allowances.</p>
2003-2004 WWEIA, NHANES	50 States	Over sampling of individuals 12-19 years and 60+ years, African Americans, Mexican Americans, low-income, and pregnant females	Individual intake	2 nonconsecutive 24-hr dietary recalls 5-step AMPM	See 2001-2002 WWEIA, NHANES.

**Table 2. Overview of USDA nationwide food surveys, 1936 to 2014
—Continued**

Survey	Population	Sample	Type of dietary data	Dietary method	Selected advances
2005-2006 WWEIA, NHANES	50 States	Over sampling of individuals 12-19 years and 60+ years, African Americans, Mexican Americans, and low-income persons	Individual intake	2 nonconsecutive 24-hr dietary recalls 5-step AMPM	Water intake collected as part of 24-hr dietary recall in AMPM (75).
2007-2008 WWEIA, NHANES	50 States	Over sampling of individuals 60+ years, African Americans, Hispanics, and low-income	Individual intake	2 nonconsecutive 24-hr dietary recalls 5-step AMPM	Summarized data tables on total intakes from both food and dietary supplements released by USDA.
2009-2010 WWEIA, NHANES	50 States	Over sampling of individuals 60+ years, African Americans, and Hispanics	Individual intake	2 nonconsecutive 24-hr dietary recalls 5-step AMPM	Discontinuation of the calculated variable providing for salt adjustment for home-prepared foods.
2011-2012 WWEIA, NHANES	50 States	Over sample of African Americans, Hispanics, Asian Pacific Islanders, and low-income	Individual intake	2 nonconsecutive 24-hr dietary recalls 5-step AMPM	Decade of joint survey integration between USDA and DHHS. Significant update of AMPM questions for ~1/3 of foods.
2013-2014 WWEIA, NHANES	50 States	Over sample of African Americans, Hispanics, Asian Pacific Islanders, and low-income	Individual intake	2 nonconsecutive 24-hr dietary recalls 5-step AMPM	Second significant update of AMPM questions for beverages.

incomes, with the two lower cost plans used in programs for low-income families affected by the Depression (18). The early food plans were revised periodically to reflect changes in food consumption as determined from USDA food surveys as well as dietary guidance and food costs, which continue to be developed by USDA (19). The least costly of these food plans, the Thrifty Food Plan, is still used in the Federal formulas for counting the Nation's poor and for setting benefit levels in the Food Stamp Program (20-22).

The 1942 Spending and Saving in Wartime Survey measured the early effects of World War II on food consumption in urban, rural, and farm families at different income levels (23). As in earlier studies, the nutritive values computed for family diets were based on values of food as they were purchased, and authors cautioned that losses in nutrients caused by preparation and household waste should be considered in comparing the results with any yardstick. Before the date of the survey, a widespread nutrition program had been carried on throughout the Nation; people were being urged to increase their consumption of milk, fruits, vegetables, and whole-grain cereals. For many families, this was a matter of education in food selection; for others, it was a matter of having money to buy these foods. Nevertheless, the survey found marked improvement from the 1930s in diets overall, but many families' intakes of several nutrients were low compared with the new standards, the Recommended Dietary Allowances (RDA) first issued in 1941. Greatest improvements were for low-income families (24). Types of information available included quantities of food used, nutritive value of diets, the effect of income on diets, food groups as sources of "dietary essentials," and the money value of both purchased food and food from other sources such as home production.

A postwar survey, Food Consumption of Urban Families in 1948, included both a nationwide survey in the spring and surveys of four cities. As in earlier surveys, inter-

viewers were selected locally and trained by USDA staff. The 1948 survey was the first in which computers were used for data analysis; a USDA staffer applied the new technology to food consumption data using computers at the Bureau of Mines (1). The findings provided basic data on food consumption patterns for use in educational, research, and marketing programs and in the use of agricultural products. Types of information available focused heavily on food consumption, including the kinds of foods used by different groups in a week, the share of income spent for food by different groups, the division of the family food dollar among different kinds of food, and the amount of food obtained without direct expenditure. Included in one survey publication was a discussion of methods of analyzing family food data, including the estimation of income elasticities (25).

Nationally Representative Surveys of Household Food Use and the Shift Toward Individual Intake Data Collection

From the 1930s to the mid-20th century, great strides were made in the distribution and storage of food products, most notably in home refrigeration. These changes affected the way people purchased and used food. Coupled with that change was the recognition of the need for nationally representative food consumption data that resulted in USDA developing larger surveys, as well as continued work in conducting smaller methodologic or special-purpose surveys of food consumption.

Some of these methodological studies explored techniques for collecting dietary data from individuals (26,27). Other studies addressed survey methodology issues such as the use of the food inventory record versus the food list recall, food discard measurement, questionnaire design and wording, and interviewer training (25, 28-31). The research on the food inventory record versus

Table 3. Nutrients estimated in USDA nationwide surveys

Nutrients	Years in surveys	Nutrients	Years in surveys
Food energy (kcal)	1955 +	Retinol (µg)	2001-02 +
Protein (g)	1955 +	Carotenoids:	2001-02 +
Carbohydrate (g)	1977-78 +	Carotene, alpha (µg)	2001-02 +
Fat, total (g)	1955 +	Carotene, beta (µg)	2001-02 +
Alcohol (g)	1985-86 +	Cryptoxanthin, beta (µg)	2001-02 +
Sugars, total (g)	2001-02 +	Lycopene (µg)	2001-02 +
Dietary fiber, total (g)	1985-86 +	Lutein + zeaxanthin (µg)	2001-02 +
Water/moisture (g)	1985-86 +	Vitamin E:	1985 - 1998
Saturated fatty acids, total (g)	1985-86 +	as alpha-tocopherol equivalents (mgTE)	2001-02 +
Monounsaturated fatty acids, total (g)	1985-86 +	as alpha-tocopherol (mg)	2003-04 +
Polyunsaturated fatty acids, total (g)	1985-86 +	Added vitamin E (mg)	2007-08 +
Cholesterol (mg)	1985-86 +	Vitamin D (D2 + D3) (µg)	2001-02 +
Individual fatty acids:		Vitamin K as phylloquinone (µg)	1955 +
4:0 (g)	1994-98 +	Vitamin C (mg)	1955 +
6:0 (g)	1994-98 +	Thiamin (mg)	1955 +
8:0 (g)	1994-98 +	Riboflavin (mg)	1955 +
10:0 (g)	1994-98 +	Niacin (mg)	1977-78 +
12:0 (g)	1994-98 +	Vitamin B-6 (mg)	1985 +
14:0 (g)	1994-98 +	Folate, total (µg)	2001-02 +
16:0 (g)	1994-98 +	Folate (DFE) (µg)	2001-02 +
18:0 (g)	1994-98 +	Folic acid (µg)	2001-02 +
16:1 (g)	1994-98 +	Food folate (µg)	1977-78 +
18:1 (g)	1994-98 +	Vitamin B-12 (µg)	2003-04 +
20:1 (g)	1994-98 +	Added vitamin B-12 (µg)	2005-06 +
22:1 (g)	1994-98 +	Choline, total (mg)	1955 +
18:2 (g)	1994-98 +	Calcium (mg)	1955 +
18:3 (g)	1994-98 +	Iron (mg)	1977-78 +
18:4 (g)	1994-98 +	Magnesium (mg)	1977-78 +
20:4 (g)	1994-98 +	Phosphorus (mg)	1985-86 +
20:5 n-3 (g)	1994-98 +	Potassium (mg)	1985-86 +
22:5 n-3 (g)	1994-98 +	Sodium (mg)	1985-86 +
22:6 n-3 (g)	1994-98 +	Zinc (mg)	1985-86 +
Vitamin A:		Copper (mg)	1994-96 +
as International units (IU)	1955 - 1998	Selenium (µg)	1994-96 +
as retinol equivalents	1985 - 1998	Caffeine (mg)	1994-96 +
as retinol activity equivalents (µg)	2001-02 +	Theobromine (mg)	1994-96 +

the food list recall confirmed the decision to adopt the list recall technique for use in future surveys. Still other surveys were conducted to provide information on levels of living for farm and nonfarm families (32).

USDA conducted four nationwide food surveys of household food use—the Household Food Consumption Survey (HFCS), 1955;

HFCS, 1965-66; Nationwide Food Consumption Survey (NFCS), 1977-78; and NFCS, 1987-88. The latter three of these surveys also contained a component that measured food intake by household members.

Results from the 1955 Household Food Consumption Survey for household food use were provided for food energy and nine

nutrients including protein, fat, calcium, iron, vitamin A, thiamin, riboflavin, niacin, and ascorbic acid as shown in table 3. The results showed an overall improvement in the adequacy of U.S. diets (33). Nevertheless, nutrient shortages were still found even among households in the upper third of the income scale, indicating continued need for dietary improvements. Results were used to develop new educational materials for both low- and high-income families (7,33).

Widespread concern for disadvantaged and low-income families in the 1950s and early 1960s led to the use of survey results as baseline data for the Pilot Food Stamp Program that was initiated in 1961 in eight economically depressed areas. A before-and-after study of food-consumption and dietary levels in an urban and a rural area showed that the Food Stamp Program increased the purchase of more nutritious foods by needy families and also expanded the market for agricultural products. A government objective was to use farm surpluses (34). The Food Stamp Program became permanent with the Food Stamp Act of 1964 (P.L. 88-525). The program was renamed the Supplemental Nutrition Assistance Program (SNAP) in October 2008 as mandated by the Food, Conservation, and Energy Act of 2008 (P.L. 110-246).

Between the surveys of 1955 and 1965-66, the availability and consumer acceptance of many new, more convenient food products changed the cooking practices and patterns of food use in many American households. For example, the use of mixes for baked products, such as cakes and muffins, and the availability of ready-made baked products led to a decrease in baking “from scratch,” and household consumption of flour, sugar, and other basic baking ingredients decreased.

A major purpose of the Household Food Consumption Survey of 1965 was to compare current household food consumption with that in earlier surveys (35,36). Diets of

about a fifth (20%) of U.S. households were rated “poor” by new standards based on the 1963 RDAs, compared with a revised figure of 15% for 1955 (16). Decreased use of milk and some milk products and of vegetables and fruits was pinpointed as the principal cause for the increased proportion of households with poor diets. Both education and action programs were stepped up as a result of the survey findings.

In the spring quarter of 1965, information on dietary intakes by individuals in households was obtained for the first time (37). Results from individual intake for the spring 1965 collection were provided for the same nutrients reported in 1955. Findings of the survey provided new information on diets of household members and were used in nutrition education programs and in estimating the effect that different levels of food fortification had on the diets of various age groups. Results showed that the groups needing the most attention were children, teenagers, and older people. The spring 1965 individual intake data were so useful as baseline data that there were many requests for enlarging their scope to include more intake days per individual, all seasons, and more questions on dietary practices. The scope of the surveys was greatly expanded in 1977-78, and the name changed from the Household Food Consumption Survey to the Nationwide Food Consumption Survey.

Between the HFCS 1965-66 and the NFCS 1977-78 surveys, the proliferation of new products was especially marked. Technological changes, such as freeze-dried coffee, and the increasing variety of commercially frozen foods reflected breakthroughs in food processing and packaging. Lifestyle changes such as increases in the proportion of women employed outside the home may have decreased the time spent in meal preparation and increased the demand for convenience foods and fast food restaurants.

The NFCS 1977-78 survey was the largest of all the USDA nationwide surveys, even

including subsequent surveys. Food use information was obtained from approximately 14,000 households and dietary intakes from the approximately 36,000 individuals in those households (38,39). Reporting from the NFCS 1977-78 survey was extensive and included food use estimates by income, season, urbanization, and region, as well as estimates of the money value of food at home and away from home. As shown in table 3, results from the individual intake portion of the NFCS 1977-78 survey were provided for food energy and 14 nutrients—five more nutrients than were reported in the 1955 and 1965-66 surveys, including carbohydrate, magnesium, phosphorus, vitamin B6, and vitamin B12.

The last USDA survey to include both a household food use component and an individual intake component was the NFCS 1987-88 survey (40,41). Most of the procedures used to obtain food intake information were similar to those used in the NFCS 1977-78 survey. One innovation of the NFCS 1987-88 survey was the use of laptop computers for interviewing that were programmed to handle the burden of a growing food list. As food supplies had increased and become more varied over the years, the number of foods on the food list recall form had also increased rapidly from approximately 200 items in 1948 to nearly 3,000 items by 1987 (12).

Results from the NFCS 1987-88 survey showed that more of the household food dollar was spent away from home, and fewer meals were consumed from household food supplies in 1987-88 than in 1977-78 (37). These changes may have resulted from a desire for increased convenience and variety. The food industry responded in a number of ways: more and varied restaurants; more microwaveable packaging; and more bakeries, delicatessens, and salad bars in supermarkets.

The collection of both household food use and individual intake information in the

same survey created heavy respondent burden and, in the NFCS 1987-88 survey, low response rates. The need to decrease respondent burden was one of the reasons USDA did not include a household food use component in subsequent surveys. Another reason for the shift from household to individual intake data collection was that the then current emphasis on diet and health gave greater urgency to the need for assessing the nutrient adequacy of diets. Household data are less than ideal for analyses of diet quality relative to dietary or nutrient requirements such as the Dietary Reference Intakes (DRI) (42). To compare household intake levels with a standard or requirement, it was necessary to adjust for the consumption of food away from home, which was not surveyed in the household component, as well as to make various assumptions related to the apportionment of food among household members and their differing nutritional needs. Also, household food consumption data included discarded food and food fed to pets, which resulted in overestimates of nutritional quality. Individual intake data represent foods as eaten, excluding food discard and including both food eaten at home and away from home, an increasingly important component of individual intake; therefore, these data are more precise than household food use data for the assessment of diet quality.

The elimination of the household food use component resulted in loss of data on the monetary value of food used at home and expenditures for food away from home, nutrients per dollar's worth of food, and the value and quantity of home-produced food. Also, because much food is purchased at the household level, the discontinuation of the household survey created a gap in tracking food from the farmer to the consumer and made it more difficult to develop food plans that meet nutritional and cost criteria as well as reflect food consumption practices of households.

To fill this data void, USDA's Economic Research Service and the Food and Nutrition Service launched the National Household Food Acquisition and Purchase Survey (FoodAPS) in 2009. FoodAPS, a nationally representative survey of 3,500 low-income and 1,500 higher income households, is designed to provide comprehensive information about household food acquisition behaviors over a 7-day period and information about household characteristics that influence food acquisition behaviors. Data collection is scheduled for 2012 with results to be finalized in 2013 (43).

Individual Intake Surveys Without the Household Food Use Component

In 1985, the first national USDA survey of dietary intake by individuals independent of a household food use component began (44). The purpose of the 1985-86 Continuing Survey of Food Intakes by Individuals (CSFII) was to collect data more frequently than every 10 years, thus providing up-to-date information on the adequacy of the diets of selected population groups and early indications of dietary changes—important considerations for data that are used in planning food assistance and educational programs and in administering a variety of public programs affecting the supply, safety, and distribution of the Nation's food. Food intake data were collected using a panel approach: collection from each individual took place on up to 6 nonconsecutive days at intervals of approximately 2 months over a 1-year period.

Between 1977 and 1985, when the CSFII was initiated, substantial changes occurred in food intakes—shifts to lower fat milk, less meat eaten separately (i.e., not as part of mixtures), and more grain products (44). These shifts, most prominent among higher income, more educated respondents, may have reflected concerns about diet and health issues. The first Dietary Guidelines for Americans were issued in 1980 (45).

In 1989, the panel aspect of the CSFII 1985-86 was dropped, and the CSFII 1989-91 was conducted using a 1-day dietary recall and 2-day food record, the same methodology as for the individual intake portion of the NFCS 1977-78 and NFCS 1987-88. Also in 1989, the Diet and Health Knowledge Survey (DHKS) 1989-91 was initiated to improve understanding of factors that affect food choices and provide a link between an individual's knowledge and attitudes and his or her dietary behavior. Individuals who were identified as the main meal planners/preparers in the CSFII were asked to answer a series of questions about their knowledge of and attitudes toward diet, health, and food safety. Data from the CSFII 1989-91 showed that eating habits followed national dietary guidelines more closely than in the past (46). However, the DHKS 1989-91 revealed that Americans' perceptions about their diets did not always match reality (47).

USDA's last individual dietary intake survey conducted before survey integration with DHHS was the CSFII/DHKS 1994-96 (48,49). Popularly known as the "What We Eat in America" survey, it was USDA's 10th nationwide survey, the sixth to include the collection of individual intake data. The development of the CSFII/DHKS 1994-96 included substantial research and planning as well as extensive collaboration with other organizations within and outside the Federal sector, including the U.S. Bureau of the Census and USDA's National Agricultural Statistics Service; the establishment of a Continuing Survey Users' Group; and the University of Texas Houston School of Public Health (50). It addressed the requirements of the National Nutrition Monitoring and Related Research Act for continuous monitoring of the dietary and nutritional status of the U.S. population. The 1994-96 CSFII collected 2 nonconsecutive days of dietary intake using in-person 24-hour dietary recalls spaced 3-10 days apart. Results from the CSFII 1994-96 were provided for food energy and 48 nutrients and food components in-

cluding for the first time 19 individual fatty acids (see table 3).

Along with improvements in data collection methods, such as the multiple-pass approach for the 24-hour dietary recall, an advance made during the 1990s involved the way information on food intake by individuals was reported to the public (50). Since the 1965-66 HFCS, average quantities of foods consumed were reported in grams or as the percentages of individuals consuming food from selected food groups or subgroups. Such information has numerous uses, including comparing food consumption over time. However, food intakes given in grams are difficult for the public to interpret. This is especially true in light of recent dietary recommendations that are given as the number of servings per day from specified food groups, as in the Food Guide Pyramid (51). To make interpretation easier, USDA developed a method for converting CSFII data on grams of food eaten into servings of food from selected food groups based on food guidance (52).

USDA food consumption surveys have provided critical data to inform policy and health issues, and this use expanded in the 1990s. A 1993 report of the National Academy of Sciences entitled *Pesticides in the Diets of Infants and Children* raised concern that current food consumption data did not provide sufficient sample sizes to estimate adequately exposure to pesticide residues in the diets of children (53). To permit better exposure estimates and, as a response to the 1996 Food Quality Protection Act of 1996 (P.L. 104-170), a survey of food and nutrient intakes by children younger than 10 years was conducted in 1998 as a supplement to the CSFII 1994-96.

The Supplemental Children's Survey (SCS) provided the Environmental Protection Agency (EPA) with information on food consumption patterns in a statistically valid sample of infants and children. The method of data collection for the SCS was identical

to that used in the CSFII 1994-96; it included 2 days of dietary intake for approximately 5,000 children from birth through 9 years of age. Data from the SCS were combined with those of the CSFII 1994-96 to form CSFII 1994-96, 1998 (48).

Food consumption data from the CSFII 1994-96, 1998 were translated into commodity-level data specified to meet the requirements of the Food Quality Protection Act of 1996. The Food Commodity Intake Database was developed as a cooperative effort by USDA and EPA for use in assessing dietary exposure to pesticide residues (54). Foods reported in the survey were translated to approximately 500 commodities to assess intakes of combination foods as disaggregated to very basic-level commodities.

Research Efforts to Improve Individual Dietary Data Collection

Methodology research has been integral to planning the increasingly complex food consumption surveys at the USDA. In the late 1990s, USDA's Food Surveys Research Group (part of ARS's Beltsville Human Nutrition Research Center) implemented an extensive dietary survey methods research program to improve dietary intake data and to develop more cost-effective methods of data collection for national surveys of food consumption.

The research program included 2 years of comprehensive methodological research, followed by a full-scale nationwide pilot study. This research was undertaken out of concern for underreporting in 24-hour dietary recalls, which has implications for the interpretation of dietary data (55,56). Further, limited funds available in the Government for nutrition monitoring purposes urged integration of USDA and DHHS dietary intake surveys from many data users, as well as part of the National Nutrition Monitoring and Related Research Act of 1990.

Plans for integration of the CSFII and the National Health and Nutrition Examination Survey conducted by DHHS had begun in the late 1990s and required research for assuring successful implementation of an integrated national dietary survey (57). The focus of the research was the refinement of the 3-step multiple-pass 24-hour dietary recall method used in the CSFII 1994-96, 1998 to improve the completeness and accuracy of dietary intake data collection, the selection and testing of food measurement aids to improve portion size estimation, and utilizing the telephone for dietary data collection.

Development of the USDA Automated Multiple-Pass Method

The objective in revising the CSFII method was to develop new approaches to help keep respondents interested and engaged in the interview process, and to help them remember all the foods they had consumed. Testing different techniques, such as varying the order of questions with a panel of 46 individuals, showed that increasing the number of passes helped to improve the recall of foods and did not increase respondent frustration (58). The results were used to revise and expand the number and order of steps in the interview from three to five, add memory cues, and increase the opportunities for respondents to remember and report additional foods. Incorporation of the new 5-step recall into a computerized method was also done to minimize respondent burden and improve consistency across all interviews. The resulting method was the USDA Automated Multiple-Pass Method (AMPM), as detailed in figure 1.

The AMPM provides a structured interview of standardized questions combined with unstructured opportunities for respondents to use their own individual strategies to remember and report foods. The AMPM navigates the interviewer posing standardized

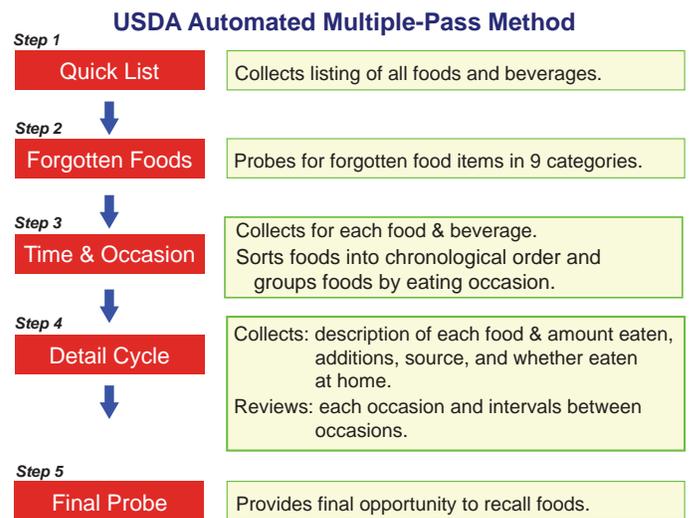


Figure 1. The USDA Automated Multiple-Pass Method.

questions and provides possible response options for hundreds of different foods and beverages. Each option is programmed to proceed to the next appropriate question through a framework of the five standardized steps.

The AMPM interview begins with the Quick List, where respondents are asked to report all the foods and beverages consumed from midnight to midnight the day before the interview. The Quick List is an unstructured, uninterrupted listing of foods that the respondent can report in any order. This allows respondents to use their own strategies to recall and report the foods consumed. A number of memory cues are included within the question suggesting that the respondents think about whom they were with and what they were doing such as working, eating out, or watching television. The question also includes references to foods eaten at home and away, and foods such as snacks, coffee, soft drinks, water, and alcoholic beverages. The next step is Forgotten Foods, in which the respondent is asked questions about nine categories of foods frequently forgotten including beverages, alcoholic beverages, sweets, savory snacks, fruits, vegetables, cheese, breads and rolls, and any other foods. The Time and Occasion step collects the time each food and beverage was eaten and the name

of the eating occasion (i.e., breakfast, lunch, dinner, snack, and beverage). The Detail and Review step collects a detailed description of each food and beverage reported (including additions to the food/beverage), amount eaten, its source (e.g., store or restaurant), and whether the food was eaten at home. During this step, a review of each eating occasion and the intervals between eating occasions are obtained to elicit additional recall. The Final Probe, the last step, provides a final opportunity for the respondent to recall foods. Memory cues about nonsalient situations when foods may be eaten and easily forgotten are given, and reporting of small amounts of foods is encouraged.

Research to Test and Validate the AMPM

The new AMPM was tested in a nationwide pilot study of 800 individuals. The pilot study, tested on a national scale and in an integrated form, utilized the food measurement aids and a computer-assisted telephone interview incorporating the new 24-hour recall methodology. Results showed that average calorie intakes and the number of foods reported were higher in the pilot study than in the 1996 CSFII (59). The success of the telephone interview in obtaining dietary recalls deemed as effective as those obtained in-person was also demonstrated in research conducted collaboratively with the Arkansas Children's Nutrition Center (60). However, the pilot study did demonstrate that using the telephone without a previous in-person interview resulted in unacceptably low response rates for national dietary surveys (57).

A major contribution of this research initiative was evaluating the accuracy of the AMPM. Information on the nature and magnitude of reporting error is critical to the interpretation of national survey data. From 2002 to 2004, the AMPM Validation Study was conducted at the Beltsville Human Nutrition Research Center to evaluate

the accuracy of the AMPM. Reported energy intake (EI) using the AMPM was compared with total energy expenditure (TEE) using the doubly labeled water (DLW) technique on 524 subjects aged 30-69 years (61). The DLW technique provides precise measures of energy expenditure in free-living individuals and may be used to validate the assessment of energy intake by other methods (62). Each of the subjects was dosed with DLW on the first day of their 2-week study period; daily urine samples were collected for determination of isotopic enrichment; and three 24-hour recalls were collected using the AMPM during this same period. The first recall was conducted in person, and subsequent recalls were over the telephone. Dietary interviews were distributed fairly equally across the days of the week, and subjects were interviewed on at least 1 weekend day and 1 weekday. Isotope kinetics was determined using a multipoint calculation technique. Among the findings were that EI compared with TEE was under-reported by 11% overall and by less than 3% for normal-weight subjects with body mass index <25, as illustrated in figure 3 (63). The OPEN Study, a DLW study conducted by the National Cancer Institute, used the earlier paper-and-pencil version of the AMPM for a sample of 480 adults. Results were similar but somewhat less accurate as compared with the AMPM Validation Study (64).

USDA also conducted smaller studies on the validity of the AMPM to measure group EI. Blanton reported that EI was not significantly different from TEE for a sample of 20 adult females (65). Rumpler and colleagues found that mean EIs were accurately reported for a sample of 12 adult males (66). Stote and colleagues reported on the number of days needed to collect usual energy and macronutrient intakes over a 6-month period for overweight subjects (67). Observational studies by Conway and colleagues also supported the effectiveness of the AMPM in collecting dietary intakes (68,69).

USDA and DHHS Dietary Survey Integration

The National Nutrition Monitoring and Related Research Act of 1990 set goals and mechanisms to bring about greater coordination of nutrition monitoring across agencies in the Federal Government. In 1998, the leadership of USDA and DHHS identified a more comprehensive integration of USDA's CSFII and DHHS's NHANES as a major priority. Under this partnership, USDA has lead responsibility for dietary collection, coding methodology and associated instruments, development and maintenance of appropriate food and nutrient databases, assignment of nutrient values to reported food, data processing systems and data processing, dietary data review, and quality control. DHHS has responsibility for sample design, survey design and operations, and contractual aspects of NHANES. Release of dietary data as part of this collaborative venture is a joint responsibility of both departments.

Integration of the dietary data collection activities from the departments has improved the ability of NHANES to assess dietary intakes of the U.S. population and improved the overall efficiency of dietary intake data collection and reporting activities for the

Federal Government. Linked with health indicators from other components of the NHANES, these data provide opportunities to study relationships between eating patterns and health conditions. The integrated survey addresses the requirements of the National Nutrition Monitoring and Related Research Act of 1990 (P.L. 101-445) for continuous monitoring of the dietary status of the American population, including low-income populations (3).

The new dietary intake survey, What We Eat in America (WWEIA), NHANES, was launched with the 2002 NHANES. Two days of dietary intake data are collected annually using the USDA AMPM on a nationally representative sample of 5,000 persons. Day-1 dietary interviews are collected in person in the NHANES Mobile Examination Center, and day-2 interviews are conducted by telephone from a central location about 3-10 days after the day-1 interview. Data are released jointly by USDA and DHHS at 2-year intervals on the Internet (70). Since 2002, continuous dietary data collection has been realized in WWEIA, NHANES with nearly 100,000 dietary recalls collected and publicly made available as detailed in table 4.

Table 4. 24-hour dietary recalls¹ available from What We Eat in America, NHANES

Collection years	Release month/year	Number of recalls		
		Day 1	Day 2	Total
2001-2002	October 2004	9,701	²	9,701
2003-2004	October 2006	8,894	8,220	17,114
2005-2006	July 2008	9,169	8,264	17,433
2007-2008	May 2010	9,118	7,715	16,833
2009-2010	June 2012	9,754	8,406	18,160

¹Number of recalls reflects reliable recalls as defined in the survey documentation released with each WWEIA, NHANES dietary dataset.

²Day 2 dietary recalls for What We Eat in America, NHANES 2001-2002 were only collected for the 2002 survey year. These recalls were not made publicly available due to NHANES's confidentiality requirements. Access to these data is possible through the National Center for Health Statistics Data Users Center.

USDA Dietary Intake Data System

In this role of dietary survey leadership, ARS's Food Surveys and Research Group (FSRG), where the activity is currently located, has developed and maintains the USDA Dietary Intake Data System (DIDS). The components of the system collectively provide the technological capability for the collection and processing of WWEIA, NHANES. The components of the system are detailed in figure 2. In addition to the AMPM for the 24-hour dietary recall, DIDS consists of two computer systems and the Food and Nutrient Database for Dietary Studies (FNDDS). The Post-Interview Processing System is for reformatting data and automatically assigning food codes and amounts, and Survey Net is for final manual coding, quality review, and nutrient analysis (58,71). The FNDDS is the database of more than 7,000 foods, their nutrient values, and weights for typical food portions used to process and analyze data from WWEIA, NHANES (72). With each

USDA Dietary Intake Data System

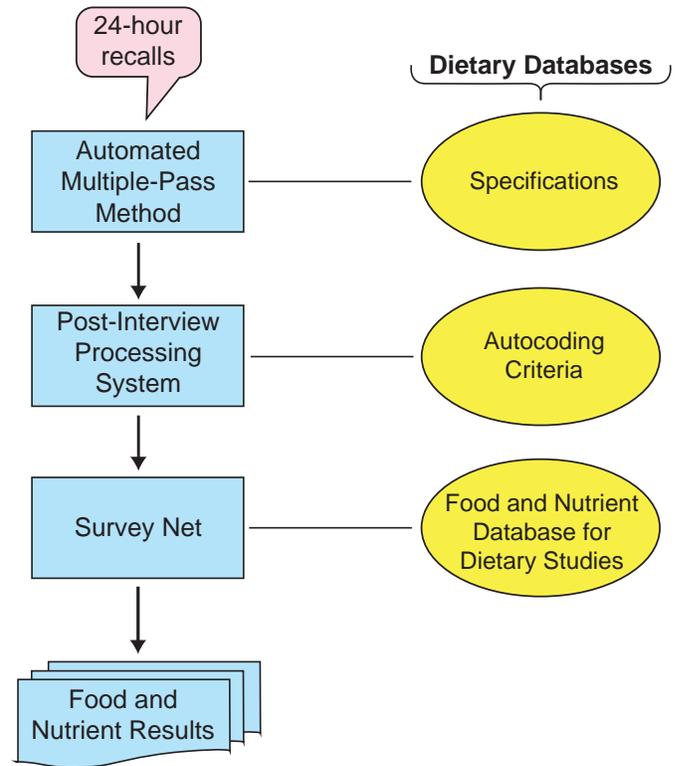
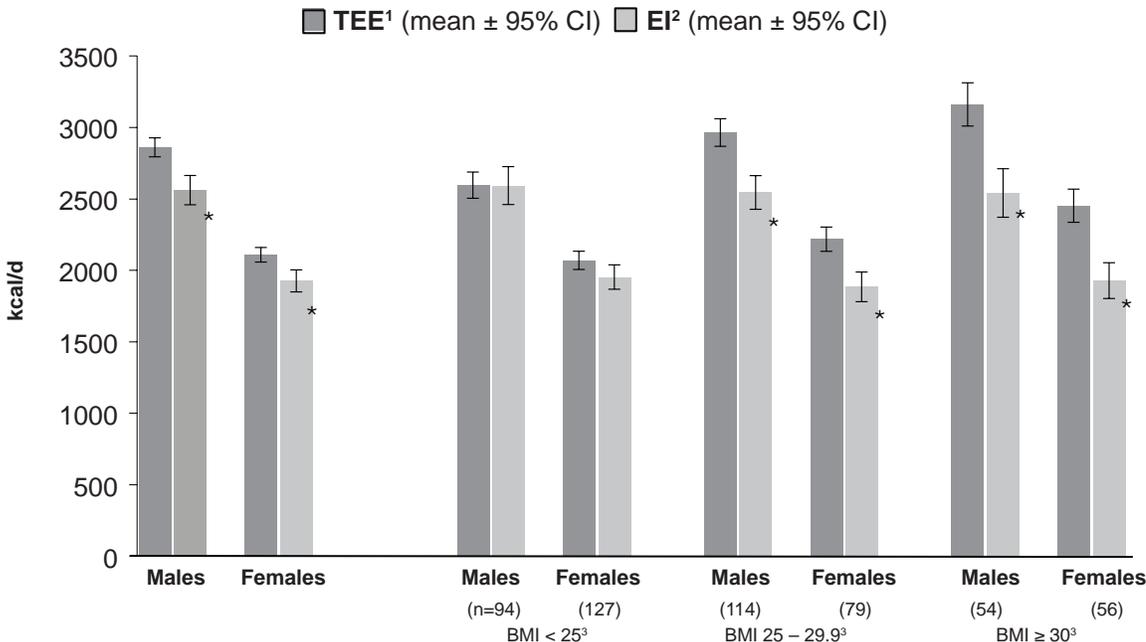


Figure 2. The relationship of data flow in the USDA Dietary Intake Data System.



¹TEE: total energy intake measured by using the doubly labeled water method.

²EI: energy intake calculated from three dietary recalls collected by using the USDA Automated Multiple-Pass Method.

*Significant at $p < 0.05$.

³Weight categories by BMI (in kg/m^2): normal weight (BMI < 25), overweight (BMI 25-29.9), and obese (BMI ≥ 30).

From AJ Moshfegh et al., American Journal of Clinical Nutrition, 2008, 88:324-32.

Figure 3. Energy measurements in men and women by BMI category using doubly labeled water in comparison to estimate intake using the Automated Multiple Pass Method.

2-year release of WWEIA, NHANES data, a new version of the FNDDS is also released to support nutrient estimates of the dietary intakes (see table 5). The underlying food composition data for FNDDS are from the current USDA National Nutrient Database for Standard Reference (73).

The need to provide additional details about foods and beverages for the FNDDS for studying dietary intakes has been met with development of value-added databases. Two such databases developed by FSRG are the Food Patterns Equivalents Database and the Food Intakes Converted to Retail Commodities Database. The Food Patterns Equivalents Database, which replaced the MyPyramid Equivalents Database, characterizes foods and beverages in FNDDS by 32 components that are used to assess how Americans are meeting the recommendations of the 2010 Dietary Guidelines for Americans. The Food Intakes Converted to Retail Commodities Database provides data for foods and beverages in FNDDS at the retail commodity level, disaggregating foods where necessary and converting them to amounts of 65 retail-level commodities (74).

Addressing the Changing Food Supply and Sources for Food and Beverages

Increasingly, Americans are consuming a larger proportion of their total daily food

intake in food away from home—27% of mean daily food energy in 1994-96 compared with 35% in 2007-2008. This shift, among other extensive food supply changes, has caused continual review and updates of the questions in the AMPM and the foods in the Food and Nutrient Database for Dietary Studies. Survey databases have continued to expand to incorporate these commercial foods.

Beverages in the American diet are playing an important role in dietary intakes. Today, beverages account for 22% of food energy and have been implicated as having a role with the obesity epidemic in the United States. Before WWEIA, NHANES 2005-2006, plain water intake data were collected after the 24-hour dietary recall via food-frequency type questions that asked about the total amounts of tap and bottled water consumed the previous day. Starting in WWEIA, NHANES 2005-2006, the collection of all types of water was begun during the 24-hour dietary recall in the same manner as for all other beverages and foods. This methodology change has been the greatest to date since the launch of the AMPM in the 2002 WWEIA, NHANES (75).

The applications developed by USDA for the collection and processing of dietary intake data are made available to the nutrition research community. Through collaborations, USDA's AMPM and related components of

Table 5. Selected characteristics of food and nutrient database for dietary studies

FNDDS version	WWEIA, NHANES survey years	USDA Standard Reference used	Foods/beverages	Number of Nutrients
1.0	2001-2002	16-1	6,974	61
2.0	2003-2004	18	6,940	63
3.0	2005-2006	20	6,921	64
4.1	2007-2008	22	7,174	65
5.0	2009-2010	24	7,253	65

Table 6. Dietary intake research collaborations with Food Surveys Research Group¹

Collaborators	Project/study	Year
Western Human Nutrition Research Center, USDA	Doubly labeled water study of non-obese women	2002
National Institute on Aging, National Institutes of Health	Healthy Aging in Neighborhoods of Diversity Across the Life Span (HANDLS)—20-year duration	2003+
Statistics Canada	Canadian Community Health Survey	2004
University of Maryland School of Medicine and Johns Hopkins University Bloomberg School of Public Health	WIC mothers in Baltimore, MD	2004
Food and Nutrition Service, USDA	School Nutrition Dietary Assessment Study-III (SNDA III)	2005
Diet Health and Human Performance Lab, Beltsville Human Nutrition Research Center, USDA	Protein and Weight Loss Study	2005
Pennington Biomedical Research Center	Preventing Obesity Using Novel Dietary Strategies (POUNDS LOST) intervention study	2005
National Cancer Institute, National Institutes of Health; and the Center for Nutrition Policy and Promotion, USDA	Automated Self-Administered 24-Hour Recall (ASA24)—adapted AMPM format and design for use of ASA24 on the Web	2005+
Research Triangle Institute International	Healthy Eating and Active Living (HEALTH) in Households of Tri-care Participants—intervention study for the Department of Defense	2006
National Cancer Institute, National Institutes of Health	5-A-Day	2006
University of Maryland School of Medicine	Toddlers Overweight Prevention Study (TOPS) conducted with WIC participants	2007
University of Vermont	Relationship between television viewing and eating	2007
Economic Research Service, USDA	Behavioral Economics Influences on Food Consumption	2008
Environmental Protection Agency	Upper Columbia River Tribal Consumption and Use Survey	2009
Food and Nutrition Service, USDA	School Nutrition Dietary Assessment Study-IV (SNDA IV)	2010
Food and Nutrition Service, USDA	School Food Purchase Study-III	2010
Australian Bureau of Statistics	National Health Study of Australia	2011
Food and Nutrition Policy Research Program, Research Triangle Institute International	Selected smaller studies starting first with a study on local/regional WIC program	2011+
Statistics Canada and Health Canada	Canadian Community Health Study	2015

¹Collaborations established through December 2011

the DIDS have been shared with others in the United States and internationally. A list of recent collaborators and their respective studies in which the USDA AMPM, FNDDS, and other DIDS components have been used is included in table 6.

Two of the largest studies that used the AMPM and related programs and databases are USDA's School Nutrition Dietary Assessment Studies III and IV, conducted in 2004-2005 and 2010, respectively (76,77). These studies were designed to provide information on the school meal programs, the school environment that affects the programs, the nutrient content of school meals, and the contributions of school meals to students' diets. Further, the AMPM is used as a basis for the Automated Self-Administered 24-hour Dietary Recall (ASA24) system developed by the National Cancer Institute. The ASA24, available on the Internet, is designed for use by researchers for epidemiologic, intervention, behavioral, or clinical research (78).

Internationally, the 2004 Canadian Community Health Survey and the 2011-13 Australian Health Survey used the AMPM in their nutrition component (79, 80). A number of other countries have based their nutrition monitoring databases and methods on those developed by USDA (81-83).

For over a century, USDA's surveys have provided benchmark data on food consumption in the United States and have set the standard for high-quality dietary assessment methodology. The current research on dietary intake survey methodology is expected to produce further improvements in estimates of food and nutrient intakes.

Acknowledgments

The author gratefully acknowledges the previous contribution of Katherine S. Tippett, MS, and Cecilia Wilkinson Enns, MS, RD, in the earlier papers on the historical overview of USDA food consumption surveys.

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FOOD and LIFE



*Yearbook
of Agriculture
1939*

UNITED STATES DEPARTMENT OF AGRICULTURE

UNITED STATES GOVERNMENT PRINTING OFFICE

76th CONGRESS, 1st SESSION

. . .

HOUSE DOCUMENT NO. 28

CHAPTER 7

History of Nutrition Education at the U.S. Department of Agriculture, 1902-2011

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1891



Figure 1. Wilbur Olin Atwater, 1844-1907, was USDA's first director of nutrition research. He is widely regarded as the father of modern nutrition research.

The Period 1891-1920s

The United States Department of Agriculture (USDA) was given authority for nutrition education and information dissemination by the Congress under President Abraham Lincoln in 1862 (1). The Act called for “the general design and duties of which shall be to acquire and diffuse among the people of the United States useful information on subjects connected to agriculture and rural development.” Subsequently, nutrition was specified as one such subject. A science-based approach to nutrition education began in this country at the USDA with the appointment of Wilbur Olin Atwater as a special agent in charge of nutrition programs for the Office of Experiment Stations, USDA, in 1891 (figure 1). Atwater is considered by many to be the father of human nutrition research in this country in that he was a leader in research on nutritional requirements (the beginning of the Dietary Reference Intakes), food composition, food consumption by the population, and the effects of socioeconomic factors on food choice. He derived the “Atwater units” of 4, 9, and 4 calories per gram for calculating the metabolizable energy content of foods based on their protein, fat, and carbohydrate content, respectively. In 1894, he published the tables of food composition and dietary standards for the U.S. population (2).

The first food tables provided data on protein, fat, carbohydrate, ash (mineral matter), and the energy value of some commonly available foods. Atwater's dietary standards were intended to represent the average needs of man for protein and total calories. Fat and carbohydrate at unspecified levels were to provide the balance in calories. Specific minerals and vitamins had not yet been identified.

In addition to being credited with initiating major areas of nutrition research at USDA, Atwater was the first to connect them, thus laying the groundwork for dietary guidance. In a *Farmers' Bulletin* published in 1902, he stated: “Unless care is exercised in selecting food, a diet may result which is one-sided or badly balanced—that is one in which either protein or fuel ingredients (carbohydrate and fat) are provided in excess.... The evils of overeating may not be felt at once, but sooner or later, they are sure to appear—perhaps in an excessive amount of fatty tissue, perhaps in general debility, perhaps in actual disease.” (3). These recommendations initiated the ongoing dietary guidance themes of variety, balance, and moderation. In this bulletin, he also set the stage for the development of food guides, which can be defined as a conceptual framework for selecting the kinds and amounts of foods of various types,

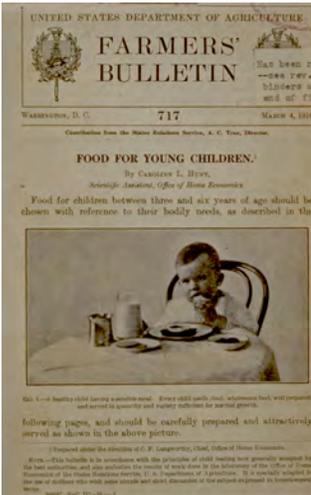


Figure 2. The first food guide aimed at U.S. consumers was written by Caroline Hunt for USDA. It was published in 1916.

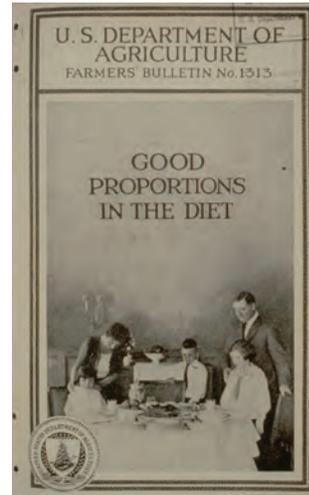


Figure 3. Another USDA food guide by Caroline Hunt provided guidance to homemakers on feeding a family of five—the average American family size in 1923.

which together provide a nutritionally satisfactory diet. He stated, “For the great majority of people in good health, the ordinary food materials... make a fitting diet, the main question is how to use them in the kinds and proportions fitted to the actual needs of the body.” For the rest of the century and continuing today, we have focused on answering this question.

Caroline Hunt, a nutrition specialist in USDA’s Bureau of Home Economics, was the first to directly address Atwater’s question of how to use ordinary foods in the kinds and proportions needed for a healthful diet. She is credited with having developed the first food guide. In 1916, “Food for Young Children” was released (4) (figure 2). This was followed in 1917 by dietary recommendations targeted to the general population in “How to Select Foods” written by Caroline Hunt and Helen Atwater, W. O. Atwater’s daughter (5). In 1921, a guide for the average family was released using the same food groups and suggesting the amounts of food to purchase each week (6). This publication was slightly modified in 1923 for use by teachers and extension workers in teaching

housekeepers how to provide for the average size family of five (7) (figure 3).

In Caroline Hunt’s food guides, foods were categorized into five groups—milk and meat, cereals, vegetables and fruits, fats and fatty foods, and sugar and sugary foods. The criteria for grouping foods were based on what was known then about nutritional needs, food composition, and usual patterns of food intake. By the 1920s, diets sufficient in calcium, phosphorus, iron, and iodine could be developed. Several foods containing vitamins A, B complex, and C had been identified, although the amounts the body needed were not yet known. The amounts of foods in Hunt’s food guides were listed in familiar household units—weight, volume, or count—and 100-calorie portions. Menus and recipes were also provided. It was assumed that most of the foods in a group were interchangeable in the diet. Individuals could choose the variety of foods that they liked and could afford in each food group. Food guides over more than a century have followed the same developmental logic in translating science into information that is meaningful and useful to the public. Table



Figure 4. In the 1920s, educational materials from USDA reflected the nutritional knowledge of the times but emphasized eating a variety of foods.



Figure 5. Educational materials from USDA in the 1920s emphasized nutrient-dense foods instead of snacks.

1 shows the major USDA food guides developed from 1916 to 2010 including the numbers of food groups and the quantities of foods recommended for each. Educational materials based on these food guides were developed for each of them (table 1). Figures 4 and 5 show some of the early educational materials. From these beginnings, USDA has remained a major force in the development of dietary guidance to help Americans to choose a healthful diet.

One of the most important ways Caroline Hunt's and Helen Atwater's dietary guidance reached the public was through the Cooperative Extension System (8). The Morrill Act of 1862 established land-grant universities, a new type of university that educated citizens in agriculture, home economics, mechanical arts, and other practical professions. The System was formalized in 1914 by the Smith-Lever Act to "extend" the resources of the land-grant universities and colleges to address public needs and bring practical information to people. This Act established the partnership between the land-grant universities and the USDA. At the heart of agricultural extension work, according to the Act, was developing practical applications

of research knowledge. The Smith-Lever Act mandated that the Federal Government, through USDA, provide each State with funds based on a population-related formula. It also required that the States provide a 100% match from non-Federal resources. Today, the USDA's National Institute of Food and Agriculture (NIFA) distributes these formula grants annually to land-grant universities across the country. The Cooperative Extension System is a unique network that allows dietary guidance produced at the Federal level to be adapted for use with local target audiences in States and territories across the country.

The 1930s

In the 1930s, the needs of families changed. Due to the widespread economic constraints of the Depression and the severe droughts in the Midwest, which had decreased jobs and food availability, families needed advice on how to select foods economically. In 1933, Hazel K. Stiebelling, a food economist in USDA's Bureau of Food and Economics, developed the first food plans (9,10). Food plans differ from food guides in that they

Table 1. Major USDA Food Guides (1916-2010): food groups and amounts to eat

Food Guide	Number of food groups	Protein-rich food				Breads	Vegetables	Fruit	Other				
		Milk	Meat						Fats	Sugars			
1916 Caroline Hunt ^(4,7) buying guides	5	Meats and other protein-rich food (10% Cal Milk, 10% Cal other)				Cereals and other starchy foods (20% Cal)	Vegetables and fruit (30% Cal)			Fatty foods (20% Cal)	Sugars (10% Cal)		
		1C milk + 2-3 svgs other/d (3 oz svg)				9 svg/d (1 oz svg)	5 svg/d (8 oz svg)			9 svg/d (1 Tbsp svg)	10 svg/d (1 Tbsp svg)		
1933 Stiebeling ^(9,10) buying guides	12	Milk	Lean meat, poultry, fish	Dry mature beans, peas, & nuts	Eggs	Flours, cereals	Leafy green yellow	Potatoes sweet potatoes	Other vegetables & fruit	Tomatoes & citrus	Butter	Other fats	Sugars
		2 C/d	9-10 svg/wk	1 svg/wk	1 svg/d	As desired	11-12 svg/wk	1 svg/d	3 svg/d	1 svg/d	na	na	na
1943 Basic Seven ⁽²³⁾ foundation diet	7	Milk and milk products		Meat, poultry, fish, eggs, dried beans, peas, nuts		Bread, flour, and cereals	Leafy green yellow	Potatoes & other fruit & vegetables	Citrus, tomato, cabbage, salad, greens		Butter-fortified margarine	Energy foods Other fats, sugars, & sweets	
		2 C or more/d		1-2 svg/d		Every day	1 or more svg/d	2 or more svg/d	1 or more svg/d		Some daily		
1956 Basic Four ^(25,26) foundation diet	4	Milk group		Meat group		Bread, cereal	Vegetable-fruit group			na			
		2 or more svg/d (1 C svg)		2 or more svg/d (2-3 oz svg)		4 or more svg/d (1 slice, 1/2 C cooked)	4 or more svg/d Incl. dark green/yellow vegetables frequently and citrus daily (1/2 C svg)						
1979 Hassle-Free ⁽³⁵⁾ foundation diet	5	Milk-cheese group		Meat, poultry fish, and beans group		Breads, cereals, rice, pasta	Vegetable-fruit group			Fats, sweets, alcohol group			
		2 svg/d (1 C svg)		2 svg/d (2-3 oz svg)		4 svg/d Include whole grain enriched (1 slice, 1/2 C cooked)	4 svg/d Incl. dark green/yellow vegetables frequently and citrus daily			Use dependent on Cal needs			

Table 1. Major USDA Food Guides (1916-2010): food groups and amounts to eat—*continued*

Food Guide	Number of food groups	Protein-rich food		Breads	Vegetables	Fruit	Other	
		Milk	Meat				Fats	Sugars
1985 Food Guide Pyramid ^(65,71) total diet example 1,600 - 2,800 Cal	6	Milk, yogurt, cheese 2-3 svg/d (1 C svg)	Meat, poultry fish, eggs, dry beans, nuts 2-3 svg/d (5-7 oz total/day)	Breads, cereals, rice, pasta 6-11 svg/d Whole grain enriched (1 slice, 1/2 C cooked svg)	Vegetable 3-5 svg/d Dark green/deep yellow; starchy/dry beans and peas; other (1 C raw, 1/2 C cooked svg)	Fruit 2-4 svg/d citrus Other (1/2 C svg)	Fats, oils, sweets Total fat not to exceed 30% Cal, sweets vary according to Cal needs	
2005 MyPyramid ^(89,90) total diet example 2,200 Cal	5	Milk 3 C/d	Meat and beans 6 oz/d	Grains 7 oz/d Whole grain (3½ oz) Refined (3½ oz)	Vegetables 3 C/d Dark green 3 C/wk Orange 2 C/wk Dry beans/peas 3 C/wk Starchy 6 C/wk Other 7 C/wk	Fruit 2 C/d	Oils 6 tsp/d	Discretionary Cal 290 Cal/d
2010 USDA Food Pattern ⁽⁹⁵⁾ total diet example 2,200 Cal	5	Milk & milk products 3 C/d	Protein foods 6 oz-eq/d Meat, poultry 29 oz/wk Seafood 9 oz/wk Nuts, seeds, soy products 4 oz/wk	Grains 7 oz-eq/d Whole grain 3½ oz-eq/d Enriched 3½ oz-eq/d	Vegetables 3 C/d Dark green 2 C/wk Beans & peas 2 C/wk Red & orange 6 C/wk Starchy 6 C/wk Other 5 C/wk	Fruit 2 C/d	Oils 6 tsp/d	Solid fats & added sugar Max 266 Cal/d

define the amounts of food to buy and use in a week. Hazel Stiebeling's food plans were designed at four cost levels to meet the nutritional needs of men, women, and children of different ages. These plans were (1) the Restricted Food Plan for Emergency Use, (2) the Minimum-Cost Food Plan, (3) the Moderate-Cost Food Plan, and (4) the Liberal-Cost Food Plan. The two lower cost food plans were used in programs for low-income families affected by the Depression.

These early food plans have been revised periodically to reflect changes in dietary guidance, food consumption, and food prices. In 1962, the Economy Food Plan was developed as a nutritionally adequate diet for short-term or emergency use (11). This plan, priced at less than the Low-Cost Plan, served as the basis for maximum food stamp allotments, as stipulated in the 1964 Food Stamp Program Act. In 1975, the Economy Food Plan was replaced by the Thrifty Food Plan, which represented a completely new set of market baskets but at the same minimal cost as the Economy Food Plan (12). As the new basis for the maximum food stamp allotments, the Thrifty Food Plan represented a minimal-cost diet based on up-to-date dietary recommendations, food composition data, food habits, and food price information. Another important difference was that the Thrifty Food Plan was designed for long-term use. The food plans have continued to be revised periodically to reflect new information (13-15). To help consumers use the Thrifty Food Plan, an educational publication, *Recipes and Tips for Healthy, Thrifty Meals*, was published in 2000 (16). It provided meal plans and recipes developed and evaluated by The Pennsylvania State University under contract with the USDA Center for Nutrition Policy and Promotion. Four-person families with limited incomes prepared and evaluated the menus and recipes for taste and quality. Although it is now outdated, it is an important historical piece.

The first family food plans developed by Hazel Steibeling were outlined in terms of 12

major food groups (table 1). The food plans recognized that some groups of foods, such as cereal foods, potatoes, and dry beans, supply nutrients more cheaply than others, and that the nutritive values of different food groups could supplement one another. Stiebeling emphasized in her guidance the importance of having the proper balance between "protective" (nutrient-dense foods) and high-energy foods. Protective foods furnish essential nutrients, such as milk for calcium and vegetables and fruits for vitamins A and C. Fats and sweets are examples of high-energy foods that are generally low in essential nutrients. This may be the first use of nutrient density as a concept for selecting foods. Today, with obesity being the number one nutritional problem, considering nutrient density in food selection has become even more important. While food plans do an excellent job for the purpose that they are intended—determining how much food to buy and estimating how much it will cost—most nutrition educators find food plans too complicated for the public to use in choosing diets unless the plans are translated into food as eaten.

The 1940s

In 1940, the Food and Nutrition Board, National Research Council, National Academy of Sciences accepted an assignment from the National Defense Advisory Commission called for by President Franklin Roosevelt to recommend a formulation of nutrient allowances for daily consumption, which would be adequate for maintenance of good nutrition in essentially the entire population of the United States (17). In May of 1941, the Committee on Food and Nutrition, National Research Council published a *Yardstick for Good Nutrition —Recommended Dietary Allowances* (18) (figure 6). It contained recommendations for calories and nine nutrients—protein, calcium, iron, vitamin A, thiamin, riboflavin, niacin, ascorbic acid, and vitamin D—for men and women who are sedentary,

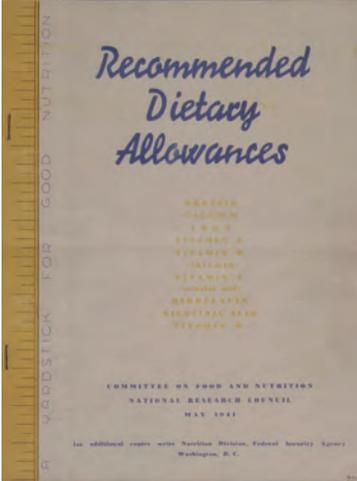


Figure 6. The first formal yardstick for good nutrition was the Recommended Dietary Allowances from the National Academy of Sciences, National Research Council Committee on Food and Nutrition in 1941.



Figure 7. The 1943 National Wartime Nutrition Guide from USDA appealed to a sense of patriotism in encouraging Americans to adopt a nutritious diet.

moderately active, or very active. It also included recommendations for children in various age groups and pregnant and lactating women. The recommendations were revised and reissued in 1943 (19). Consideration was given to three more nutrients not covered in the original recommendations—iodine, copper, and vitamin K. The published booklet was only 6 pages long. Between then and 1989, 10 revisions of the Recommended Dietary Allowances (RDA) were published (20). The 10th edition was 285 pages long. In the early 1990s, the conceptual base and the development process for the RDA underwent serious deliberation and major revision (21). Between 1997 and 2005, the Institute of Medicine (IOM) published six volumes of Dietary Reference Intakes (DRI) covering a total of 45 nutrients, energy, and other food components (20). The IOM also issued two reports describing ways to apply DRIs in planning and assessing diets. Each revision of the RDAs or the DRIs triggered a new assessment of the guidance given to meet the recommendations. It is intended that the DRIs will be revised when substantial new research data are available and when there is concern about intake by the population. The DRIs for calcium and vitamin D were

the first to be revised in 2010. All the reports are freely accessible at <http://fnic.nal.usda.gov/DRIsreports>.

In the 1941 RDA report (18), a food guide, developed with USDA's help, was presented to show how the nutrient recommendations could be met. The guide showed amounts to eat each day from nine food groups: milk, eggs, meat, vegetables, fruit, potatoes, butter or fortified margarine, cereal and bread, and sugars. As World War II dragged on, the rationing of some foods—meat, sugar, butter, and canned goods—became necessary in the United States. Because of rationing and evidence from national surveys that many Americans had poor diets, USDA issued the National Wartime Nutrition Guide (22) (figure 7). The early nine food groups became seven; eggs were put in the meat group, and sweets were omitted. Rather than numbers of servings or amounts of food groups to eat, this guide suggested alternate food groups to select when foods from a particular group were scarce. For example, it was suggested that if butter and fortified margarine were scarce, one should choose more foods from the green and yellow vegetables group or the milk group, which could be counted on

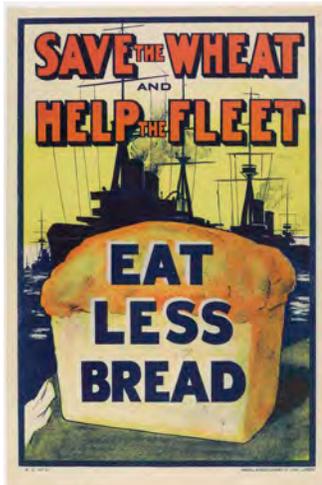


Figure 8. During both World Wars, USDA created advertisements to encourage the public to limit consumption of certain foods in order to free them up for shipment to troops in combat.



Figure 9. This poster promoted home canning and “victory gardens” to combat food shortages during World War II.



to supply more vitamin A. A portion of the 6-page bulletin was devoted to 12 hints on conservation, such as “use every scrap” and “don’t take more food on your plate than you will eat.” Posters of the era also emphasized the conservation message, but in some instances, they provided questionable dietary advice (figures 8 and 9).

Following the war, the *National Wartime Nutrition Guide* was revised and reissued in 1946 as the *National Food Guide* (23) (figure 10). Unlike the earlier guide, this food guide—better known as the “Basic Seven”—suggested the number of servings of each food group needed daily (table 1). Although waste was still discouraged, the emphasis on conservation now was gone. In addition to the seven main food groups, “energy foods” were mentioned. It was suggested that foods such as fats (other than butter and fortified margarine), sugars and sweets, and refined, unenriched grains provide chiefly energy, whereas the foods in the Basic Seven food groups also protect health. The graphic presentation of the food guide was a circle, which made a lasting impression in the minds of many people. The Basic Seven was used for about 12 years, but its

complexity and lack of specificity regarding serving sizes led to the need for modification and simplification.

In 1946, President Harry Truman signed the National School Lunch Act (24). The program was intended to assist schools in providing nutritionally balanced, low-cost or free lunches to children. It was not intended to be a nutrition education program, but its power to influence by setting an example should not be underestimated. Today, school lunches must meet Federal nutrition requirements that are consistent with the Dietary Guidelines for Americans, but local school food authorities make decisions about what specific foods to serve and how they are prepared. In the 2010 9-month school year, 5,277.8 million lunches were served through the National School Lunch Program (<http://www.fns.usda.gov/pd/sl-summar.htm>).

The 1950s

In 1956, Louise Page and Esther Phipard, nutritionists with USDA’s Agricultural Research Service, introduced the rationale

FOOD GROUPS



Figure 10. The National Nutrition Guide from 1946 was commonly known as “the Basic 7.”

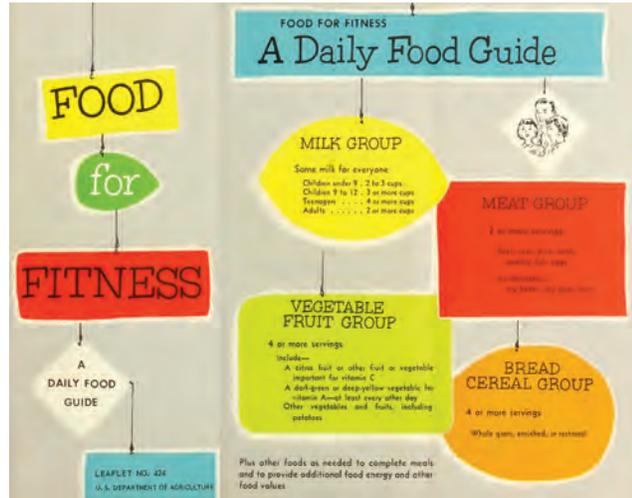


Figure 11. In 1958, USDA replaced “the Basic 7” guide with “the Basic 4,” similar to current dietary recommendations in both types and amounts of foods to be eaten.

for a new food guide with four food groups in *Essentials of an Adequate Diet* (25) (table 1). The publication was not intended for the general public, but rather for professionals involved in nutrition education, such as Cooperative Extension System educators. The report presented a food pattern—numbers of servings to eat from each of four food groups—and it gave the details of how the nutrient profiles for the food groups were developed. The nutrient profiles were based on weighted consumption of foods within the food groups by the population. The report also indicated the intake of energy and eight nutrients—protein, calcium, iron, vitamin A value, thiamine, riboflavin, niacin, and ascorbic acid—that would be derived by following the food pattern. The scientific basis for this food guide and subsequent food guides and dietary guidance is dependent on food consumption and food composition data developed by USDA. The Page and Phipard food pattern was for a foundation diet; that is, by eating the minimum number of servings of nutrient-dense foods in each food group, a major share—not all—of the energy and nutrient needs would be met. As calculated, the food guide provided 1,255 calories. For a

foundation diet, it was expected that most individuals would eat more food than the guide called for to satisfy their calorie needs and bring nutrient levels closer to the RDAs. National surveys at the time showed that American diets fell short of the RDAs for vitamins A and C and calcium; thus, the guide stressed good sources of these nutrients from the vegetable, fruit, and milk groups. The meat group featured animal protein sources as well as dry beans and peas, important for their contribution of iron and the B vitamins. Fats, oils, sugars, and unenriched refined cereal foods were listed under that heading “Foods not emphasized in the daily plan,” although it was recognized that fats were important in the absorption of vitamins A and D and as a source of important fatty acids.

After an extensive review of the document by Page and Phipard, a consumer publication, *Food for Fitness—a Daily Food Guide*, was released in 1958 (26) (figure 11). It became known as the “Basic Four.” In the 6-page bulletin intended for the public, the composition of the food groups was briefly described, and quantities of food to count

as a serving were specified. Little guidance was given on the selection of fats and sugars or on appropriate calorie intakes. However, because of its emphasis on getting enough nutrients, the Basic Four remained a focal point of nutrition education for more than 2 decades. It was presented graphically as a mobile, not a circle. Many people, however, seemed to confuse it with the graphic presentation of the Basic Seven and remember it as a circle.

The Period 1960-1985

Beginning in the early 1960s, a series of publications from the American Heart Association began to link diet and heart disease (27). During the next 2 decades, an intense interest in the role of diet as a controllable risk factor in the etiology of several chronic diseases developed. Interpreting the research and coming to conclusions regarding appropriate dietary guidance was strongly debated in the scientific literature. The media covered the debate, and both public interest and confusion were high. USDA first formally addressed amounts of fatty acids as well as total fat in planning diets in its revision of the family food plans in 1962 (11). The 1974 bulletin, *Fats in Food and Diet*, gave consumers the information available on dietary fats and heart disease and on the amounts of fat, saturated fatty acids, and cholesterol in foods (28).

On September 21, 1959, Public Law (P.L.) 86-341 authorized the Secretary of Agriculture to operate a food stamp system through January 31, 1962 (29). The Eisenhower Administration never used the authority. However, in fulfillment of a campaign promise made in West Virginia, President John F. Kennedy's first Executive Order called for expanded food distribution. On February 2, 1961, he announced that food stamp pilot programs would be initiated. In 1964, under the Johnson administration, the Food Stamp Act was passed. The official purposes of the

Act included strengthening the agricultural economy and providing improved levels of nutrition among low-income households. The Act also brought the pilot programs under Congressional control. The Food Stamp Program has been amended many times and has grown dramatically. When President George W. Bush's veto was overridden, the Food, Conservation and Energy Act of 2008—better known as the “Farm Bill”—was passed, and the Program was reauthorized and renamed the Supplemental Nutrition Assistance Program (SNAP). In 2010, participation was over 40 million people at a cost of \$68 billion.

In 1966, under the Johnson Administration, Congress passed the Child Nutrition Act, which authorized the Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) (31). This is a Federal grant program administered by USDA's Food and Nutrition Service (FNS). It provides nutrition education and nutritious food to aid low-income pregnant women, breastfeeding women, infants, and children up to 5 years of age who are at nutritional risk. In 1974, the first year the program was permanently authorized, 88,000 people participated. In 2004, average monthly participation was about 7.9 million. Currently, 50 States, 34 Tribal Organizations, American Samoa, the District of Columbia, Guam, the Northern Mariana Islands, Puerto Rico, and the U.S. Virgin Islands participate. In fiscal year 2010, participation was 9 million people, and the annual cost was \$6.7 billion (<http://www.fns.usda.gov/pd/wisummary.htm>).

In 1969, again in response to the needs of the poor, Congress established the Expanded Food and Nutrition Education Program (EFNEP) (32). It operates through a partnership between USDA's National Institute of Food and Agriculture (NIFA) and the land-grant universities' Cooperative Extension System. It is designed to reach limited-resource audiences, especially youth and families with young children. It provides



Figure 12. The Hassle-Free Guide to a Better Diet was published by USDA in 1979 and included the fats, sweets, and alcohol group in addition to the Basic 4 food groups.

a comprehensive, integrated, experiential education program of about 10 to 12 lessons that address four areas—diet quality, physical activity, food safety, and food resource management. EFNEP has a rigorous evaluation system that has shown it to be effective. Currently, it operates in all 50 States and in American Samoa, Micronesia, the Northern Marianas, Puerto Rico, and U.S. Virgin Islands. Although matching funds from the States are not required, many States choose to add resources to the Federal allocation, because they recognize the value of this program. In 2010, the EFNEP Federal Appropriation was \$67.5 million (http://www.nifa.usda.gov/business/awards/formula/10_efnep_final.pdf).

In 1977, Congress took action to quell the controversy and public confusion about the relationship between diet and chronic disease by releasing the landmark *Dietary Goals for the United States* (33). Senator George McGovern chaired the committee, and the report is often referred to as “the McGovern Report.” The committee set quantitative goals for intakes of protein (12% of calories), and, for the first time, intakes of carbohydrate (58% of calories), fat (30% of

calories), saturated fatty acids (15% of calories), cholesterol (300 mg), sodium (5 g), and refined and processed sugars (10% of calories). These goals were the subject of great controversy among nutritionists, physicians, and the food industry—both on the basis of the strength of the scientific rationale and on the practical difficulty of meeting the recommendations with commonly consumed foods and usual diets. The goal for fat was particularly hard to meet. However, the goals marked a tipping point for dietary guidance.

In 1977, under the administration of Jimmy Carter, Congress passed the National Agricultural Research, Extension and Teaching Policy Act (34). This Act established USDA as the lead agency of the Federal Government for research, extension, and teaching in the food and agricultural sciences, and directed that research into food and human nutrition be established as a separate and distinct mission of the Department. With this legislation, Congress supported USDA’s traditional emphasis on the nutritional needs of normal, healthy individuals, rather than the needs of individuals requiring clinical and therapeutic dietary treatment.

Dietary Guidelines for Americans 1980-2010



Figure 13. The Dietary Guidelines for Americans were established by Congress to be released in 1980 and are mandated to be reexamined every 5 years.

Partly in response to the “Dietary Goals” and the growing concern about overconsumption, USDA presented a new food guide, the “Hassle-Free Guide to a Better Diet” (figure 12), in a colorful booklet entitled *Food in 1979* (35). This 64-page booklet was a decided break from the past both in what was presented and the way it was presented. The Hassle-Free Guide was similar to the Basic Four in that it described a foundation diet, with the same numbers of servings for the milk, meat, fruit and vegetable, and grain groups (table 1). However, for the first time, a very clear emphasis was placed on moderation. A fifth food group was identified as the Fats, Sweets, and Alcohol group. Specific examples of fats and sweets to minimize in diets were given. Even within each of the four food groups, foods that were low, medium, or high in nutrient density were listed. It also gave examples of menus that would provide three different levels of calories ranging from 1,200 to 2,400 calories. Guidance was given on how to decrease sodium and increase fiber intake. Equally dramatic was a change in presentation style. For the first time, a full-color, conversational, magazine style was used. Beautiful color pictures of foods were shown along with modern

recipes that included the calories per serving. The Hassle-Free Guide was intended to replace the Basic Four. However, it went relatively unnoticed because of limited circulation due to its high cost and also to the controversy that ensued from the “Dietary Goals” and the release of the 1980 Dietary Guidelines for Americans.

Under the Carter Administration, USDA and the U.S. Department of Health and Human Services (HHS) came together to issue authoritative, consistent dietary guidance for the public. In 1980, Secretary of Agriculture Robert Bergland and Surgeon General Julius Richmond released the 20-page first edition of *Nutrition and Your Health: Dietary Guidelines for Americans* (figure 13) (36). The purpose was to give guidance to promote health and reduce the risk of chronic diet-related diseases. The guidelines addressed issues for which there was considerable consensus and which were thought to have the greatest potential effect on public health. The guidelines were based in part on the 1979 Surgeon General’s Report (37). They were written for the public in simple terms and gave qualitative guidance, such as “avoid excess....” Specifically, the guidelines called

for a variety of foods to provide essential nutrients while maintaining recommended body weight and moderating dietary constituents of concern—fat, saturated fat, cholesterol, and sodium. Although the guidelines were directional rather than quantitative, the relationship between certain guidelines and health was questioned. The controversy continued, and numerous organizations developed new sets of dietary guidelines. Without understanding the sometimes-subtle differences in purpose and target audience, new guidelines were often viewed as a repudiation of past guidelines. While the scientific debate continued, diet books and products proliferated. Allegiance was divided among those who were generally pleased with the 1980 Dietary Guidelines, those who strongly supported the “Dietary Goals” and did not think the 1980 Guidelines had gone far enough in setting quantitative standards, and those who saw the Guidelines as going beyond the current science. In fact, there were file cabinets filled with angry letters to the Secretary of Agriculture.

In the remaining days of the Carter Administration, USDA published a 30-page booklet that gave menus and recipes to help people to follow the 1980 Dietary Guidelines (38). Two new manuscripts—*A Dieter’s Guide* and *Eating the Moderate Fat & Cholesterol Way*, by essentially the same authors as *Food* (35)—were ready for publication. Clearly, their focus was on the moderation message. With questions concerning the 1980 Dietary Guidelines for Americans remaining unanswered, the two new publications were too controversial for USDA to publish at the time. Subsequently, the American Dietetic Association published them in 1982 (39,40).

Almost immediately after the release of the 1980 Dietary Guidelines, the Senate called for the establishment of the Federal Dietary Guidelines Advisory Committee to review the Dietary Guidelines (41). The Advisory Committee was composed of nine members appointed by the Secretary of Agricul-

ture—three recommended by HHS, three recommended by USDA, and three recommended by the National Academy of Sciences. The Committee members were Bernard Schweigert (Chair), Henry Kamin, David Kritchevsky, Robert Olson, Lester Salans, Robert Levy, Sanford Miller, Judith Stern, and Fredrick Stare. The Executive Secretary was Isabel Wolf, Administrator of the USDA agency responsible for the Guidelines, Human Nutrition Information Service (HNIS).

In 1985, the Federal Dietary Guidelines Advisory Committee completed its work and turned in its report to the Secretary of Agriculture and the Secretary of Health and Human Services (42). In addition to reviewing the research basis for the Guidelines, they considered all public comments the Departments had received concerning the Guidelines. Their four meetings were open to the public. The changes recommended by the Committee were minor, mostly to improve clarity. For example, it was recommended that the guidelines not be numbered to avoid giving the impression of a hierarchy. They wanted to communicate that all the guidelines were intended to work together in the total diet. In addition, cautions were included against following unsafe weight-loss diets, use of large-dose supplements, and consumption of alcoholic beverages by pregnant women. They noted that excess calories are a factor in increasing blood cholesterol, and they made it clear that “sugar,” as referred to in the Guidelines, is not only sucrose but also other kinds of caloric sweeteners. With these changes, Secretary of Agriculture John Block and Secretary of Health and Human Services Margaret Heckler jointly released the 24-page second edition of the Dietary Guidelines for Americans (figure 13) (43). With the recommendations of a committee of experts in an open forum, the joint release of the Guidelines by USDA and HHS, and endorsements of the 1980 or 1985 Dietary Guidelines by important nutrition professional associations (44,45,46), the controversy over the relationship between

diet and health and the Dietary Guidelines died down.

The 1985 Dietary Guidelines Advisory Committee also made several recommendations to the Departments. One of the recommendations was that the Government use the Guidelines as the basis of nutrition programs. The Secretaries of Agriculture and Health and Human Services echoed this recommendation when the Guidelines were released. To ensure this and to respond to Congress's request that the Federal Government "speak with one voice" on matters related to nutrition, USDA formed the Dietary Guidance Working Group on January 2, 1986. Nine USDA agencies that played a role in nutrition research and/or education were represented in the working group along with a liaison from HHS. A similar committee was established at HHS. All Federal nutrition education materials directed to the public were, and still are, required to be reviewed and approved by these groups prior to publication to ensure that the information is consistent with the Dietary Guidelines for Americans or is based on new medical or scientific knowledge determined to be valid by the Secretaries. In 1994, a Memorandum of Understanding was signed by USDA and HHS to formalize the review process. The review and approval process is still going on today, and it ensures that the dietary guidance message from the Federal Government is a consistent one.

The Period 1985-1990

In the late 1980s, USDA developed and disseminated a number of publications and other materials designed to help the public use the Dietary Guidelines. These included *Dietary Guidelines and your Diet* (47), which was a series of seven publications, one on each of the seven Dietary Guidelines. *Dietary Guidelines and Your Diet: Home Economics Teacher's Guide* (48) was specifically designed to help teachers communicate the Dietary Guidelines principles to students.

Using the Dietary Guidelines was a series of four colorful, focus-group-tested bulletins designed to show how to put all the Guidelines into practice at the same time while carrying out daily activities—*Preparing Foods and Planning Menus Using the Dietary Guidelines*; *Making Bag Lunches, Snacks and Desserts Using the Dietary Guidelines*; *Shopping for Food and Making Meals in Minutes Using the Dietary Guidelines*; and *Eating Better When Eating out Using the Dietary Guidelines* (49-52). All materials included an explanation of the scientific rationale for the Guidelines written in consumer language. They also included tips, food sources of nutrients, menus, and recipes, as well as games and quizzes to engage the audience.

In 1988, Food Stamp Nutrition Education (FSNE) began with creative thinking in one State (53). Cooperative Extension faculty in Brown County, Wisconsin, and University of Wisconsin extension staff discovered that by committing State and local funding and contracting with the State food stamp agency, an equal amount of Federal dollars could be secured to expand the reach of nutrition education to low-income people in that area. Other universities soon followed. In 1992, seven States conducted FSNE using \$661,000 in Federal funds. Growth of FSNE has occurred mainly through the Land-Grant University System's Cooperative Extension System. The funding and administration of the program comes from USDA's Food and Nutrition Service (FNS). USDA's NIFA provides leadership for FSNE programs carried out by the Cooperative Extension System. It promotes well-trained staff; effective program planning, management, and reporting; identification and use of effective and appropriate resources; and improved consistency and clarity of communication among FSNE's many partners. FSNE is delivered directly through group and individual interactive learning opportunities and indirectly through the distribution of print and video materials. Social marketing campaigns are also used. Regard-

less of the delivery approach used, FSNE is a learner-centered and behavioral-focused program. With the change in the name of the Food Stamp Program to the Supplemental Nutrition Assistance Program, FSNE became SNAP-Ed. In 2010, Congress appropriated \$379 million for the program (<http://www.nal.usda.gov/fsn/ApprovedFederalFundsSNAP-Ed01202010.pdf>). Through 2010, States were required to contribute an equal or greater share of funds to the program, so program cost would have been at least double. The Healthy Hunger-Free Kids Act of 2010, signed by President Barack Obama on December 13, 2010, eliminated the requirement for the State contribution.

On December 29, 1988, a new Dietary Guidelines Advisory Committee was established by USDA and HHS to determine if revision of the 1985 edition of the Dietary Guidelines was warranted and, if so, to make recommendations for revision. The Committee consisted of nine nutrition scientists and physicians—Malden Nesheim (Chair), Lewis Barness, Peggy Borum, Wayne Callaway, John LaRosa, Charles Lieber, John Milner, Rebecca Mullis, and Barbara Schneeman. The Executive Secretaries were Betty Peterkin (USDA) and Linda Meyers (HHS). Major resources for the review identified by the two

Departments were the Food and Nutrition Board's 1989 edition of the *Recommended Dietary Allowances* (54), *Diet and Health: Implications for Chronic Disease Risk* (55), and the *Surgeon General's Report on Nutrition and Health* (56). The Committee held three meetings that were announced in the Federal Register and open to the public.

On May 14, 1990, they sent a 48-page report to the Secretaries of Agriculture and Health and Human Services (57). It contained specific wording for a new edition of the consumer bulletin on the Dietary Guidelines, and it provided a rationale for recommended changes. It also included a summary of the

comments that had been received from the public. The basic tenets of the earlier Dietary Guidelines were reaffirmed, which promoted healthful eating through variety and moderation instead of dietary restriction. For the first time, the Guidelines suggested numeric goals for total fat—30% or less of calories—and saturated fat—less than 10% of calories. It was made clear that the recommendations were to be carried out over several days, rather than for one meal or one food. One of the biggest changes was to revise “Eat foods with adequate starch and fiber” from the 1985 Guidelines to “Choose a diet with plenty of vegetables, fruits and grain products” in 1990. The shift was from food components to food groups. The Committee recognized that the existing Dietary Guidelines were well established as Federal nutrition policy, and they recognized the importance of stability in dietary guidance messages directed to the public. Based on the Committee's report, Secretary of Agriculture Clayton Yeutter and Secretary of Health and Human Services Louis Sullivan released the 28-page third edition of the consumer bulletin, *Nutrition and Your Health: Dietary Guidelines for Americans* in 1990 (58). The design and presentation of the 1990 bulletin was almost identical to the 1985 bulletin, with the exception that the background color of the cover was black (figure 13). For the future of USDA's nutrition education work, the most significant addition to the 1990 Guidelines was the inclusion of USDA's new Food Guide in tabular, not graphic, form.

A very important piece of legislation was passed in 1990—the National Nutrition Monitoring and Related Research Act (59). In addition to calling for a plan to integrate the two independent food and nutrition monitoring surveys conducted by the USDA and the HHS, it made long-lasting changes in nutrition education. The review of the scientific literature and the publication of the Dietary Guidelines for Americans that started in 1980 was made mandatory every 5 years. In addition, these guidelines were

to be “...promoted by each Federal agency in carrying out any Federal food, nutrition, or health program...” Therefore, by this Act, the Dietary Guidelines became the statement of Federal nutrition policy and the basis for all related programs such as nutrition education and promotion programs, food guides, and food plans such as the Thrifty Food Plan, which provides the cost basis for the SNAP, the National School Lunch Program, and WIC. It also gave a legislative basis for continuation of USDA’s Dietary Guidance Working Group that began in 1986 for the purpose of ensuring that all dietary guidance directed to the general public would be consistent with the Dietary Guidelines for Americans. The Monitoring Act of 1990 expired in 2000, but the Departments have continued to function as though it were in place.

The Period 1990-1995

A process that came to fruition in the early 1990s had actually begun 12 years earlier. With the release of the first edition of the Dietary Guidelines in 1980 (36), USDA began work on a new and very different kind of a food guide. Its purpose was to show consumers how to put the Guidelines into practice. There was a strong conviction that if the new food guide was to be accepted by consumers, it had to be evaluated and accepted by the professional community first. Therefore, an iterative process of development, presentation, feedback, and revision was carried out. It was considered essential that the development process be fully documented and open for peer review, and that the documentation include the purpose or the underlying goals of the food guide, the specific nutritional objectives, the food composition and food consumption databases used, and data to show that the goals and objectives specified could be achieved repeatedly.

The underlying goals of USDA’s new food guide were based on a study of the evolution of food guides (60,61) as well as on a needs assessment of the professional community conducted through a cooperative agreement with Cornell University in 1983 (62). Approximately three-fourths of the nutritionists surveyed wanted the Basic Four replaced. The criticisms of the Basic Four were related to the failure to insure nutrient adequacy for the full array of nutrients for which RDAs had been established by 1980 (63), the failure to address nutritional concerns about excess intake of food components as expressed in the 1980 Dietary Guidelines (36), and the failure to communicate effectively. Two-thirds of the nutritionists surveyed indicated that they would prefer a food guide for the total diet rather than a foundation diet. Other studies indicated that the very familiarity of the Basic Four negatively influenced its ability to communicate (64). Consumers regarded the Basic Four as old-fashioned, something they already knew even if they did not have formal evidence. As a result of this review process, the underlying goals established for development of a new food guide were to achieve the following:

- Focus on overall health rather than on single diseases;
- Be based on current scientific research;
- Address the total diet, including concerns about both adequacy and moderation;
- Be realistic by meeting nutritional objectives with ordinary foods;
- Be flexible by allowing for maximum consumer choice;
- Be useful by reflecting the way consumers think about and use food;
- Be practical by accommodating feeding families or other groups; and
- Be evolutionary and anticipate the direction of future dietary recommendations.

The details of the development of what was called “A Pattern for Daily Food Choices” were published in the mid-1980s (65,66).

Concerns about both adequacy and moderation were addressed. Related to adequacy concerns, the objectives for protein, vitamins, and minerals were 100% or more of the RDAs for healthy people age two and older. The objectives for carbohydrate and fiber were to provide amounts greater than the usual intake through increased use of vegetables, fruits, and grains, especially whole-grain products. Related to moderation concerns, the limit for total fat was set at 30% or less of energy; and for saturated fatty acids, the limit was set at less than 10% of energy. The limit for cholesterol was 300 mg; and for sodium, it was 2,400 mg. The intent for added sugars was to provide the balance of energy needed without exceeding usual intakes. The objective for total energy was to cover the range recommended for moderately active individuals.

Food groups were formed primarily on the basis of nutrient content, but the way foods were generally used in meals and the way foods were grouped in past food guides were also considered (table 1). Within some of the major food groups, subgroups of foods were identified to emphasize nutrients of concern. For example, vegetables were separated into five subgroups to focus on their specific contributions of vitamins, minerals, and fiber; and grain products were separated into enriched and whole-grain products to emphasize important nutrients and fiber. As in the Hassle-Free Food Guide, foods relatively high in fat or added sugars and relatively low in vitamins and minerals were classified into a separate group called fats, oils, and sweets. Serving sizes were used as they had been in the Basic Four. Determining the numbers of servings of the five nutrient-dense food groups and the allowances for fats and sugars in the total diet was a two-phase process. First, nutrient profiles were established that defined the quantities of nutrients that one could expect to obtain on average from a serving of a food group or subgroup. The typical pattern of food consumption in the United States was taken

into account by developing average nutrient profiles for the groups and subgroups weighted on the basis of the consumption of foods within them. In keeping with the original goal of developing a highly flexible food guide, only lean or low-fat forms of foods without added fats or sugars were used to develop the food group nutrient profiles. For example, the nutrient profile for the meat group included lean cuts of meat trimmed of all the fat and poultry without skin. This approach allowed the determination of the numbers of servings of food groups needed to meet the objectives for nutritional adequacy while keeping low the levels of food components for which overconsumption was a concern. Ranges in the numbers of servings of food groups were established to cover the range of nutrient and energy intakes recommended for different sex and age groups. The energy provided by these food groups composed of low fat, lean choices without added fats or sugars ranged from about 1,200 to about 2,000 kcal. In the second phase of the process, the differences between the energy calculated as coming from the nutrient-dense food groups in phase 1 and the energy intakes recommended by the Food and Nutrition Board in 1980 (63) were used to determine the amounts of fats and sugars that could be added to the diet. The amount of discretionary fat—which included nondiscretionary fats from lean meats and poultry and fish and even the small amounts from grains, vegetables, and skim milk—that could be added was constrained to keep the total to below 30% of energy. In this way, it was thought that consumers would be free to choose the sources of fat they preferred, for example, higher fat meats or whole milk.

The new food guide “A Pattern for Daily Food Choices” was first presented to consumers in 1984 as part of the nutrition course “Better Eating for Better Health,” jointly developed by USDA and the American National Red Cross (67). The course, which consisted of six 2-hour sessions, was extensively evaluated and found effective with its par-

1984

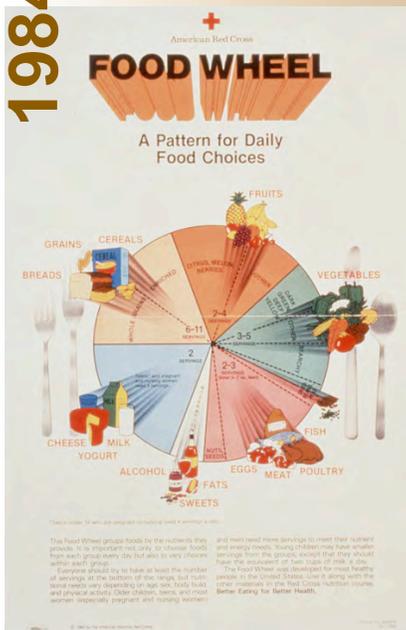


Figure 14. “A Pattern for Daily Food Choices” depicted the diet as a wheel. It was developed jointly by USDA and the American Red Cross in 1984.

1989



Figure 15. Educational materials related to the Dietary Guidelines for Americans included the “Eating Right ... the Dietary Guidelines Way” campaign of 1989.

ticipants, who were adults of various education and income levels. The food guide was shown graphically as a wheel (figure 14). As part of the Red Cross course, the Food Wheel was an effective tool for nutrition education. However, in a study conducted by The Pennsylvania State University in which focus groups of household food managers reviewed a selection of nutrition print materials, the food wheel graphic was rated as outdated and repetitive of the Basic Four information previously learned in school (68). Participants failed to notice that the familiar shape of the circle contained new guidance messages on the moderation of fat and added sugars. In an earlier study (69), household food managers were found to react negatively to nutrition materials that seem to focus only on food groups (variety message), because they perceived the information to be old and already known. However, adding information on the fat, sugars, and sodium content of foods to information on the importance of variety sparked their interest. In the Red Cross nutrition course, the graphic was seen in the context of the entire course in which considerable attention was given to implementation of all the Dietary Guidelines, including guidance on moderation. In

The Pennsylvania State University study, participants dismissed the circle shape as old without really looking at it. Clearly, the circle graphic for the new food guide was not going to be effective using an unmediated delivery mechanism.

In July 1989, the USDA nutrition education staff kicked off a very new type of educational effort—a media-targeted campaign called “Eating Right... the Dietary Guidelines Way.” All materials and communications were branded with the “Eating Right...the Dietary Guidelines Way” logo (figure 15). A market research company, Porter Novelli, guided us in the campaign. In the past, USDA had developed print materials and made them available to consumers through the Government Printing Office and to nutrition educators in the Cooperative Extension System and American Dietetic Association, who often reprinted the materials for their clients. This meant that materials were usually used exactly as they had been developed and that the audience generally consisted of people already interested in the subject matter, which made the potential impact somewhat limited. The new campaign was different in that it was directed to information mul-

tipliers, providing them with materials they could use to produce their own articles and educational efforts, thereby greatly increasing the potential reach.

Three phases of the campaign were conducted featuring three different themes. The first phase of the campaign featured the four colorful, magazine-style booklets published earlier in 1989 (49-52). The second phase of the campaign, which began in May 1990, featured 17 fact sheets on good sources of vitamins, minerals, and dietary fiber, and a booklet on the calorie content of foods. The third phase of the campaign, which began in November 1990, featured the newly released third edition of the Dietary Guidelines for Americans and new USDA survey data on food and nutrient intake by the population. USDA's new Food Guide in tabular form was included in all the campaign materials as well as in the 1990 Dietary Guidelines bulletin. A fourth phase of the campaign was scheduled to begin in April 1991 featuring the new food guide graphic that was in development. However, the campaign was canceled when the graphic was put on hold.

Major activities of the "Eating Right..." campaign included the release of press kits for each of the three phases of the campaign. The press kits included the featured items, stories on the topics covered in the featured items, story ideas, fact sheets, reproducible graphics and charts, information about the agency, as well as a list of contacts and their information. These were sent to over 3,000 major newspapers and magazines. Over 3,500 smaller newspapers received a "repro-booklet" of camera-ready stories and graphics. The broadcast media outreach involved over 100 TV and radio interviews broadcast in eight major U.S. media markets. The professional outreach targeted nearly 1,000 nutritionists, home economists, and health professionals through direct mailings, as well as over 15,000 professionals through presentations and exhibits at 15 professional meetings. A public-sector

outreach targeted each member of Congress and the Agriculture Commissioner and Governor in each State. Through the media portion of the campaign alone, a potential audience of nearly 150 million was reached. Counting only the pickup of which we were aware, more than 250 articles were printed in newspapers, magazines, and professional publications.

In recognition of the new proactive approach that USDA was taking in nutrition education, the American Dietetic Association awarded the agency its President's Circle Award for nutrition education in October 1991 at its 74th annual meeting. This award was created to recognize the development and dissemination of scientifically sound nutrition information that is unique in concept, creative in presentation, and free from specific commercial messages or endorsements. The nutrition education staff was very happy to win the first award for the Department from the American Dietetic Association. However, a food company charged USDA with copyright infringement for using the term "Eating Right..." because it sounded similar to the name of one of their products. The campaign was ended. However, the American Dietetic Association soon adopted the concept and has continued to use the slogan "Eat Right America."

One of the important things learned in the course of the "Eating Right..." campaign was that materials were needed that would convey as simply and concisely as possible what consumers needed to know in order to put the food guide into action. Work began in earnest in 1988 on what was hoped would be one of many publications on the food guide. The plan was for the first publication to contain an appealing graphic that would convey in a memorable way the key messages of the food guide—variety, proportionality, and moderation. This was a difficult task, because no food guide graphic had ever conveyed all three messages. Most

had been successful only at conveying the variety message. It was thought that variety could be easily conveyed by presenting the six categories of food in the food guide. It was deemed desirable that the graphic convey proportionality by presenting the relative amounts of food in the various food groups to eat daily. It was recognized that the most difficult message to convey would be moderation of fat, saturated fatty acids, added sugars, cholesterol, and sodium in relation to the total diet. It was hoped that by itself, the graphic would convey the simplest interpretation of variety, proportionality, and moderation, but that it would also arouse curiosity to learn more. The graphic was intended as a springboard for more indepth guidance rather than as a stand-alone piece.

Again, Porter Novelli was contracted to design a consumer bulletin devoted entirely to the new food guide and including an illustration of its key principles. Their first task was to evaluate comprehension and perceived usefulness of the new food guide with the target audience. The target audience for the food guide publication was to be the same as for the bulletin that presented the Dietary Guidelines for Americans, that is, adults with at least a high school education, who were not overly constrained by food cost concerns and who had eating patterns typical of the general U.S. population. Later developmental work and publications were to focus on other target audiences, such as low-income populations, young children, and groups with eating patterns distinctly different from the usual U.S. pattern.

In the first phase of Porter Novelli's work, four focus groups consisting of men or women 21 to 55 years of age were used to assess general familiarity with the basic concepts of the food guide and to comment on five different graphic presentations of the food guide. A circle graphic was perceived as unimaginative, old-fashioned, or providing information already known. Participants thought two graphics that used blocks rep-

resenting the minimum number of servings arranged in a circle or row did not convey enough information, because neither the ranges in the numbers of servings of the nutrient-dense food groups nor the fats, oils, and sweets group was shown. Clearly, the message of moderation was not conveyed by the block designs. An inverted pyramid design showing grains at the top and fats and added sugars at the bottom tip was disliked by many, because it was perceived as being precarious or off-balance. On the other hand, the pyramid design was well received. It was seen as new, interesting, and easy to remember. Therefore, the pyramid was selected for further development, because it was thought to best convey the key guidance principles of variety, balance, and moderation. The importance of the total diet was shown by the integrity of the geometric shape, in that if one of the food group blocks was removed, it would no longer be a geometric shape. Variety among food groups was shown by the individual names of the food groups and by their separate sections in the graphic. However, variety within food groups was shown by the pictures of several foods within each group. Proportionality or balance among the food groups was conveyed by the size of the food group sections in the graphic and the text indicating numbers of servings. Moderation of foods high in fat and added sugars was shown by the small size of the tip of the pyramid and the associated "use sparingly" text. Moderation related to food choices within the food groups was shown by the density of the fat and added sugars symbols in the food groups. The last message was very difficult to convey by the graphic alone. Because the graphic was already very complex, it was decided that the message about moderation in saturated fatty acids, cholesterol, and sodium would be conveyed in the text and not in the graphic.

In the second phase of Porter Novelli's work, using USDA's text, they designed a bulletin featuring the food guide pyramid. During the

fall of 1990, the brochure was reviewed to identify confusing or missing information in the text and to test several variations of the pyramid graphic. Focus groups consisting of men or women over 21 years of age were used—three groups 36 to 55 years of age and one group 56 years of age or older. The focus of the brochure on healthful eating was understood, and participants were positive about its purpose. However, concerns were raised about organization, length, and repetition of information. There was considerable controversy about the coverage of alcohol. As a result, the sections were reorganized and shortened, and discussion of alcohol was deemphasized. As had been shown in the first phase of the research, the pyramid shape appeared to easily convey the concept of variety, proportionality, and moderation. The participants clearly understood that guidance was being given on selecting foods from various food groups. Participants considered the pyramid illustration to clearly present the relative numbers of servings suggested for each food group. As one participant said, “One thing this pyramid idea gives you, as opposed to the Basic Four, is trying to remember how many servings of each—you look at it and you know you are supposed to eat more of the bread and cereal and less of the dairy. Plus the symbols show you where the fat is.” The message seemed to be clear.

Participants were most interested in the concept of moderation. During the development of the new food guide graphic, it was recognized that it would be difficult to communicate both the concept that fats and sugars are food components, chemical compounds that can be part of foods in several food groups, and the concept that fats, oils, and sweets are a separate food group high in fat and added sugars. The fat and added sugars symbols concentrated in the tip and sprinkled throughout the rest of the food groups were intended to show that foods in the fats, oils, and sweets group are concentrated sources of these chemical compounds

and that foods in other food groups can also be sources. The intent was that consumers would see both ways of moderating fat and added sugars in the total diet, that is, by moderating foods in the fats, oils, and sweets group and by moderating foods high in fats and added sugars in the other five food groups. There was considerable debate over whether pictures of high-fat and high-sugar foods should be used in the tip of the pyramid versus symbols for fat and added sugars alone. Using both created a very cluttered design. After reading the brochure, most participants agreed that the omission of the fat and added sugars symbols did not convey the same message as their inclusion. As one participant noted, “The one thing it did, which I thought was interesting, was that I don’t think we are aware of the oil and the sugar and the fats that are already in the foods, so that we don’t have to add to it.... I think it’s important, because I don’t think people realize how much is already in their foods.”

In the third phase of the work, further testing was done to ensure that the pyramid graphic would convey the key messages without accompanying text. Alternate designs for the cover of the brochure were also tested. Inclusion on the cover of a symbol indicating that fat should be limited to 30% of calories peaked interest. Sixty women, 30-75 years of age, were interviewed using a series of open-ended and rating questions. The conclusion was that the graphic communicated most of the intended messages to the target audience, even without accompanying text. The results indicated that although the meaning of the fat and added sugars symbols was not likely to be clear to everyone without accompanying text, the symbols were not distracting.

The Pattern for Daily Food Choices, developed in the early 1980s (65,66), was revised based on the 1990 Dietary Guidelines (58) and the 10th edition of the RDAs (54). The changes required were very minor (table 1).

During 1990 and 1991, the draft text of the bulletin and the pyramid sketches were sent for external peer review to over 30 nutrition educators. Although the food guide was presented only in tabular form in written materials accompanying the “Eating Right... The Dietary Guidelines Way” campaign, the graphic was presented and explained at professional conferences and in discussions with newspaper, magazine, radio, and television reporters. The draft food guide bulletin was also reviewed for consistency with the 1990 edition of the Dietary Guidelines for Americans by USDA’s Dietary Guidance Working Group and HHS’s corresponding committee. Preprint copies of “USDA’s Food Guide Pyramid” were approved by the Administrator of USDA’s Human Nutrition Information Service and the Assistant Secretary over the agency. The goal was to have what was to be called “USDA’s Food Guide Pyramid” text and graphic fully vetted among the professional community before its release as part of the “Eating Right...” campaign. Because of the long lead-time needed for textbook publishing, agency staff met with at least 30 publishers to arrange the substitution of the Pyramid for older food guides. In February 1991, page boards were sent to the printer, and availability was advertised by the Government Printing Office. The development of the food guide and the graphic was detailed in two publications (70,71).

In an unfortunate turn of events, an article by Malcolm Gladwell that included an illustration of the Pyramid appeared on the front page of the Washington Post on Saturday, April 13, 1991 (72). It incorrectly implied that USDA would be telling people to eat less meat and dairy products. The National Cattlemen’s Association was in Washington, DC, for its annual meeting and had scheduled a meeting with the new Secretary of Agriculture, Edward Madigan, on Monday morning. Subsequently, in letters to the Secretary, the National Milk Producers Federation joined the Cattlemen’s Association in demanding

that USDA withdraw the Pyramid because of the placement of their food groups in the graphic (73). They were concerned that they had not been informed or consulted about a new food guide to replace the Basic Four. Two weeks later, it was announced that the Pyramid would be withdrawn so that it could be tested with children and low-income groups. This testing had not been done, because these were not the target audiences for the publication. The news coverage was intense, most of it very negative for the Department. In fact, coverage continued over the next year through the first Gulf war. In early May, the House Committee on Government Operations requested that USDA provide all of its records concerning the Pyramid as a basis for holding hearings. In July, USDA’s Office of the Assistant Secretary for Food and Consumer Services announced that a contract had been signed with a consulting firm to conduct further research to test graphic alternatives to the Pyramid. The staff that had produced the Pyramid was not involved in the research.

Initial focus group research with different graphic designs produced ambiguous results. USDA’s Office of the Assistant Secretary for Food and Consumer Services, along with HHS, contracted for more research to be done. This research was conducted in two phases—qualitative and quantitative. In the qualitative phase of the work, a total of 26 focus groups were conducted including 84 children in grades 5, 8, and 11, and 67 adults in two age groups on food assistance programs. Three racial/ethnic groups were included—Black, White, and Hispanic—and work was conducted in three cities across the country. Three special focus groups were also conducted—one with the elementary and secondary school teachers of science and home economics, one with food industry representatives associated with various commodity groups, and one with representatives of several professional associations and advocacy groups. One-on-one, structured interviews were also conducted—21 interviews

1992

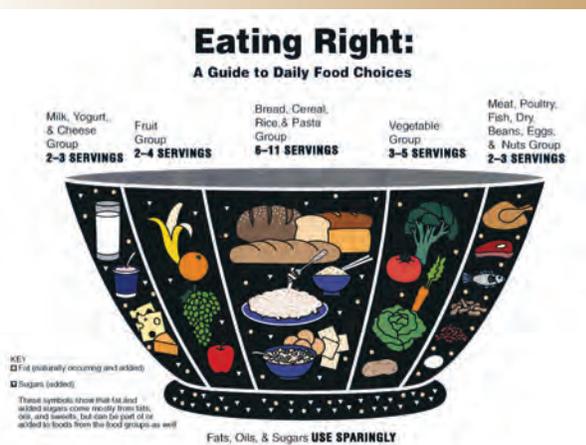


Figure 16. During development of the Food Guide Pyramid, one of the graphics tested in 1991 and rejected after consumer testing was this bowl.

1992

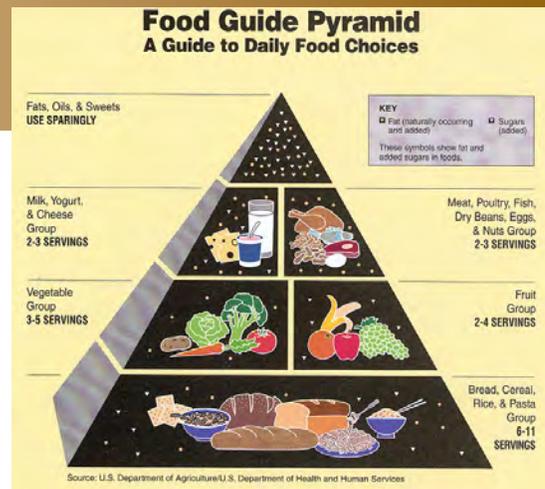


Figure 17. The Food Guide Pyramid released in 1992 garnered high recognition among the U.S. public and was widely adopted by the food industry.

with children in grades 5, 8, and 11, and another 21 with adult participants in the Food Stamp Program. Several alternative graphics were tested, such as two variations on the pyramid, 10 variations on a bowl, and several pie charts and shopping carts. Initially, a right triangle and a quarter-circle were reviewed, but they were eliminated because it was impossible to make the milk group and the meat group the same size. Final testing was done on a bowl (figure 16) and a pyramid (figure 17). In summary, the focus groups evaluated the effectiveness of the graphics in conveying variety, proportionality, and moderation differently. The pyramid was rated highest by the focus groups of children, teachers, and the professional/advocacy group. Although the food industry group did not think the bowl designs conveyed proportionality well, they liked the vertically divided bowl design, because it did not stack foods.

The quantitative phase of the research was designed to measure the relative ability of the pyramid and the bowl to communicate the key concepts of the food guide—variety, proportionality, and moderation. Over 3,000 individuals were interviewed at five sites

across the country. For analytical purposes, the sample population was grouped by education level, gender, and race/ethnicity; adults were grouped by household income; and children were grouped by whether or not they received free or reduced-price school lunches. The test instrument was a structured questionnaire consisting of 60 questions. The initial data analysis that was reported to the Departments in January 1992 indicated that the effects of the bowl and the pyramid were virtually indistinguishable, but that children, minorities, and low-income adults preferred the bowl design because they associated it with food.

At this point, the USDA's Office of the Assistant Secretary in charge appointed an external expert committee composed of highly respected nutrition experts. This committee recommended that the original staff that produced the Food Guide Pyramid be brought in to review the research report. An internal committee was formed composed of nutritionists from several USDA agencies and from HHS. The committee recommended that the data be reanalyzed, correcting several serious mistakes and using a scoring system weighted to emphasize the con-

1992

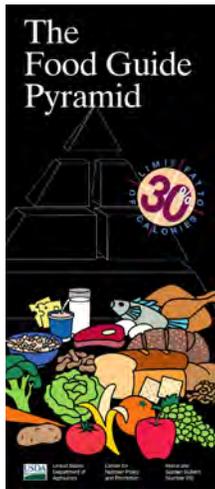


Figure 18. Additional consumer outreach materials were created for the Food Guide Pyramid. This 1992 brochure highlighted restriction of fat to no more than 30 percent of daily calories.

1999

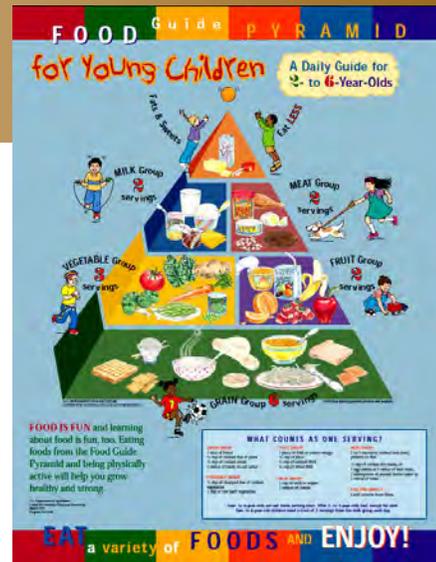


Figure 19. The Food Guide Pyramid was adapted in 1999 for children aged 2-6 years.

cepts of proportionality and moderation. The relatively simple variety concept had been tested by only one question that involved the respondents to read the names of the food groups. With this question, no difference was found between the bowl and the pyramid designs. However, for the concepts of proportionality and moderation, the pyramid was found superior, with the differences being large and highly significant. Earlier concerns that consumers would incorrectly see foods at the top of the pyramid as being superior to those at the bottom were not supported. In fact, the bowl design was found to convey more misinformation. The internal review committee sent a letter to the Deputy Assistant Secretary stating that the research would only support adoption of the pyramid graphic.

Release of the Food Guide Pyramid graphic was jointly announced by the Secretaries of USDA and HHS on April 28, 1992 (figure 17). Secretary of Agriculture Edward Madigan explained that great care had been taken in research to ensure that the message sent to children and low-income people was understandable. He clearly defined the 33 changes that had been made in the

original pyramid. For example, the scoop of elbow macaroni in the breads and cereals group was replaced by a plate of spaghetti, the purple cabbage was replaced by green cabbage, peanuts were added to the illustrations in the meat group, the wheat stalk was eliminated from the breads and cereal group, and whole grain products were added. Ironically, the negative publicity surrounding the cancellation of the original Pyramid in 1991 drew public attention to the 1992 release. Release of the slightly modified Pyramid in 1992 was accompanied by a press conference and front-page newspaper and broadcast news coverage. The graphic was immediately picked up by the media and by educators including kindergarten teachers. The food industry used it on labels and in advertising. Many other countries used the graphic design to present their own food guides. There was even a dog nutrition pyramid. In October 1992, USDA released the bulletin presenting the Food Guide Pyramid (figure 18) (74).

In October 1993, the USDA staff who developed the Pyramid was again awarded the President's Circle Award for nutrition education by the American Dietetic Associa-

tion. On hand to accept the award with the author were Fran Cronin, Anne Shaw, and Sally Kott from USDA's Information Office, and Dan Snyder from Porter Novelli. Carole Davis, who was part of the development team, was not able to attend. Writing in 1998, Marion Nestle said, "In its six years of existence, the Pyramid has become the most widely distributed and best recognized nutrition education device ever produced in this country. It appears in nutrition education materials, posters and textbooks, in advertisements and package labels, and cookbooks, and on board games. It is recognized by an astonishing 67% or more of American adults. It is demonstratively iconographic as it has spawned numerous analogs illustrating specific dietary patterns. By any criterion of recognition or dissemination, the Pyramid has been highly influential." (75).

In some ways, the Pyramid has been a victim of its own success. The graphic was so easy to understand and use as a teaching tool that it was often used without any recognition of the text that was supposed to accompany it. For example, in the bulletin, it was explained that the lower numbers of servings in the recommended ranges were for lower calorie diets (about 1,600 calories), and the higher number of servings were for higher calorie diets (about 2,800 calories). Further, the meaning of a serving was explained. In the bulletin, it was recommended that people choose several servings a day of foods made from whole grains. Advice was given on how to avoid too much saturated fat, cholesterol, and sodium. Throughout the bulletin, recommendations were given for choosing foods in each food group lower in total fat and added sugars, essentially promoting the nutrient density concept. These messages and others were lost when only the graphic was used. As had been originally intended, research was conducted on a graphic presentation of the food guide for young children, and in 1999, a graphic presenting the "Food Guide Pyramid for Young Children: A Daily Guide for 2-6 Year-Olds"

(figure 19) was released by USDA's Center for Nutrition Policy and Promotion (76).

In August 1994, USDA and HHS appointed an 11-member Dietary Guidelines Advisory Committee to review the 1990 edition of the Guidelines. This set of guidelines was the first to be developed after the process had been made mandatory by the National Nutrition Monitoring and Related Research Act of 1990. The Advisory Committee members were Doris Calloway (Chair), Richard Havel (Vice-Chair), Dennis Bier, William Dietz, Cutberto Garza, Shiriki Kumanyika, Marion Nestle, Irwin Rosenberg, Sachiko St. Jeor, Barbara Schneeman, and John Suttie. The HHS Executive Secretaries were Linda Meyers and Karil Bialostosky, the USDA Executive Secretaries Eileen Kennedy and Debra Reed. The Committee held three meetings that were announced in the Federal Register and open to the public. The Committee also received oral and written comments from the public. In June 1995, the Advisory Committee submitted its report to the Secretaries of USDA and HHS (77). Specific wording for the consumer bulletin was recommended, and the rationale for each of the changes suggested was given. USDA and HHS accepted the recommended revisions to the 1990 Dietary Guidelines without substantive change. On January 2, 1996, Agriculture Secretary Dan Glickman and HHS Secretary Donna Shalala announced the release of the 43-page fourth edition of the Dietary Guidelines for Americans (figure 13) (78). Although the 1990 edition of the Guidelines included USDA's food guide in tabular form, the 1995 edition featured the pyramid graphic, as well as considerable text explaining what a serving is and how to use the food guide. The goal was to place emphasis on the total diet. For example, the guideline "Use sugars only in moderation" was changed to "Choose a diet moderate in sugars." One of the most important changes was the emphasis, for the first time, on physical activity as well as diet. A specific recommendation was given to accumulate 30 minutes or more of mod-

erate physical activity on most, preferably all, days of the week, and examples of moderate physical activity were given. A healthy weight chart and information on food labels were included for the first time.

The Period 1995-2011

In 1998, the Secretaries of USDA and HHS appointed an 11-member Dietary Guidelines Advisory Committee to review the 1995 Dietary Guidelines for Americans and recommend what changes, if any, should be made. The Committee consisted of Cutberto Garza (Chair), Suzanne Murphy (Vice-Chair), Richard Deckelbaum, Johanna Dwyer, Scott Grundy, Rachel Johnson, Shiriki Kumanyika, Alice Lichtenstein, Meir Stampfer, Lesley Tinker, and Roland Weinsier. The Executive Secretaries from USDA were Carole Davis and Shanthy Bowman, and from HHS Kathryn McMurry and Joan Lyon. The Committee held four meetings that were announced in the Federal Register and open to the public. The Committee also received oral and written comments from the public. On June 20, 2000, the Advisory Committee submitted its 79-page report to the Secretaries of USDA and HHS (79). Specific wording for the consumer bulletin was recommended, and the rationale for each of the changes suggested was given. USDA and HHS accepted the recommended revisions to the 1995 Dietary Guidelines without substantive change. On May 27, 2000, USDA Secretary Dan Glickman and HHS Secretary Donna Shalala released a 40-page booklet for professionals (figure 13) (80) and a 10-page brochure for consumers (81) in English and Spanish. This marked a highly significant change in the process for developing the guidelines. Instead of a two-step process, a three-step process was used. The step added was the development of a policy document in between the Advisory Committee report and the consumer brochure. The policy document was developed by USDA and HHS to interpret the Advisory Committee's report for

policymakers, especially those who set Federal food-related policies, health professionals, the food industry, and highly interested consumers. It was longer and contained more detailed and complex information than the consumer bulletin. On the other hand, the brochure designed for consumers was shortened and somewhat simplified. In addition, the consumer brochure was formatted in a way that could be easily reproduced. This, along with other support materials, was made available on the Center for Nutrition Policy and Promotion's Web site at <http://www.cnpp.usda.gov/DietaryGuidelines.htm>.

President Bill Clinton announced the new guidelines in his radio address. He specifically mentioned the importance of including whole-grain foods and a variety of fruits and vegetables every day and moderating saturated fat, cholesterol, sugars, salt, and alcohol in the diet. He also mentioned the most important change in the Dietary Guidelines—the inclusion of two new guidelines. One emphasized the importance of handling and storing food safely, and the other emphasized the enormous benefits of physical activity. A major change was also made in the way in which the Guidelines were organized and presented. They were clustered into three groups: Aim for fitness, Build a healthy base, and Choose sensibly—the ABCs of good health. The “Aim for fitness” cluster included a guideline on healthy weight and one on physical activity. As in the 1995 Guidelines, 30 minutes of moderate activity on most days of the week was recommended. An emphasis was placed on making physical activity part of the daily routine. In the “Build a healthy base” cluster, the “Eat a variety of foods” guideline that had been in the first four editions on the Dietary Guidelines was changed to “Let the Pyramid guide your food choices.” Extensive information was included on the Pyramid in both the booklet for professionals and the brochure for consumers. For example, charts showing the number of servings

recommended at three calorie levels and examples of what counts as a serving were included. As in the 1995 Guidelines, the Pyramid graphic was included, but this time, the Pyramid for children was also included. The guideline on choosing a diet with plenty of grain products, vegetables, and fruits was split into two guidelines to give further emphasis to whole-grain products. The guideline on food safety was included in this cluster. The “Choose sensibly” cluster included guidelines on saturated fat, cholesterol, and total fat, sugars, salt, and alcoholic beverages. The total number of guidelines increased, for the first time, from 7 to 10.

On May 15, 2003, HHS and USDA announced in the Federal Register (82) the intent to establish the 2005 Dietary Guidelines Advisory Committee and to solicit nominations for membership. The 13-member committee consisted of Janet King (Chair), Lawrence Appel, Yvonne Bronner, Benjamin Caballero, Carlos Camargo, Fergus Clydesdale, Vay Liang Go, Penny Kris-Etherton, Joanne Lupton, Theresa Nicklas, Russell Pate, F. Xavier Pi-Sunyer, and Connie Weaver. The Executive Secretaries from USDA were Carole Davis and Pamela Pehrsson, and from HHS Kathryn McMurry and Karyl Rattay. The Committee used a very different approach for establishing the new Dietary Guidelines. Rather than considering how the year 2000 *Dietary Guidelines* should be changed, the Committee posed a large number of questions. Questions were prioritized, and an extensive search of the scientific literature was done. The Committee worked closely with the USDA staff to see if nutrient recommendations could be met with the current or a revised Food Guide Pyramid. They also invited experts to make presentations on controversial issues. In a change from the past, they addressed some of the dietary issues related to the increase in the population of older and more overweight people who have chronic, diet-related diseases. They utilized the concept of “discretionary calories,” which meant, as in the Food Guide

Pyramid dietary pattern, those calories remaining within a person’s caloric allowance after all nutrient recommendations are met. In a departure from previous editions of the Guidelines, a specific message concerning sugars was dropped. The rationale for limiting one’s intake of added sugars was reorganized to be included in guidance about choosing carbohydrates wisely, staying within energy needs and controlling calorie intake. The Committee held five public meetings that were announced in the Federal Register. They were open to the public, and written and oral public comment was sought. On August 19, 2004, the Committee submitted an extensive, well-documented report to HHS Secretary Tommy Thompson and USDA Secretary Ann Veneman (83). Specific wording was recommended for the Dietary Guidelines, and 27 recommendations were made for future research.

Based on the Advisory Committee report, USDA and HHS developed the 70-page 2005 Dietary Guidelines for Americans (figure 13) (84). As in 2000, this document was directed to policymakers and professionals. It gave 41 key recommendations—23 for the general public and 18 for groups with special needs. These were grouped under the following nine major messages:

- Consume a variety of foods within and among the basic food groups while staying within energy needs.
- Control calorie intake to manage body weight.
- Be physically active every day.
- Increase daily intake of fruits and vegetables, whole grains, and nonfat or low-fat milk and milk products.
- Choose fats wisely for good health.
- Choose carbohydrates wisely for good health.
- Choose and prepare foods with little salt.
- If you drink alcoholic beverages, do so in moderation.
- Keep food safe to eat.

At the same time as the release of the policy document, a 10-page consumer brochure was released (85). The many recommendations in the policy document were summarized in three key messages:

- Make smart choices from every food group.
- Find your balance between food and physical activity.
- Get the most nutrition out of your calories.

Special cautions were also added about food safety and alcohol consumption. The rationale behind this three-step development process for the Dietary Guidelines was to give policymakers and professionals the basis on which they could make decisions or develop education and information programs.

While the consumer bulletin contained advice on choosing foods wisely, it did not suggest a food guide. But in the appendix to the 2005 Dietary Guidelines policy document, two diet plans were given: the DASH (Dietary Approaches to Stop Hypertension) from HHS and a plan from USDA. The latter was a revision of the food plan used for the Pyramid (84). The original Food Guide Pyramid was meant to be evolutionary (71). It was recognized that the guide would need to be updated as nutrient recommendations, data on food consumption, and data on the nutrient content of food changed. In 2000, Shaw, Escobar, and Davis published an article that presented a six-step decision-making tree that would lead to a final decision as to whether or not USDA's food guide should be revised (86). The first two steps in the decisionmaking tree identified the specific source and nature of new nutrition standards and considered data on the prevalence of inadequate intakes in the population. The goal here was to establish priorities for changing the food guide. For example, if a large change in a nutrient standard was recommended by a highly reputable source, and there was evidence of inadequate intake by the population, then consideration of a

change in the food guide would be a high priority. The third step assessed the ability of current food guide recommendations to meet the proposed new nutrient standards. If the current food guide did not meet the proposed standards, then a fourth step was carried out in which changes in the food guide to meet the standards were systematically tested. The fifth step considered the consistency of any potential modifications with the objectives of practicality and usefulness. A final step recognized that some nutrient recommendations may have no feasible dietary solution and that supplements must be considered.

This decisionmaking process was used to begin revision of the food patterns used in the Food Guide Pyramid shortly after the release of the 2000 Dietary Guidelines for Americans. As in the development of earlier food guides, the most current dietary recommendations, food consumption, and food composition data were used in the development process. The process was even more open and transparent than it had been in the past. For example, nutritional goals for each age/gender group were published in the Federal Register for comment by professionals and the public in September 2003 (87). When the Dietary Guidelines Advisory Committee for development of the 2005 Dietary Guidelines was formed in 2003, collaboration between USDA and the Committee also began on development of a food guide pattern (88). The technical research that was undertaken and that resulted in the revision of the original Pyramid food intake patterns has been well documented (89,90). Recommendations were made for food group intake for 10-calorie levels ranging from 1,000 to 3,200. For ease of comparison with the Food Guide Pyramid, table 1 shows the pattern for a 2,200-calorie diet.

The Food Guide Pyramid graphic itself was also a concern. It was questioned whether the original Food Guide Pyramid graphic could convey some new concepts, such as

the increased emphasis on physical activity, types of fatty acids, and whole grains. There was also concern about consumer misinterpretation of serving sizes and vegetable subgroups. Consumer research on the ability of the original graphic to convey these messages has been detailed by Britten et al. (91). Rather than increasing complexity of the graphic, a decision was made to create a new graphic that would be used to “brand” food guidance messages and materials to remind consumers to make healthy food choices. Instead of having the graphic itself be used as a teaching tool, a series of educational tools were developed. The widespread use of the Internet and the ability to personalize educational messages and to keep the information current all made the Internet the best choice for the development of educational tools. An overall communications plan for the consumer interface of the new food guidance system was outlined in a July 2004 Federal Register notice (92).

Work on the development of a new graphic began in October 2004 under contract to Porter Novelli, the communications firm that had developed the original pyramid graphic (93). More than 10 graphic presentations and 7 slogans were tested using focus groups and an innovative Internet interview technique. Participants ranged in age from 21 to 60. They represented a mix of education level, marital status, and household income. Low-income groups were not targeted, and children were not included. The consumers that were tested expressed a desire for continuity, as represented by the pyramid shape, as well as a desire for updated information. In this author’s view, the widespread use and familiarity of the original Food Guide Pyramid released in 1992 seems to have made people think of it as old. (There were instances where people in their 50s commented that they remembered learning about the Pyramid in grade school!) Consumer testing also revealed that images that were personal, active, and motivational were well received. The graphic chosen was



Figure 20. The Food Guide Pyramid transitioned to MyPyramid in 2005 and incorporated physical activity as a theme to combat increasing obesity.

a pyramid shape with vertical color bands to represent food groups and a figure of a person walking up the steps to indicate physical activity (figure 20). The slogan chosen was “Steps to a Healthier You.”

The seminal feature of the MyPyramid Guidance System that sets it apart from earlier food guides is its ability to utilize the Internet to personalize dietary guidance. Numerous educational tools are now available and continue to be added to the Web site <http://www.choosemyplate.gov/tools.html>. Some examples include “The Daily Food Plan,” which allows consumers to enter their age, gender, height, weight, and activity level to get a personalized food plan. “MyPyramid Tracker” allows consumers to get an assessment of their current eating and physical activity patterns. Food patterns specific for pregnant and lactating women have been developed. Special materials have also been developed for children, including a graphic, classroom materials, and an interactive computer game. On June 10, 2008, a “corporate challenge” was announced with the purpose of forming partnerships with industry to encourage their use of MyPyramid messages in promoting healthy food and life-

style choices. These interactive tools are still available, but the graphic has been changed to MyPlate.

For the 2010 edition of the Dietary Guidelines for Americans, USDA and HHS appointed an Advisory Committee of 13 nationally recognized experts in nutrition and health to review the 2005 edition of the Guidelines to determine if and what revisions were needed. Committee members were Linda Van Horn (Chair), Naomi K. Fukagawa (Vice-Chair), Cheryl Achterberg, Lawrence Appel, Roger Clemens, Miriam Nelson, Sharon Nickols-Richardson, Thomas Pearson, Rafael Pérez-Escamilla, Xavier Pi-Sunyer, Eric Rimm, Joanne Slavin, and Christine Williams. Between October 2008 and May 2010, the Advisory Committee held six public meetings. The final report was submitted to the Secretaries of USDA and HHS in June 2010 (94). The process for development of the 2010 Advisory Committee Report differed from the past in two important ways. First, the transparency of the process was greatly increased by the use of webinars to broadcast meetings and the availability of all materials presented at the meeting and transcripts of all discussion via the Internet (<http://www.cnpp.usda.gov/dietaryguidelines.htm>). Consequently, awareness by the scientific community and the public was increased. A second important difference was the implementation of USDA's Nutrition Evidence Library, which uses a rigorous, systematic process to review literature to answer specific questions related to guidance issues. The scientific community across the country was involved in the process through a review of scientific articles using the evidence-based systematic process. All of this information is available to the public on the USDA Web site www.NEL.gov so that the process and the rationale for the conclusions drawn by the Advisory Committee can be transparent. While the recommendations made in the report were consistent with those in past reports, they differed in two important ways. First, great emphasis

was placed on obesity; and second, the role of the environment in influencing food choices and physical activity was recognized.

An opportunity for public comment on the Advisory Committee Report was provided by a request for comment published in the Federal Register and a public meeting with opportunity to provide oral testimony. Comment was also solicited from USDA and HHS agencies on potential policy implications of the Report. Based on all of this, USDA and HHS nutritionists began the process of translating the Advisory Committee Report into a Federal policy document intended for use by professionals in the development of policy and consumer materials and strategies. The final draft was reviewed by an external group of academicians to ensure the accuracy and clarity of the translation and was cleared by the two Departments. USDA Secretary Tom Vilsack and HHS Secretary Kathleen Sebelius jointly released the 112-page 2010 Dietary Guidelines for Americans on January 31, 2011 (95).

The Policy Document includes 23 key recommendations for the general population and 6 for subpopulation groups. There are two overarching concepts. The first is maintaining calorie balance over time to achieve and sustain a healthy weight, which can be accomplished by controlling calorie intake through monitoring food and beverage intake, physical activity, and body weight; by reducing portion sizes; by making better choices when eating out; by limiting screen time; and by increasing physical activity and avoiding inactivity. The second is focusing on consuming nutrient-dense foods and beverages, which can be accomplished by increasing intake of vegetables and fruits, whole grains, fat-free and low-fat dairy products, and seafood; and by reducing intake of foods and beverages high in solid fats, added sugars, and sodium and by replacing these foods with nutrient-dense foods and beverages while staying within calorie needs.

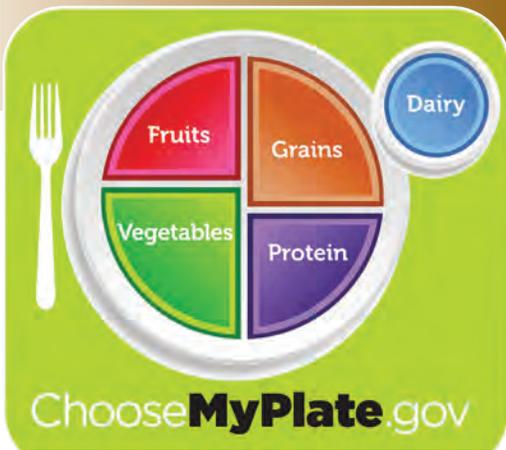


Figure 21. MyPlate replaced MyPyramid in 2010 providing a more intuitive visual representation of the approximate servings of recommended food groups.

The Policy Document also provides USDA's suggested food patterns for achieving the recommendations using the USDA food patterns at various calorie levels with alternate vegetarian patterns and HHS's DASH diet (Dietary Approaches to Stop Hypertension).

As part of the communication strategy to increase awareness of the Dietary Guidelines for Americans, USDA's Center for Nutrition Policy and Promotion (CNPP) has posted several consumer pieces on its Web site including a brochure, menus, recipes, and tips (<http://www.choosemyplate.gov/ipsresources/printmaterials.html>). Also available on this Web site are graphics of USDA's new icon, MyPlate (figure 21). It is not intended to be a teaching tool as the first Food Guide Pyramid had been, but rather a "memory jog" to remind consumers to have a healthy diet. The message to make half your plate fruits and vegetables is especially clear. It is expected that the consumer research done to develop the icon will be published soon.

As in the past, one of the most important resources in getting nutrition education messages to consumers is the Cooperative Extension System established in 1914. Over

the years, information needs have become more specialized, and the Internet has become an increasingly important method of communication. Recently, the Cooperative Extension System, in partnership with USDA, has established interactive, virtual centers of excellence, called "Communities of Practice," on topics of greatest interest to consumers. One Community of Practice on nutrition, called "Families, Food and Fitness," focuses on obesity prevention (http://www.extension.org/families_food_fitness). More than 300 Extension professionals provide answers to questions, short articles, recipes, videos, and interactive tools. The information is organized around six topics known to be related to obesity prevention—fruits and vegetables, physical activity, preparing and eating more meals at home, beverages, portion size, and sedentary behavior. All information is peer reviewed before it is released.

Future

Current interest in obesity as a major health risk is high and likely to continue well into the future. This influences the content of nutrition education messages. Approximately 17% (or 12.5 million) of children and adolescents aged 2-19 years are obese (<http://www.cdc.gov/obesity/childhood/data.html>). The problem is worse among African-American and Hispanic children. The Obama Administration has taken a great interest in childhood obesity. On February 9, 2010, First Lady Michelle Obama initiated the *Let's Move!* Campaign (<http://www.letsmove.gov/about>). The goal is to solve the challenge of childhood obesity within a generation. It will focus on giving parents helpful information, fostering environments that support healthy choices, providing healthier foods in schools, ensuring that families have access to healthy, affordable food, and helping kids become more physically active. Also on February 9, 2010, President Obama signed a memorandum

establishing a new interagency Task Force on Childhood Obesity, which delivered a report to the President 90 days later. The report detailed an interagency plan including key benchmarks and an action plan. A progress report was delivered to the President in February 2011 (http://www.letsmove.gov/sites/letsmove.gov/files/TaskForce_on_Childhood_Obesity_May2010_FullReport.pdf).

New research on the factors that influence obesity and new research on the best strategies for preventing obesity can also influence the nutrition education message. The National Collaborative on Childhood Obesity Research (NCCOR), which began in 2009, is an ongoing collaboration among the USDA, the Centers for Disease Control and Prevention, the National Institutes of Health, and the Robert Wood Johnson Foundation (<http://www.nccor.org/index.html>). Its mission is to maximize outcomes from research, build capacity for research and surveillance, create and support the mechanisms and infrastructure needed for research translation and dissemination and support evaluations. Two very useful products were released in 2011. The Measures Registry is a searchable database of diet and physical activity measures relevant to childhood obesity research. The Catalogue of Surveillance Systems provides pertinent information about existing surveillance systems that contain data relevant to childhood obesity research. Users can identify and compare surveillance systems to meet their research needs, and they can get information about how to obtain the data.

New research that leads to the establishment of new nutrient and dietary recommendations can influence the nutrition education message. A Federal interagency Dietary Reference Intakes Steering Committee is considering the factors in deciding when to initiate the process to revise the Dietary Reference Intake (DRI) for a specific nutrient. Primary factors are the availability

of new, high-quality research data and concern about consumption by the public.

New research that leads to the establishment of new dietary patterns that are the basis of USDA food guides can influence the nutrition education message. CNPP has initiated a systematic, evidence-based review of the process for developing the dietary patterns for its Nutrition Evidence Library (<http://www.nel.gov/>). Interagency groups of technical experts and stakeholders have been established to guide the review process.

Commentary

In 1996, in a chapter on the different ways in which nutrient standards, dietary guidelines, and food guides define a healthful diet (96), I expressed the hope that the very distinct and separate processes used to develop the RDAs, the Dietary Guidelines for Americans, and USDA's food guides would come together. It is my belief that they have. The Institute of Medicine (IOM) devoted two volumes to guidance on the appropriate use of the Dietary Reference Intakes in planning and evaluating diets of individuals and groups (21). The 2005, 2010 Dietary Guidelines Advisory Committees used new nutrient standards published by the IOM, and the Committees worked with the USDA staff using mathematical modeling techniques to develop food intake patterns that would meet the nutrient standards (88). The development process for USDA's food guide patterns takes into account both the Dietary Guidelines for Americans and the IOM's nutrient standards and their guidance on how to use these standards. The coming together of these very important distinct but interrelated activities creates a synergy, which I hope will continue. I speculated in 1996 that recommendations for a healthful diet would become more personalized. I was thinking then of nutrient standards and dietary guidelines. To a small extent, this

is also beginning to happen, with guidance being given for some segments of the population. I did not imagine then how personalized food guides would become. The use of the Internet with MyPyramid and MyPlate has enabled food guides to be personalized by age, sex, height, weight, and activity level, and individuals to track their progress in relation to guidance. Millions of people are being reached in a way that was not possible before. The research base for all these activities gets better and stronger, but the primary challenge remains, as it did when Atwater initiated the scientific basis for dietary guidance, to put into practice what we already know.

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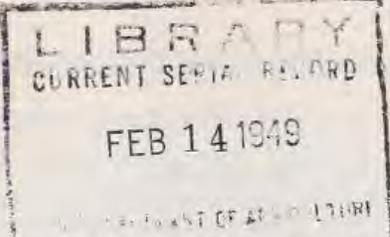
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REPORT OF THE CHIEF OF THE BUREAU OF HUMAN NUTRITION AND HOME ECONOMICS, AGRICULTURAL RESEARCH ADMINISTRATION, 1948

UNITED STATES DEPARTMENT OF AGRICULTURE,
Washington, D. C., September 28, 1948.

Dr. P. V. CARDON,
Agricultural Research Administrator.

DEAR DR. CARDON: I submit herewith the report of the Bureau of Human Nutrition and Home Economics for the fiscal year ended June 30, 1948.

Sincerely,

HAZEL K. STIEBELING,
Chief.

CONTENTS

	Page		Page
Food and nutrition.....	2	Family economics—Continued	
Food composition.....	2	Economic data for Outlook	
Home food preparation.....	4	Conferences.....	12
Home canning.....	5	Housing and household equipment..	13
Home freezing.....	6	Development of new farmhouse	
School lunch recipes.....	6	plans.....	13
Nutritional requirements.....	7	Step-saving kitchen plans.....	13
Family economics.....	8	Pressure saucepans.....	14
Food consumption in cities.....	8	Cooking utensils.....	14
How families use their incomes..	9	Textiles and clothing.....	15
Adjustments of rural families to		Quality of fabrics in retail mar-	
economic change.....	11	kets.....	15
Consumption of home-produced		Fabric deterioration.....	15
food.....	11	Clothing construction.....	16
Meal patterns on the farm.....	12	Publishing results.....	16

The Bureau of Human Nutrition and Home Economics completed on June 30, 1948, its first quarter century of research on behalf of the Nation's homemakers.

In June 1923 the Secretary of Agriculture announced that "pursuant to provisions contained in the Agricultural Appropriations Act for the fiscal year 1924" the Office of Home Economics would become the Bureau of Home Economics on July 1, 1923. Eight leaders in home economics whom he had invited to help plan the organization of the new agency recommended the following divisions of work: Food and nutrition, clothing and textiles, economics (including household management), housing and equipment, home relations, art in the home. The research program of the Bureau today is concerned primarily with the first four of these fields.

CHAPTER 8

Coordination of Human Nutrition Research Activities at the U.S. Department of Agriculture

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Abbreviations

AMS	Agricultural Marketing Service
ARS	Agricultural Research Service
CDC	Centers for Disease Control and Prevention
CFEI	Consumer and Food Economics Institute
CFSAN	Center for Food Safety and Applied Nutrition
CNPP	Center for Nutrition Policy and Promotion
CSFII	Continuing Survey of Food Intakes by Individuals
CSFP	Commodity Supplemental Food Program
CSREES	Cooperative State Research, Education, and Extension Service
CSRS	Cooperative State Research Service
Delta NIRI	Lower Mississippi Delta Nutrition Intervention Research Initiative
DHHS	Department of Health and Human Services
ERS	Economic Research Service
ES	Extension Service

FDA	Food and Drug Administration
FNB	Food and Nutrition Board
GFHNRC	Grand Forks Human Nutrition Research Center
HEW	Health, Education and Welfare
HNIS	Human Nutrition Information Service
HNRD	Human Nutrition Research Division
HNRIM	Human Nutrition Research Information and Management
HSRS	Human Subjects Research Subcommittee
ICHNR	Interagency Committee on Human Nutrition Research
IPA	Intergovernmental Personnel Act
JMNEC	Joint Nutrition Monitoring Evaluation Committee
JSHNR	Joint Subcommittee on Human Nutrition Research
NAL	National Agricultural Library
NAREEEAB	National Agricultural Research, Extension, Education, and Economics Advisory Board
NCHS	National Center for Health Statistics
NHANES	National Health and Nutrition Examination Survey
NIDDK	National Institute of Diabetes and Digestive and Kidney Diseases
NIFA	National Institute of Food and Agriculture
NIH	National Institutes of Health
NLEA	National Labeling and Education Act
NPL	National Program Leader
OSTP	Office of Science and Technology Policy
RDA's	Recommended Dietary Allowances
SACHRP	Department of Health and Human Services Secretaries Advisory Committee on Human Research Protection
SEA	Science and Education Administration
UC-Davis	University of California-Davis Campus
USAID	U.S. Agency for International Development
USDA	U.S. Department of Agriculture
WIC	Special Supplemental Nutrition Program for Women, Infants, and Children

Introduction

Funding for human nutrition research and other activities is secured through Congressional action and usually authorized in a Farm Bill that is negotiated and passed approximately every 5 years. Background information for Congressional action was frequently obtained through Congressional Committee hearings, such as the Senate Select Committee on Nutrition and Related Human Needs. Highlights of some of these negotiations are presented in some of the earlier chapters. Human nutrition research and related activities, by their nature, are multidisciplinary endeavors and require coordination from the outset. With the involvement of only a few Federal agencies and a relatively small budget, early coordination activities were easily incorporated with “line management” (program, budget, etc). However, as human nutrition research became increasingly complex and expansive, as ARS moved to decentralized “line management,” and as USDA was given the responsibility for coordination of human nutrition research within the Federal Government, these coordinating and program direction activities were vested in ARS’s National Program Staff. It is within this staff that the National Program Leaders (NPL) for Human Nutrition functioned. This chapter outlines the committees and working groups that have been developed to successfully coordinate the many human nutrition programs sponsored by the Federal system and the National Program Leaders responsible for this activity. A summary of USDA budgets for human nutrition activities also is presented by quinquennial increments starting with FY1978.

Congressional Action in Support of USDA Human Nutrition Research—Selected Examples

During a difficult domestic economic period, Congress appropriated \$10,000 in 1885 to initiate human nutrition research programs in the United States. This action was brought about by a recommendation from Secretary of Agriculture J. Sterling Morton, encouragement of businessman Edward T. Atkinson, and vision for specific programs by W.O. Atwater (1). A decade later, Atwater successfully requested that his collaborators at the States’ Experiment Stations and many of his colleagues support the recommendation of USDA for a 50-percent increase in appropriations. By 1901, similar activity increased the budget to \$20,000 (1). Later in the 20th century, consumer demand for information on preservation of foods and information leading to development of “complete” diets for soldiers during World War I provided political pressure to further increase appropriations and firmly launch the Human Nutrition Program within USDA.

An important landmark event for human nutrition in the United States was the National Nutrition Conference for Defense convened by President Franklin D Roosevelt in 1941. This conference had its origin when approximately 40% of the men physically examined under the Selected Service Act were found unfit for military service (2). As many as one-third of those rejected were thought to be suffering from disabilities directly or indirectly connected to poor nutrition. This meeting of nutrition and health experts hastened publication of the first Recommended Dietary Allowances (RDAs) by a committee of the National Research Council, of which several members were USDA scientists (3).

The decades of the 1960s and 1970s saw much scientific and political activity that had far-reaching impact on social

programs and nutrition policy in America. As early as 1963, Senator Milton Young's (R-ND) proposal was adopted that called for substantial increases in funding for the food and nutrition programs of USDA (4). Part of his proposal included establishment of regional human nutrition research laboratories within the United States, which served as the stimulus for the development of human nutrition research centers at Grand Forks, ND, Houston, TX, and Boston, MA.

In 1967, Congressional hearings on the possible occurrence of widespread hunger and malnutrition in the United States led to the establishment of the Senate Select Committee on Nutrition and Related Human Needs. An outcome of these hearings was the Ten-State Nutrition Survey (1968-1970) conducted by the Nutrition Program of the Department of Health, Education and Welfare (HEW), which was located in the National Institutes of Health (NIH). Preliminary findings from the Survey for Texas and Louisiana reported to Congress by Arnold Schaefer in January 1969 indicated that malnutrition occurred in a large proportion of the population studied. Senator Ernest Hollings (D-SC) reported to the Senate that widespread hunger and malnutrition also existed in his State, and a trip by Robert Kennedy through Appalachia and parts of the South confirmed considerable malnutrition in those areas of the country. About the same time, Jean Mayer, then Professor of Nutrition at Harvard's School of Public Health, used his association with the National Coalition Against Hunger, a group representing 66 million citizens, to persuade President Richard Nixon to host the White House Conference on Nutrition in 1969. From this conference came many recommendations, among them such programs as Food Stamps, expansion of the Women, Infants, and Children Nutrition Program (WIC), and nutrition labeling of foods with emphasis

on the relationship between nutrition and chronic diseases.

The Senate Select Committee on Nutrition and National Needs (1968-1977), chaired by Senator George McGovern (D-SD) with minority co-chair Senator Robert Dole (R-KS), served as a vehicle for the translation of recommendations from the White House Conference on Nutrition (5). The committee held several hearings. The most definitive was testimony by numerous nutritionists and other scientists, during "The Killer Diseases" hearings in the summer of 1976, that unanimously established a connection between diet and major chronic diseases (5). Early the next year, the first Dietary Goals for the United States emerged from this committee with much controversy, but based primarily on the testimony and consultation of D. Mark Hegsted, Professor of Nutrition at Harvard's School of Public Health—eat less food (calories); less meat; less fat, particularly saturated fat; less cholesterol; less sugar; and more unsaturated fats, fruits, vegetables, and cereal products (6). Of course, the egg, meat, and milk producers were the most vocal in their opposition to the Dietary Goals. Nonetheless, the Second Edition of the Dietary Goals for Americans appeared in late 1977 with only minor changes: "Eat less meat" was removed from the original Goals (5). Dietary Goals and subsequently Dietary Guidelines, a seminal accomplishment and a landmark in nutrition in the United States, have since been part of our society (7).

At the time, Senator McGovern also chaired the Agriculture Committee of the Senate, the committee responsible for the Farm Bill. In 1976, T.W. Edminster, ARS Administrator, proposed to Senator McGovern and to the committees he chaired a greatly expanded program for human nutrition research in ARS, complete with budget and promotion of regional centers (8). During hearings for the Dietary Goals, Donald Fredrickson, Director of the National Institutes of Health,

1894



W.O. Atwater, the first senior investigator, coordinated extensive programs to engage the expertise of investigators at the States' Experiment Stations as well as at several universities and colleges.

1906



Charles Ford Langworthy, Atwater's assistant and successor, managed the Human Nutrition Investigations as he focused on home economics-type research and activities.

testified that his agency should not take a position on the Dietary Goals for fear of compromising the objectiveness of that research organization (5). All of these testimonies contributed to the legislation in the 1977 Farm Bill that specified that nutrition should be a major program in USDA. At the same time, USDA was given a Congressional mandate—The Organic Act of 1862, as amended in 1977, Section 1405—which states:

“The Department of Agriculture is designated as lead agency of the Federal Government for agriculture research (except with respect to the biomedical aspects of human nutrition concerned with diagnosis or treatment of disease), and the Secretary, in carrying out the Secretary's responsibility, shall ... establish jointly with the Secretary of Health, Education and Welfare procedures for coordination with respect to nutrition research in areas of mutual interest.”

Numerous individuals associated with nutrition in America have (mis)interpreted the language of this Act to mandate that USDA “take lead responsibility for human nutrition research.” In fact, human nutrition research was one of the areas included in the definition of “food and agricultural sciences” of the Bill (Section

1404), and Congress clearly delineated responsibilities of HEW: “It is the intent of this Congress in enacting this title to augment, coordinate, and supplement the planning, initiation, and conduct of agricultural research programs existing prior to the enactment of this title, except that it is not the intent of Congress in enacting this title to limit the authority of the Secretary of Health, Education, and Welfare under any Act which the Secretary of Health, Education, and Welfare administers” (9). However, “... coordination with respect to nutrition research ...” was taken seriously, as discussed later in this chapter.

Congressional action also was required to fund the startup, construction, and ongoing operations for each of the human nutrition research centers. Chapters in this volume describe these activities for each center (10-14). Actually, most of the expansion of the human nutrition research program resulted from efforts of scientists at institutions and local politicians at the locations of the human nutrition centers, rather than from USDA budget requests. Even after these centers became operational, most of the annual budget increases resulted from Congressional mandates in response to requests from politicians in the centers' respective States. This resulted

1923



Louise Stanley was the first chief of the new Bureau of Home Economics.

1940



Lelia Booher succeeded Louise Stanley. Photo courtesy of the General Mills Archives.

1943



Henry Sherman succeeded Lelia Booher as the chief of the Bureau of Home Economics.

in research expansion at centers receiving mandated funds regardless of needs at other locations. It is interesting to note that Congressional funding for the Jean Mayer USDA Human Nutrition Research Center on Aging in Boston, MA, resulted from the first “Congressional earmarks” initiated by the then new president of Tufts University, Jean Mayer. (15).

Early Coordination Activities

Early nutrition research programs in USDA were coordinated by the leaders of these investigations. Thus, W.O. Atwater, the first senior investigator, coordinated the extensive programs for which he had the vision to initiate (1894-1906). He saw the opportunity to engage the expertise of investigators at the States’ Experiment Stations as well as at several universities and colleges (1). Similarly, Charles Ford Langworthy (1906-1923), Atwater’s assistant and successor, managed the Human Nutrition Investigations as he focused on home economics-type research and activities (1). Louise Stanley (1923-1940), the first chief of the new Bureau of Home Economics, and her successors, Lelia Booher (1940-1942), Henry Sherman (1943), and Hazel Stiebeling (1944-1963), also managed and

coordinated a more extensive bureau of programs and accompanying scientists (16). As early as 1943, an Interagency Committee on Nutrition Education was formed and was responsible for “coordinating nutrition services made available by Federal, State, and other agencies” (17). USDA provided the Secretariat for this group while its members represented education, extension, research, public health, and related programs.

With the reorganization of the Agricultural Research Service (ARS) in 1963, nutrition and consumer use research was administratively merged with utilization research activity at four large regional laboratories located in Albany, CA, New Orleans, LA, Peoria, IL, and Philadelphia, PA. Ruth Leverton was appointed ARS Assistant Deputy Administrator under Deputy Administrator Fred Senti and was given the responsibility of coordinating all human nutrition-related activities (18). Her program benefitted from the increased funding of the food and nutrition program of USDA initiated by Senator Milton R. Young (R-ND) (4). Specifically, several new scientists were hired at Beltsville, MD, including Willis Gortner as director, and a new “field laboratory” was started at Grand Forks, ND. in 1970 (18). Also, Harold H. Sandstead was hired as the first director of

1944



Hazel Stiebeling became chief of the Bureau of Home Economics.

1963



Ruth Leverton was appointed ARS Assistant Deputy Administrator under Deputy Administrator Fred Senti and was given the responsibility of coordinating all human nutrition-related activities.

the Grand Forks Human Nutrition Research Laboratory, and Robert Rizek was appointed director of Consumer and Food Economics Research Division replacing Faith Clark, who had retired earlier. From the outset of human nutrition programs sponsored by the U.S. Congress, due largely to the efforts of W.O. Atwater, coordination had been part of “line management”—the offices responsible for budget, programs, etc. This would soon change.

Regionalization of ARS Management

In addition to the administrative and research activities in the Washington, DC, area, ARS had over 100 research sites spread across the United States and in several foreign countries. The agricultural problems of the United States in the 1960s required multidisciplinary research teams to solve and, to add to the administrative complexity, these issues were generally located in specific regions of the country. As a result, under President Richard Nixon, Secretary of Agriculture Clifford Hardin, Director of USDA Science and Education Ned Bayley, and ARS Administrator T.W. Edminster, management of ARS was geographically regionalized in 1972. Initially, four areas were identified. ARS research

currently is managed in five geographical areas of the country. A National Program Staff was established to enhance development and coordination of National Research Programs of the agency. Today, this matrix-style organization has matured to where it “... assesses the full spectrum of scientific needs of the Agency ...” (19). Human nutrition is currently one of 22 national/international research programs of ARS (20).

Relative to human nutrition programs, this reorganization separated the Grand Forks Human Nutrition Research Laboratory from the Human Nutrition Research Division (HNRD) at Beltsville and created the first field center of the program, Grand Forks Human Nutrition Research Center (GFHNRC) (10). All remaining Human Nutrition Research Programs (HNRD and Consumer and Food Economics Institute [CFEI]) were in the Washington, DC, area.

Willis A. Gortner was appointed the first National Program Staff Scientist for Nutrition and Family Living (table 1). Prior to this new assignment, he was Director of HNRD, where he had reorganized and redirected programs to expand research on human requirements and nutritive value of foods (18). Gortner oversaw the appointment

1972



Willis A. Gortner was appointed the first National Program Staff Scientist for Nutrition and Family Living.

1978



D. Mark Hegsted was appointed as leader of the Human Nutrition Center formed within the Science and Education Administration.

Table 1. ARS National Program Staff scientists for human nutrition*

Scientist	Tenure
Willis A. Gortner	1972-1976
James (Jack) Iacono	1977-1978
Human Nutrition Center	1978-1981**
James (Jack) Iacono	1981-1982
Gerald F. Combs, Sr.	1983-1991
Jacqueline Dupont	1991-1996
Frankie Schwenk	1994-1996
Margaret Bogle (Acting)	1996-1997
Joseph Spence (Acting)	1996-1997
Carla Fjeld	1998-1999
Joseph Spence (Acting)	2002
Kathleen (Kathy) Ellwood	1999-2002
Barbara Schneeman	1999-2000***
Johanna Dwyer	2001-2002***
Mary (Molly) Kretsch	2004-2009
David Klurfeld	2004-present
John Finley	2009-present

* Many Human Nutrition scientists served in an “acting” capacity between terms of permanent appointees and/or in conjunction with National Program Leaders.

** Coordination of programs was conducted by staff of the Human Nutrition Center office.

*** Assistant Administrator for Human Nutrition with specific program and outreach coordination responsibilities. See chapter for details.

of Walter Mertz as his replacement at HNRD, and a request went to Congress for a new Children’s Nutrition Research Center at Baylor College of Medicine in Houston, TX (11). Also, the North Dakota legislative contingent was successful in markedly increasing funding for GFHNRC during this period (10). Gortner retired in 1976, and he and his wife Susan subsequently moved to the San Francisco, CA, area, where he became interested in the anthropology of ancient Indian tribes of California. He died in 1993.

James (Jack) Iacono was appointed the second National Program Leader for Human Nutrition (NPL) activities after Gortner’s retirement (table 1). Previously, he had been Research Leader of the Lipids Nutrition Laboratory, HNRD at Beltsville, where he initiated and conducted lipid studies related to diet and cardiovascular health of humans (18). These early experiments established the focus of many additional studies at that laboratory. One of Iacono’s far-reaching activities during his tenure as NPL was the organization of a site visit at Baylor College of Medicine in early 1977, requested by the House Agriculture and Related Agencies Subcommittee of the Appropriations Committee, in support of a USDA center to study nutritional requirements of children,



James (Jack) Iacono was appointed the second National Program Leader for Human Nutrition activities after Gortner's retirement.

adolescents, and mothers during pregnancy and lactation (11). From among more than 40 competing requests that Iacono reviewed, the establishment of the USDA/ARS Children's Nutrition Research Center at Baylor College of Medicine was announced in Congress in late 1978. With another reorganization of USDA and formation of the Human Nutrition Center, responsibilities for coordination of programs moved to that Center, and the National Program Leader for Human Nutrition was no longer needed. Iacono was appointed Associate Director of the Human Nutrition Center in 1978.

USDA Human Nutrition Center

Jimmy Carter, elected President in 1976, designated Bob Bergland as Secretary of Agriculture, who in turn appointed M. Rupert Cutler to serve as Assistant Secretary for Conservation, Research and Education. With assistance from Ned Bayley, Cutler created a new agency, the Science and Education Administration (SEA), in January 1978 by merging Agricultural Research Service (ARS), Cooperative States Research Service (CSRS), Extension Service (ES), and National Agricultural Library (NAL). This reorganization was a further effort to increase cooperation and coordination

in conducting research and education activities and to provide a single focus to the fragmented activities of the Department.

As a result, the Human Nutrition Center was formed within SEA, separated from ARS also within SEA, under which all human nutrition activities were administratively placed and coordinated. Hegsted, an outstanding nutritionist, was appointed as leader of this new Center in 1978 (5). A Competitive Grants Office also was established under Joe L. Key, Director. The establishment of a USDA Human Nutrition Center seemed most appropriate in view of USDA's Congressional mandate in the 1977 legislation directing the USDA to coordinate human nutrition research in areas of mutual interest between USDA and the Department of Health, Education, and Welfare.

Hegsted and Iacono focused on establishing and coordinating the programs at each of the new centers (Houston, TX, and Boston, MA) during their "startups," which were managed as cooperative agreements with ARS. In addition, research programs continued at Beltsville and Grand Forks that required coordination/cooperation with the "new" centers. Also, the Consumer Nutrition Center, directed by Rizek, had a section that provided dietary guidance for the country (7). The Dietary Goals and newly released Dietary Guidelines continued to spark much controversy within the medical/clinical interests, the agricultural community, and the Food and Nutrition Board of the National Academy of Sciences (FNB). Rizek had entered the fray by requesting a contract with FNB to make recommendations on the consumption of specific food components highlighted in the Dietary Goals. Iacono, realizing that Phil Handler, President of the National Academy of Sciences, and members of FNB were at odds with the statements of the Dietary Goals, convinced Rizek to withdraw his request and support for an FNB review (5). Nonetheless, members of the



Gerald Combs, Sr., served as ARS's Assistant Deputy Administrator for Human Nutrition from 1983 to 1991.

Consumer Nutrition Center produced several pamphlets outlining practical approaches to meet the new Dietary Guidelines (7).

The Human Nutrition Center probably could have developed an effective program had it been allocated sufficient funds. However, SEA itself struggled with the coordination, and in some cases reversal, of the many decisions that previously had been made within its agencies. With the change of political party of the Executive Branch in 1980 (with Ronald Reagan as President) and appointments of John Block as Secretary of Agriculture, Richard Lyng as Deputy Secretary of Agriculture, and Terry Kinney, Jr., as Assistant Secretary for Science and Education, Block directed Kinney to disband SEA and re-establish ARS, CSRS, ES, and NAL as independent agencies and entities. At the same time, the Human Nutrition Center also was abolished, and all human nutrition research activities (Centers) were administratively returned to the geographical administrative system (Areas) of ARS.

The Consumer Nutrition Center, also part of the Human Nutrition Center, formed the basis of a new agency, Human Nutrition Information Service (HNIS), which had its own administrator (Isabel Wolf was the first).

The Administrator of HNIS reported to the Assistant Secretary for Food and Nutrition Service, thereby separating HNIS even more from human nutrition research activities and requiring coordination (21). Hegsted was reassigned as Senior Scientist and soon took the position of Associate Director for Research at the New England Regional Primate Center, from which he retired (5). He died in 2009. Iacono returned to the position of National Program Leader for Human Nutrition, where he coordinated the orderly transfer of the Western Human Nutrition Research Center from the Department of Defense and integration into ARS (13). Shortly thereafter (1982), he was appointed Director of that Center, when the position became vacant when Howerde Sauberlich moved to the University of Alabama at Birmingham (13). Iacono retired in 1994 and died in 2006.

Coordination of Human Nutrition Research Activities

It was the good fortune of one of the authors of this chapter (GFC) to serve as ARS's Assistant Deputy Administrator for Human Nutrition from 1983 to 1991 (table 1). The coordination and oversight of research conducted at the five USDA Human Nutrition Research Centers and human nutrition-related research at other ARS laboratories was the responsibility of the National Program Leader for Human Nutrition. In addition, the National Program Leader was expected to coordinate all of the human nutrition research activities of other agencies within USDA, as well as serve as the primary liaison with other Government agencies engaged in human nutrition research. This required coordination mechanisms within USDA and with other Federal agencies involved in human nutrition research.

Table 2. Scientific coordination activities of Human Nutrition National Program Leaders (NPL)

Coordination level and committee title	Dates*
Coordination at level of Federal Government	
Joint Subcommittee on Human Nutrition Research (JSHNR)	1978-1983
Interagency Committee on Human Nutrition Research (ICHNR)	1983-present
Dietary Guidelines Advisory Committee	1983-present
National Advisory Council on Child Nutrition	1970-1989
National Advisory Council on Maternal, Infant, and Fetal Nutrition	1966-present
USDA/DHHS Nutrition Education Committee for Maternal and Child Nutrition Publications	1980-1999
Joint Nutrition Monitoring Evaluation Committee (JMNEC)	1983-1988
Interagency Committee on Nutrition Monitoring	1988-1991
Interagency Board for Nutrition Monitoring and Related Research	1991-2002
Label Harmonization Task Force	1983-1990
Coordination within USDA	
Subcommittee for Human Nutrition (Human Nutrition Coordinating Committee)	1983-present
Dietary Guidance Working Group	1983-present
Diet Appraisal Research Working Group	1992-present
Nutrition Education Working Group	1992-present
Human Nutrition Board of Scientific Counselors	1984-1996
Nutrition, Education and Research Coordinating Council	1994-1996
National Agricultural Research, Extension, Education, and Economics Advisory Board (NAREEEAB)	1996-present
Coordination within ARS	
Human Nutrition Center Director's meetings	1983-present
NPL representation on other committees	
National Institutes of Health (NIH) Nutrition Coordinating Committee	1975-present
Office of Science and Technology Policy (OSTP), Committee on Science, Human Subjects Research Subcommittee (HSRS)	1991-present
Department of Health and Human Services Secretaries Advisory Committee on Human Research Protection (SACHRP)	2002-present
National Institute of Diabetes and Digestive and Kidney Diseases (NIDDK) Advisory Council	1993-present

*Dates are approximate and best estimates in reconstruction of activities.

Coordination Within USDA

The Subcommittee for Human Nutrition was established in 1983 under the USDA Research and Education Committee of the Secretary's Policy and Coordination Council (table 2). Still active today, this Subcommittee was later renamed "USDA Human Nutrition Coordinating Committee." The committee holds quarterly meetings with the primary purpose of ensuring communication among Departmental agencies involved in human nutrition activities. Participating USDA agencies include ARS, National Institute of Food and Agriculture (NIFA)—formerly Cooperative State Research, Education, and Extension Service (CSREES)—Agriculture Marketing Service (AMS), Center for Nutrition Policy and Promotion (CNPP), Economic Research Service (ERS), Food and Nutrition Service (FNS), Food Safety and Inspection Service (FSIS), and National Agricultural Library (NAL). In addition, members include liaison representatives of DHHS's Office of Disease Prevention and Health Promotion (ODPHP), Food and Drug Administration (FDA), and the National Institutes of Health (NIH). The Subcommittee is chaired by ARS's National Program Leader(s) for Human Nutrition.

The Committee serves as USDA's mechanism to explore and recommend positions on human nutrition-related policy issues. It developed a food and nutrition policy statement, a directory of USDA activities related to human nutrition, a statement of the role of USDA in human nutrition, and a 5-year plan. In addition, the Subcommittee established a Dietary Guidance Working Group to ensure that USDA speak with one voice and conform to the Dietary Guidelines for Americans. Later, the Committee added the Dietary Appraisal Research Working Group, an information-sharing group for Federal researchers who collect and analyze dietary survey data, and the Nutrition Education Working Group,

who coordinates these activities across many agencies of the Department (table 2).

The Committee members also provided information needed for the preparation of annual reports to Congress on the human nutrition research activities of the Department, as required by Section 1452(b) of the National Agricultural Research, Extension, and Teaching Policy Act Amendments of 1985 (7 U.S.C.3173 note).

The Human Nutrition Board of Scientific Counselors was established in 1984 by the Secretary of Agriculture as an outside group of well-established scientists in human nutrition and related fields to advise the Secretary regarding program direction, priorities, and quality of the Department's human nutrition research and education activities (table 2). At the first meeting, three task groups were formed: Solutions to Human Nutrition Problems Through Changes in the Agricultural/Food System; Food Composition; and Implications of the RDAs and Dietary Guidelines. A fourth task group, Nutrition Education, was formed in 1986 to determine the initiatives required to formulate and integrate a broad-based nutrition education program with efficient use of present resources. The Board functioned through specific task group and workshop meetings as needed, with meetings of the entire Board scheduled annually.

USDA's Assistant Secretary for Research and Education or USDA's Assistant Secretary of Food and Consumer Services chaired each session of the entire Board. The Board generated a number of policy recommendations, which were submitted to the Secretary and included in the annual report to Congress. This Board was superseded by the National Agricultural Research, Extension, Education, and Economics Advisory Board (NAREEEAB) established as part of legislation in the 1996 Farm Bill (table 2).

USDA Human Nutrition Center Directors' meetings were arranged by the National Program Leader for Human Nutrition at roughly quarterly intervals (table 2). Meetings were usually held at one of the USDA Human Nutrition Research Centers or at the Plant, Soil and Nutrition Laboratory on the Cornell University campus to allow the Center Directors and others in attendance to see the facilities and become acquainted with studies in progress and opportunities for future collaborative research. Recently, meetings have been conducted via teleconference on a monthly basis with only one or two onsite meetings per year.

USDA's mission in human nutrition research was (~1985) "to plan and conduct research to define nutritional requirements and dietary practices to meet the nutritional requirements necessary for maximal performance and optimal human health and well-being to the American people at all stages of life" (22). Four approaches to achieve this objective were—

1. Define nutritive requirements at all stages of life,
2. Determine the nutritive content of agricultural commodities and processed foods as eaten and establish the bio-availability of nutrients in these foods,
3. Improve human status by making available techniques to assess the effectiveness of nutrition programs, and
4. Integrate knowledge of human nutritional needs and the agricultural/food system.

The mission was recently modified as follows: "to define the role of food and its components in optimizing health throughout the life cycle for all Americans by conducting high national priority research" (23). The four priorities to achieve this mission currently are—

1. Nutrition monitoring and the food supply,
2. Scientific basis for dietary guidance for health promotion and disease prevention,
3. Prevention of obesity and related diseases, and
4. Life stage nutrition and metabolism.

Coordination at the Federal Level

The Joint Subcommittee on Human Nutrition Research (JSHNR) was chartered under the aegis of the Office of Science and Technology Policy's (OSTP) Federal Coordinating Committee for Science, Engineering and Technology in September 1978 (table 2). Under the auspices of the OSTP, the JSHNR accomplished most of its objectives, and the decision was made that issues related to human nutrition research could be adequately addressed through the establishment of a collaborative mechanism by the Federal agencies that support human nutrition research. To realize this goal, DHHS and USDA created the Interagency Committee on Human Nutrition Research (ICHNR) in July 1983, subsequent to the termination of the JSHNR in June 1983.

The Interagency Committee on Human Nutrition Research (ICHNR), formed in 1983 to coordinate nutrition research at the Federal level, is co-chaired by the USDA Assistant Secretary for Science and Education and the DHHS Assistant Secretary for Health (table 2). The ICHNR included representatives from the U.S. Departments of Agriculture, Commerce, Defense, and Health and Human Services; U.S. Agency for International Development; National Aeronautics and Space Administration; National Science Foundation; and the Office of Science and Technology Policy. The ICHNR meets quarterly to exchange relevant information concerning human nutrition activities. Example of joint activities sponsored by

ICHNR included—

1. Establishment of the Human Nutrition Information Management (HNRIM) system, a computerized database of ongoing Federal food and nutrition research, to facilitate rapid exchange of information. This research included biomedical and behavioral areas; food science; nutrition monitoring and surveillance; nutrition education methodology; and effects of socioeconomic factors, intervention programs, and policies on food consumption and nutritive status.
2. Preparation of a comprehensive Federal 5-year plan for human nutrition research. Areas of research proposed for special Federal attention were normal human requirements of nutrients, energy requirements, role of nutrients in health promotion, food composition, bioavailability of nutrients, nutrition monitoring, nutrition education, and effect of Federal policy and socioeconomic factors on food consumption.
3. Sponsored biennial conferences among scientists from Federally supported Human Nutrition Research Units and Centers for coordination and exchange of findings in specific research areas. Reports given at these conferences were published. In the mid-1990s, these meetings were suspended in favor of scientists reporting research results at their respective professional meetings, such as at the annual Experimental Biology meeting.

In addition, joint USDA-DHHS committees were formed as needed to insure collaboration with respect to specific issues. The following are some examples:

The Dietary Guidelines Advisory Committee (DGAC) was established in 1983 by the

Secretary of Agriculture to review the “Dietary Guidelines for Americans” first published jointly by USDA and DHHS in 1980 (table 2). Nine members were appointed to the Committee—three selected by USDA and three by DHHS—and three were selected from a list recommended by the National Academy of Sciences. The “Dietary Guidelines for Americans” have been revised by subsequent Committees and published jointly by USDA and DHHS at approximately 5-year intervals.

The most recent Committee (2008-2010) consisted of Linda Van Horn (Chair), Naomi Fukagawa (Vice-Chair), Cheryl Achterberg, Lawrence Appel, Roger Clemens, Miriam Nelson, Shelly Nickols-Richardson, Thomas Pearson, Rafael Pérez-Escamilla, Xavier Pi-Sunyer, Eric Rimm, Joanne Slavin, and Christine Williams (24). The size of the Committee was increased from 9 to 11 in 1998 and to 13 in 2008.

The National Advisory Council on Child Nutrition and the National Advisory Council on Maternal, Infant, and Fetal Nutrition studied the operation of the Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) and related programs such as the Commodity Supplemental Food Program (CSFP), which is part of Food and Nutrition Service’s Special Nutrition Programs. Both Councils reported their recommendations to the President and Congress. The National Advisory Council on Child Nutrition was abolished as part of PL 101-147 (101st Congress, January 1989-October 1990), which reauthorized Special Supplemental Food Program for Women, Infants, and Children (WIC), Commodity Distribution, School Breakfast, and Nutrition Education and Training Programs through fiscal year 1994. However, the National Advisory Council on Maternal, Infant, and Fetal Nutrition remains active and meets at least once a year.

The USDA/DHHS Nutrition Education Committee for Maternal and Child Nutrition Publications was established in 1980 by the DHHS Assistant Secretary for Health and the USDA Assistant Secretary for Food and Consumer Services to provide a systematic mechanism for USDA and DHHS agencies to report plans and progress related to maternal and child nutrition education to avoid duplication and to facilitate coordination and enhance effective use of resources. Although a meritorious committee, it held very few meetings and was discontinued in 1999.

The Joint Nutrition Monitoring Evaluation Committee (JNMEC) was established by USDA and DHHS in October 1983 to review, interpret, and report information from the National Nutrition Monitoring System on the nutritional status of the population (table 2). It produced a report, "Nutrition Monitoring in the United States: A Progress Report from the Joint Nutrition Monitoring Evaluation Committee, 1986." This committee was superseded by the Interagency Committee on Nutrition Monitoring.

The Interagency Committee on Nutrition Monitoring was established in 1988 to increase overall effectiveness and productivity of nutrition monitoring efforts (table 2). Member agencies included the U.S. Department of Defense, U.S. Department of Veterans Affairs, U.S. Agency of International Development, the Census Bureau, the Bureau of Labor Statistics, and other agencies within USDA and DHHS that conduct nutrition monitoring activities. This Committee sponsored a report (25). The Committee was superseded by the Interagency Board for Nutrition Monitoring and Related Research.

The Interagency Board for Nutrition Monitoring and Related Research was formed in response to legislation in The National Nutrition Monitoring and Related Research Act of 1990 (table 2). One of the provisions

of this Act was to establish a coordinated Federal effort with a central focus for national nutrition monitoring of the U.S. population. The Interagency Board included representatives of 22 Federal agencies that either conduct nutrition monitoring surveys and related research or are major users of nutrition monitoring data (26). Many of these representatives were the same as those on the Interagency Committee on Nutrition Monitoring. Three reports were sponsored by this Board that provided information about the dietary, nutritional, and nutrition-related health status of Americans (27,28).

The Label Harmonization Task Force was formed by USDA and DHHS in 1983 to recommend a uniform and effective standard for displaying nutrition-related information on food labels in the United States and to provide consumers with nutrition information that will allow them to make informed dietary decisions (table 2). The functions of this task force were integrated into activities of the Food and Drug Administration when the Nutrition Labeling and Education Act (NLEA) was passed in 1990, thereby making food labeling mandatory in the United States.

Gerald F. Combs, Sr., was intimately involved in the establishment and startup of many Human Nutrition Research Coordinating Committees and working groups that were formed in response to Congressional mandates. Many of these groups or their successors are still active today and provide oversight and guidance as was originally intended. Combs retired in 1991 and shortly thereafter moved to Hattiesburg, MS, where he is Adjunct Professor of Food and Nutrition at the University of Southern Mississippi. He continues to write on the history of nutrition and nutrition research at USDA and other agencies he served during his very active and productive career (22,29,30).



Jacqueline (Jackie) Dupont was appointed ARS's Nutrition National Program Leader.

Arkansas Children's Nutrition Center. A site visit committee, formed at the request of Congress, reviewed the Arkansas Children's Hospital's request to become the sixth USDA Human Nutrition Research Center in January 1994 (14). From among several other requests, the Arkansas site was selected, and Congress appropriated \$1.2 million later in 1994 for the start of the Arkansas Children's Nutrition Center. The specific mission of this Center is to investigate dietary factors that will maximize the health of children from conception through adolescence with special emphasis on unique nutrition and health issues of Arkansas and the Lower Mississippi Delta region. This Center is also operated under a cooperative agreement with ARS.

Highlights of Coordination Activities 1991 to Present

Jacqueline (Jackie) Dupont was appointed ARS's Nutrition National Program Leader (NPL) in 1991 (table 1). She had been a scientist at the Human Nutrition Research Division in Beltsville, MD, during the 1950s-1960s, progressed through the academic ranks at Colorado State University, and later served as Chair of the Department of Food and Nutrition at Iowa State University. Dupont was a recognized leader in research on essential fatty acids and continued to serve on international committees on lipid requirements throughout her NPL tenure. Besides remaining active on all of the coordination committees and working groups while a National Program Leader, she lent her input to several events that required her expertise, including the following:

Ten-Year Comprehensive Plan for the National Nutrition Monitoring and Related Research Program. This plan, as mandated by the National Nutrition Monitoring and Related Research Act of 1990, provided direction for nutrition monitoring and reporting of results for the 10-year period 1992-2002 (31).

USDA Human Nutrition Information Service (HNIS). HNIS was closed in 1994, and all activities were transferred to ARS (7,21). Food composition data activities and nutrition survey functions were incorporated into the Beltsville Human Nutrition Research Center's Nutrient Data Laboratory and Food Surveys Research Group, respectively. Nutrition education activities (and Dietary Guidelines) and the Family Economics Research Group were further transferred to the USDA Food and Nutrition Service's Center for Nutrition Policy and Promotion (CNPP). The National Agriculture Library was administratively returned to ARS, but it soon became a separate entity within USDA. At the same time, a USDA Departmental Regulation was issued that established a Nutrition Education and Research Coordinating Council (table 2) with the specific purpose of coordinating all activities addressing research and education relating to human nutrition, including scientific and economic research as well as public education and information programs within the Department (32).

National Agricultural Research, Extension, Education, and Economics Advisory Board (NAREEEAB). This board was created as



Frankie Schwenk was appointed National Nutrition Program Leader.

part of the Federal Agricultural Improvement and Reform Act of 1996 (1996 Farm Bill) to provide advice to the Secretary of Agriculture and land-grant colleges and universities on national priorities and policies related to agricultural research, education, extension, and economics (table 2). The original Farm Bill (1966) called for a board of 31 members, but recent legislation (2008) reduced the number to 25. A few of the pertinent areas called out in the legislation were national human health associations, national nutrition science societies, national food organizations, and food retailing and marketing interests. The establishment of this board superseded the Human Nutrition Board of Scientific Counselors and the Nutrition Education and Research Coordinating Council (table 2).

PL-480 Foods Reformulation. Current U.S. international food assistance programs began after World War II. One of these programs outlined in Title II of Public Law 480 of 1954 (Food for Peace Program) and administered by the U.S. Agency for International Development (USAID) continually reviews nutrient adequacy of foods provided for this program. One such review conducted in early 1996 concluded that new and improved products were needed for this program. As part of this

initiative, a task force of six ARS scientists, whom Dupont had considerable influence in recommending, was assembled to formulate a revised set of nutrient specifications that would allow flexibility in meeting nutritional needs with least cost blends of available commodities. A summary of the discussions and recommendations was prepared for USAID—"Report of USDA ARS Task Group on Nutrient Standards for Grain Blends—February 7, 1997."

Dupont retired in 1996 and returned to her native Florida, where she became Adjunct Professor of Nutrition, Food and Exercise Sciences at her alma mater, Florida State University.

Frankie Schwenk was appointed National Nutrition Program Leader in 1994 (table 1). Previously, she had been Research Leader of the Family Economics Research Group at HNIS. When that agency closed, she moved to ARS. Besides assisting Dupont with NPL activities, Schwenk's primary responsibility was shepherding the Lower Mississippi Delta Nutrition Intervention Research Initiative (Delta NIRI) (33). This unique initiative, born from earlier Congressional action, is a research effort to design, execute, and evaluate nutrition interventions directed at improving the health and well-being of the people residing in the lower Mississippi Delta region of Arkansas, Louisiana, and Mississippi. It is executed by a partnership of ARS/USDA with six institutions of higher education and research in the three States (33). Schwenk moved to the Maryland Cooperative Extension Service in 1996, from which she retired in 2001.

Margaret Bogle was appointed Acting National Program Leader for Human Nutrition in late 1996 as an IPA (Intergovernmental Personnel Act) with University of Arkansas for Medical Sciences (table 1). In addition to all of the duties of an NPL, Bogle was successful in moving the headquarters of the Delta NIRI program from



Kathleen (Kathy) Ellwood was appointed National Program Leader for Human Nutrition.

the Washington, DC, area to Little Rock, AR. In mid-1997, she was appointed Executive Director of this nutrition intervention program and relocated to Little Rock, AR, as a Federal employee.

Carla R. Fjeld was appointed National Program Leader for Human Nutrition in 1998 (table 1). She had previously been a Senior Scientist with the International Atomic Energy Agency and had considerable experience in human nutrition issues worldwide. Her unique contribution during her tenure as NPL was conception and organization of the conference “Foods, Phytonutrients, and Health,” in collaboration with Roger Lawson, National Program Leader for Horticulture and Sugar. This conference was the first of its kind at ARS, and it brought together scientists from agriculture, nutrition, health, and agribusiness to discuss how advances in biotechnology, genetics, and related sciences could be used to increase concentrations of natural, health-enhancing compounds in plants, called “phytonutrients.” The conference was a scientific success (34). Fjeld left ARS in 1999 and has since developed *Ola Verde*, a health food business in Nicaragua.

Kathleen (Kathy) Ellwood was appointed National Program Leader for Human

Nutrition in 1999 (table 1). She earned her Ph.D. at the University of Maryland at College Park while working with Sheldon (Shelly) Reiser at the Carbohydrate Nutrition Laboratory of BHNRC. Subsequently and prior to her appointment as NPL, she was a scientist at the Center for Food Safety and Applied Nutrition at the FDA (CFSAN) and Director of the Human Nutrition and Food Safety Programs at USDA/CSREES. In addition to the coordination and budget activities of the NPL position (table 2), Ellwood initiated, planned, and coordinated several workshops to bring together scientists from various disciplines, such as plant, animal, and food sciences as well as genetics, which complimented nutrition science in an attempt to increase interaction and forge new research areas. Workshop topics included energy metabolism/body composition, nutrition and genomics, nutrition and immunology, and nutritional enhancement of plant and animal foods through genetics. She was involved in the formation of the Human Nutrition Research Centers Outreach Committee, which greatly enhanced the visibility of the program.

Ellwood also was highly involved in the integration of the dietary intake surveys conducted independently by USDA and the Centers for Disease Control and Prevention (CDC). As part of the 10-year plan for National Nutrition Monitoring and Related Research, integration was proposed of the dietary portion of NHANES (National Health and Nutrition Examination Survey) conducted by the National Center for Health Statistics (NCHS) of CDC and of CSFII (Continuing Survey of Food Intakes by Individuals), which was the nutrition monitoring activity sponsored by USDA/ARS. A memorandum of understanding was signed in 1998 by representatives of ARS and NCHS to formalize this integration (35). Several workshops were conducted, which sought input from many of the stakeholders of food consumption data, and outlined research areas needed to improve the quality of these data (36).

Assistant Administrator for Human Nutrition

1999-2000

2001-2002



Barbara Schneeman



Johanna Dwyer

Ellwood moved back to CFSAN in 2002 as Director of the Division of Nutrition Programs at FDA and as Lead Scientist for Nutrition. She retired in 2010 and now serves as a consultant and scientific advisor on various nutrition-based initiatives.

Barbara Schneeman, Assistant Administrator for Human Nutrition (1999-2000) (table 1). ARS Administrator Floyd Horn (1998-2001) promoted human nutrition activities in the agency, and REE Under Secretary Joseph Jen (2001-2006) had a vision of “food as a product of American agriculture.” Following discussions among the directors of the ARS Human Nutrition Research Centers and Horn, the position of Assistant Administrator for Human Nutrition was created to “give human nutrition more visibility in USDA.” Schneeman was the first to serve in this position. She was Professor of Nutrition and Dean of the College of Agricultural and Environmental Sciences at University of California-Davis (UC Davis) and was well known in the nutrition community for her research on gastrointestinal metabolism of carbohydrates and fiber. While at USDA, she improved liaison between appropriate Congressional staff and critical administrators at both USDA and NIH relative to the importance of

nutrition and health outcomes, especially obesity. Schneeman later returned to an administrative position at UC Davis and subsequently became Director of the Office of Nutrition, Labeling and Dietary Supplements at FDA.

Johanna Dwyer, Assistant Administrator for Human Nutrition (2001-2002) (table 1). Dwyer was Director of the Frances Stern Nutrition Center at Tufts-New England Medical Center. She also held positions at the Friedman School of Nutrition and Policy, the Tufts University School of Medicine, and the Jean Mayer USDA Human Nutrition Research Center on Aging. With the integration of CSFII and the dietary portion of NHANES nearly complete, Dwyer organized a scientific workshop. The goals were to determine how to meet current and anticipated Federal needs for dietary data on foods, nutrients, other food components and dietary supplements that are presently collected in the integrated dietary survey. Another goal was how to address major needs and problems associated with the provision and use of the desired data output for policy and research purposes and implications of improvements. Discussions and outcomes at this workshop held in June 2002 were reported in the *Journal of Nutrition Supplement* (37). With the change in Administrator at ARS in 2001 (Edward B. Knipping) and the outbreaks of foodborne microbial contamination, less emphasis was placed on the visibility of human nutrition activities in the agency, and the position of Assistant Administrator for Human Nutrition was abandoned. However, funds were redirected to a second position of National Program Leader for Human Nutrition, which became effective in 2004. Dwyer returned to Tufts for a short period but then took a position (“on-loan from Tufts”) as Senior Nutrition Scientist at NIH’s Office of Dietary Supplements.

Joseph Spence was appointed Acting National Program Leader for Human

National Program Leaders for Human Nutrition

**Acting 1996-1997,
1998 & 2002-2004**



Joseph Spence

2004-2009



Mary (Molly) Kretsch

2004-Present



David Klurfeld

2009-Present



John Finley

Nutrition in 2002 (table 1). He had been Director of BHNRC for nearly 10 years, during which he oversaw operation of the Center, integration of food surveys and food composition data groups into the Beltsville Human Nutrition Research Center after HNIS was closed, and initiation of construction of two new buildings for human nutrition research.

During Spence's tenure, the integration of CSFII and of the dietary portion of NHANES was completed and renamed "What We Eat in America-NHANES." Data collection by the new survey began in early 2002. Despite a series of conferences and workshops that highlighted the need and importance of data from "What We Eat in America-NHANES," Congress did not reauthorize continuation of the National Nutrition Monitoring and Related Research Program until the Food, Conservation, and Energy Act of 2008 (2008 U.S. Farm Bill) was passed, but without authorization of funding (38). Nonetheless, the integrated survey continued with data from the first survey released in 2004 and data from subsequent surveys made available in 2006 and in 2010 (39).

Spence was appointed ARS Deputy Administrator for Nutrition, Food Safety, and Quality in 2004. This was a new position

created by ARS to provide increased visibility and support for human nutrition and food-related research. This new position in part superseded that of Assistant Administrator for Human Nutrition previously held by Schneeman and Dwyer. Subsequently (2008), Spence was appointed Director of the Henry A. Wallace Beltsville Agricultural Research Center (BARC), which includes BHNRC (21).

Mary (Molly) Kretsch was appointed National Program Leader for Human Nutrition in 2004 (table 1). Kretsch had been a scientist with the Western Human Nutrition Research Center, where she made substantial advances in understanding the influence of mild deficiencies (iron, vitamin B6) on cognitive function (13). She was one of the "original scientists" who transferred when that Center was moved from the Department of Defense to USDA in 1980. Kretsch was appointed Deputy Administrator for Nutrition, Food Safety, and Quality in 2009, subsequent to Spence's appointment as Director of BARC.

David Klurfeld was appointed National Program Leader for Human Nutrition in 2004 (table 1). He and Kretsch were the first of the dual National Program Leaders for Human Nutrition. Klurfeld was Professor

and Chair of the Department of Nutrition and Food Science at Wayne State University, where he directed research on the effect of diet on markers of cancer risk. He served as chair of the ARS Strategic Planning Team who shepherded the development of the Agricultural Research Service Strategic Plan for FY 2006-2011 (40).

John Finley was appointed National Program Leader for Human Nutrition in 2009 subsequent to Kretsch being appointed Deputy Administrator (table 1). Finley was a scientist at the Grand Forks Human Nutrition Research Center, where he investigated the metabolism of selenium in plants (primarily broccoli) and its influence on seleno-containing and other secondary plant compounds—compounds important in the potential reduction of cancer risk in humans.

Both Klurfeld and Finley currently provide coordination of the USDA Human Nutrition Program through chairing current committees and workshops (table 2), preparing budgets, and serving as spokespersons for the program. In addition, they serve as ex-officio members of several

“Other Committees” that are concerned with NIH Human Nutrition Programs and Human Subjects Protection (table 2).

The National Program Leader program of ARS is nearly 4 decades old and, relative to human nutrition activities within the Agency and the Federal Government, serves as an effective and efficient coordination and promotion mechanism. Considering the distinct missions of the six ARS Human Nutrition Research Centers as well as all of the other human nutrition-related activities ongoing within USDA and other Federal agencies, the National Program Leaders for Human Nutrition provide a current source of relevant information for these programs.

Human Nutrition Research and Monitoring Budgets

Figure 1 shows the budgets for human nutrition and monitoring from 1978 to 2010. Dollars for Nutrition Education and Family Economics Research have been removed as this program was transferred to CNPP when HNIS was closed in 1994. Current-year dollars are shown, as well as budgets

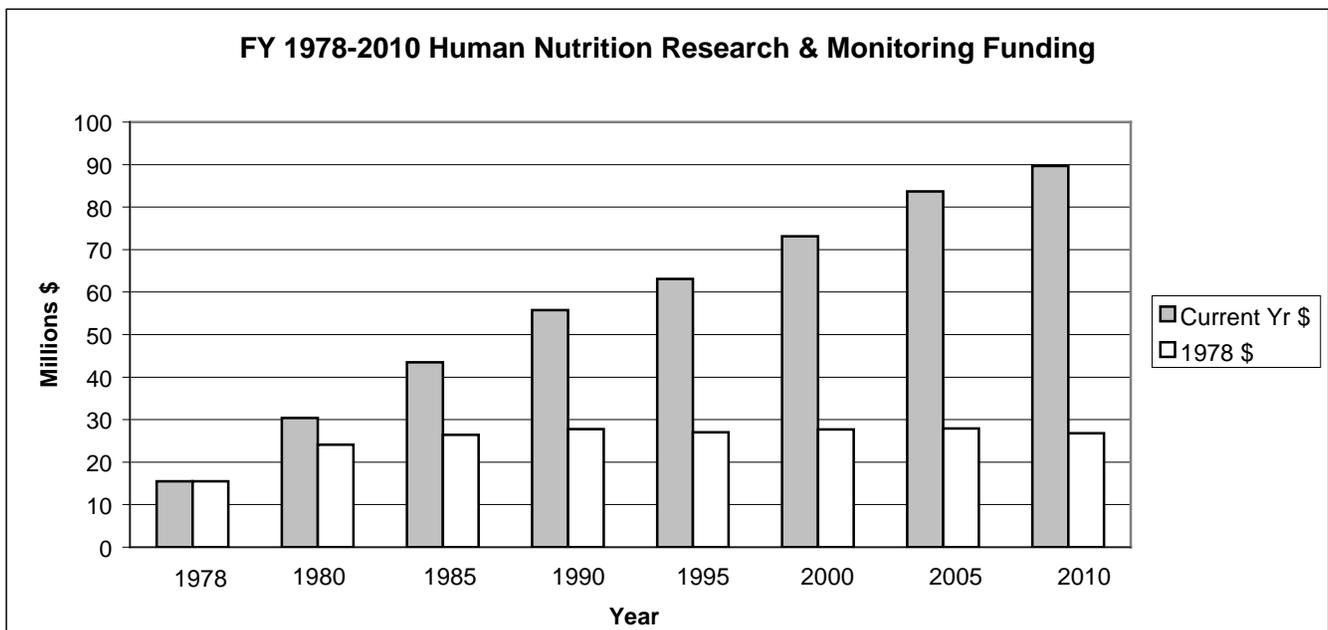


Figure 1. Fiscal year 1978-2010 human nutrition research and monitoring funding. Shaded bars represent yearly funding in millions of dollars. Open bars are yearly funding values adjusted to 1978 dollars based on Bureau of Labor Statistics CPI inflation calculator (<http://data.bls.gov/cgi-bin/cpicalc.pl>).

adjusted to 1978 dollars. The display of these data was begun in 1978 as that was the first year specific human nutrition research monies could be identified. Prior to that time, research funds were co-mingled with food safety and food research monies.

Relative to data shown in figure 1, yearly budgets consistently increased. However, when these values were adjusted to 1978 dollars, only the period 1978-1980 showed a substantial increase. This is the period when several of the ARS Human Nutrition Research Centers (Houston, Boston, and California) were established and began active research programs. In contrast, since 1980, budgets for human nutrition research and monitoring at USDA have remained constant when adjusted to 1978-equivalent dollars. As highlighted earlier in this chapter, the majority of the budget increases resulted from Congressional mandates in response to requests from politicians in those States where research Centers reside rather than from USDA budget proposals based on carefully characterized/justified nutrition-health-linked research priorities. This has resulted in research expansion at Centers receiving mandated funds regardless of needs at other locations.

It is interesting to realize that the first Congressional appropriation for human nutrition research was \$10,000 in 1885. In 2010 dollars, this would approach one-half million. Yet this is not a very large sum, even in terms of 2010 dollars, considering all that W.O. Atwater initiated and accomplished. Perhaps it is an indication of the enormous network of collaborators and cooperators he established and the large dividends it has paid in terms of establishing a human nutrition research base that has greatly advanced our knowledge, not only in America but worldwide.

Acknowledgments

The critical review of this manuscript by David Klurfeld and his assistance in verifying coordination committees and their dates of activity are greatly appreciated. Critical reviews by Kathleen Ellwood and Joe Spence also are gratefully acknowledged. The efforts of Peggy del Collo and Jill Stetka in researching and validating budget numbers are acknowledged with thanks.

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CHAPTER 9

History of the Grand Forks Human Nutrition Research Center

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Expansion of the USDA-ARS Human Nutrition Research Program

The idea for a national system of human nutrition research centers was conceived by William E. Cornatzer, M.D., Ph.D., Professor and Head of the Department of Biochemistry at the University of North Dakota School of Medicine. After visiting the USDA-Agricultural Research Service's (ARS) nutrition research laboratories in Beltsville, MD, in 1962 as a member of the USDA Human Nutrition and Consumer Use Research Advisory Committee, Dr. Cornatzer voiced his concerns about a need for an enhanced program of human nutrition research within USDA. In his view, such a program would include the establishment of a decentralized system of USDA national laboratories, one of which he envisioned on the campus of the University of North Dakota.

Dr. Cornatzer's efforts proved key to establishing a USDA nutrition laboratory in Grand Forks. This is indicated by a letter to him from U.S. Senator Milton R. Young

(R-ND) (1), "If it had not been for your initiative, this laboratory never would have been a reality." Acknowledging that USDA had never expanded its modest program in nutrition research at Beltsville, MD, Senator Young observed: "There is more need for emphasis on nutrition and nutritional research now than when they were carrying on their campaign for adequate laboratory facilities." In his 1962 written testimony to the Senate Subcommittee on Agricultural Appropriations, Dr. Cornatzer stated that "there is a great need for an expanded program of research in Nutrition," and reminded the Subcommittee of USDA's responsibility "for the nutritional well-being of our people." He concluded: "I visited the nutritional facilities at Beltsville in the summer of 1962 and found them in need of additional space, equipment and staff . . . There is a need for a new nutritional laboratory." Dr. Cornatzer observed that such a laboratory should be located on a university campus, preferably one with a medical school. He noted: "The medical school staff will have biochemists, nutritionists, and physiologists, which

can aid in the supervision of research and contribute to the stimulation of ideas that spark creativity.” In his oral testimony, Dr. Cornatzer addressed the limitations in knowledge concerning human nutrition and emphasized the need for a USDA human nutrition research laboratory (2).

On September 12, 1963, Senator Young presented to the Senate a “Proposed Program for Expanded Research in Food and Nutrition,” prepared by ARS at his request (3). While the ARS authors were not identified, the proposal most likely was prepared by Edith Weir and/or Callie Mae Coons. The proposal was consistent with Dr. Cornatzer’s vision. It stated that the program would “help meet national requirements for food and nutrition research during the next three years.” It called for \$8.92 million for new research facilities, including three regional laboratories (\$1.9 million), each with a professional staff of 15-20 scientists, and a plan to increase the total effort, ultimately, to 148 scientists and a budget of \$9.2 million (including \$4 million for extramural contracts and grants). The proposal cited legislative authority for such a program as deriving from the charge of the Congress in establishing the U.S. Department of Agriculture—“to acquire and to diffuse among the people of the United States useful information on subjects connected with agriculture in the most general and comprehensive sense of that word” It also cited the Research and Marketing Act of 1946, which authorized “research into the problems of human nutrition and the nutritive value of agricultural commodities, with particular reference to their content of vitamins, minerals, amino and fatty acids, and all other constituents that may be found necessary for the health of the consumer and to gains or losses in nutritive values that may take place at any stage in their production, distribution, processing, and preparation for use by the consumer.”

Origin of the Grand Forks Human Nutrition Research Center

William Cornatzer’s vision of a national system of USDA human nutrition laboratories included one on the campus of the University of North Dakota in Grand Forks, ND (UND). In fact, the laboratory in Grand Forks was the first of these units to be established. Its mission arose out of several statements in the ARS proposal (3): “The role of the so-called minor minerals in nutrition requires greater study This research includes investigations relating to—nutrient requirements of persons at different stages and different conditions of life; the effects of nutrient balance, environmental conditions, and other factors on metabolic processes Special attention will be given to nutrients for which data are sparse or nonexistent and that recent research has demonstrated are important to man. Among these nutrients are mineral elements important in biological enzyme systems and in blood formation.”

While the proposed program was approved in 1964, the Congress did not make funds available until 1966, when it appropriated \$50,000 for planning a laboratory at Grand Forks. Funds were not available for construction until 1968, when \$490,000 was appropriated to ARS for this purpose. As this amount was some \$92,000 less than the low bid for the Grand Forks facility, USDA provided the necessary additional funds at Senator Young’s behest.

Land for the laboratory was donated to the Federal Government by the State of North Dakota. The selected parcel was immediately adjacent to the campus of the University of North Dakota and close to its School of Medicine. Planning and construction of the original 18,000-square-foot building cost about \$633,000.

The opening of the new laboratory was celebrated in September 1970 with a



Harold H. Sandstead, M.D., was appointed Director of the Grand Forks Human Nutrition Research Center.

symposium on “Newer Trace Elements in Nutrition” (4). This was hosted jointly by the ARS Human Nutrition Division and the UND School of Medicine. Some 180 scientists participated, including such internationally recognized trace element researchers as Eric Underwood (University of Western Australia), Bert Vallee (Harvard University), Boyd O’Dell (University of Missouri), Howard Ganther (University of Wisconsin), Helen Cannon (U.S. Geological Survey), James A. Halsted (U.S. Veterans Administration), Mattie R. Spivey-Fox (U.S. Food and Drug Administration), Klaus Schwarz (National Institutes of Health), Walter Mertz (ARS), Milton Scott (Cornell University), Mark Hegsted (Massachusetts Institute of Technology), Paul Weswig (Oregon State University), Richard Luecke (Michigan State University), Richard Doisy (St. Louis University), and Nobel Laureate Edward Doisy (St. Louis University).

Nutrition Research at Grand Forks: the Early Years, 1970-1984

Establishing the laboratory. The new laboratory was named the Grand Forks Human Nutrition Laboratory and organized as a field station of the ARS Human Nutrition Research Division in Beltsville,

MD, which was then directed by Willis A. Gortner. The two-floor facility comprised seven wet laboratories, a small conference room, administrative offices, storage and mechanical rooms, with a small (7,200 sq ft) clinical research facility located on the second floor. The latter consisted of eight bedrooms, a communal toilet and shower, a treatment room, a nurse’s station, a commons/dining area, a kitchen, a clinical laboratory, and a number of offices. The facility opened with a staff of three: Scientist Forrest H. Nielsen, Ph.D., Building Maintenance Technician Ben Bailey, and Secretary Marguerite Lynch. The unit operated with an appropriated budget of \$290,000.

Leadership. In 1971, Harold H. Sandstead, M.D., a clinical investigator, was named Laboratory Director. He would become Center Director the next year.

Organizational changes in USDA. In 1972, the Laboratory was transferred to the Dakotas Area, then directed by Claude H. Schmidt, Ph.D., as a unit of the North Central Region of ARS, which was then led by Earl Glover. With the establishment of the USDA National Human Nutrition Center, directed by D. Mark Hegsted, Ph.D., the laboratory was renamed the Grand Forks Human Nutrition Research Center (GFHNRC). When the USDA National Human Nutrition Center was terminated during the Reagan Administration, the GFHNRC once again became a unit of ARS in what was then its Northern States Area. With a later reorganization, the GFHNRC became part of the agency’s Northern Plains Area.

Facilities development. During the early 1970s, the Center’s facilities were improved by construction of a human whole-body radiometer for in vivo measurement of gamma-emitting isotopes (1973), addition of an exercise physiology laboratory, and enlargements of the clinical research space (1975).

Major additions were made to the GFHNRC in the late 1970s and 1980s. In the late 1970s, Senator Mark Andrews (R-ND) sponsored legislation that authorized \$3.5 million for construction of a new wing to the building. Construction of the addition began in 1980, increasing the floor space to about 77,000 sq ft at a cost of \$6.835 million. This addition, which was completed in 1983, provided two floors of vivarium space (with clean/dirty corridor design), conference rooms/library, administrative offices, a new clinical laboratory, a state-of-the-art metabolic kitchen, an enhanced exercise physiology laboratory, and a 14-bedroom metabolic research unit.

Staffing development. In 1971, a clinical investigator, Harold H. Sandstead, M.D., a biochemist, Gary W. Evans, Ph.D., and a clinical chemist, Kim P. Vo-Khactu, Ph.D., were hired. The staff grew with subsequent hires: an experimental nutritionist, Leslie M. Klevay, M.D., S.D., and a biochemist, Gary J. Fosmire, Ph.D., in 1972; an immunologist, Robert S. Pekarek, Ph.D., a half-time psychologist, Edward Halas, Ph.D., and a chemist, Robert A Jacob, Ph.D. (replacing Vo-Khactu) in 1974; a chemist, Carol J. Hahn, Ph.D., in 1975; a clinical investigator, Juan M. Munoz, M.D., in 1976; a nutritional biochemist, David B. Milne, Ph.D. (replacing Jacob), one fifth-time research physicist, Glen I. Lykken, Ph.D., and a half-time neuropsychologist, Donald M. Tucker, Ph.D., in 1977; a chemist Phyllis E. Johnson, Ph.D., a clinical investigator, Wesley K. Canfield, M.D., (replacing Munoz), and an immunologist, Tim R. Kramer, Ph.D., in 1979; and a biochemist, James C. Wallwork, Ph.D. (replacing Fosmire) in 1979. Staff departures during this period were Vo-Khactu (1974), Hahn (1976), Jacob (1976), Munoz (1977), Pekarek (1977), Fosmire (1979), and Evans (1982).

Relationship with University of North Dakota. In 1972, the GFHNRC executed a Broad Form Cooperative Agreement with

UND. This agreement enabled UND graduate students to perform their research at the GFHNRC and UND statistician George Logan, M.S., (later LuAnn Johnson, M.S.) to provide statistical analytical support to GFHNRC scientists.

Research program. By 1975, the GFHNRC research program included six basic science units¹ and one clinical research unit. The basic science units were led as follows: Nickel and Other Ultra-Trace Elements—Nielsen; Copper, Cholesterol and Heart Disease—Klevay; Facilitators of Zinc and Copper Intestinal Absorption—Evans; Zinc, Immunity and Inflammation—Pekarek; Zinc and Development and Function of the Brain—Sandstead and Fosmire; and Cadmium Toxicity—Sandstead and Klevay. The clinical research unit was led by Sandstead and Klevay. Initially, the research focused on the effect of sources of dietary fibers and phytate, including hard red spring wheat bran, soft white wheat bran, durum bran, wheat germ, corn bran, soybean hulls, and carrot powder on the intestinal absorption of zinc, copper, iron, calcium, and magnesium; the dietary requirements for zinc, copper, iron, calcium, and magnesium; and concentrations of serum cholesterol, insulin, and glucose. Also measured were the metabolic effects of subclinical zinc and copper deficiencies, interactions between zinc and copper, and the effect of folic acid on intestinal absorption of zinc.

Research accomplishments. The GFHNRC produced the following significant research findings during this era:

- Showed that a modest daily intake (26 g) of hard red spring wheat (Waldron variety) bran decreased serum total- and LDL-cholesterol concentrations and increased the rate of glucose clearance from the blood of healthy men (5,6)₂.
- Showed that zinc deprivation in rats during pregnancy and/or lactation impairs brain growth and development,

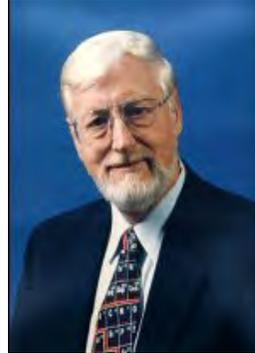
and results in variety of abnormal behaviors in nutritionally rehabilitated adult offspring (7-10). This finding was background for later studies with children showing that zinc is essential for cognitive and psychomotor functions (11,12).

- Discovered that low iron nutriture impairs brain electrophysiology in humans (13).
- Demonstrated that uncomplicated zinc deficiency in a human suppressed cell-mediated immunity (14), and that zinc deficiency is common among patients with intestinal malabsorption syndromes (15,16).
- Found that zinc treatment of pregnant, low-income teenagers nearly eliminated the need for respiratory assistance in their newborn infants (17).
- Observed that some U.S. diets do not provide adequate amounts of copper (18,19); this and other research at the GFHNRC renewed interest in copper as a nutrient of concern for cardiovascular health (20-22).
- Discovered that boron in nutritional amounts is beneficial for bone formation in chicks, suggesting that this element is possibly essential for higher animals (23).
- Showed that low intakes of nickel (24) are beneficial for bone formation and lipid metabolism in animal models, suggesting that this element is possibly essential for higher animals.

The GFHNRC developed the following useful innovative research tools:

- GRAND (Grand Forks Research Analysis of Nutrient Data)—a system for evaluating and planning of diets. This included the trace element contents of more than 3,000 foods, which facilitated the development of rotating menus for long-term experiments on the GFHNRC metabolic unit.
- A method for determining whole-body surface losses of trace elements (25,26).

1986



Forrest Nielsen, Ph.D., was appointed Director of the Grand Forks Human Nutrition Research Center.

This facilitated the determination of normal surface losses of copper, zinc, and magnesium.

- A method for the synthesis of chromium picolinate (27), which was thought to be beneficial in glucose-intolerant individuals (28,29). This substance became a best-selling nutritional supplement.

Nutrition Research at Grand Forks: the Middle Years, 1984-2001

Funding. Between 1984 and 1990, Senator Quentin Burdick (D-ND) was instrumental in the GFHNRC budget growing from \$5.5 million to \$8.2 million (figure 1) and remaining at nearly that level during the 1990s. By 2000, the GFHNRC appropriation had increased to \$8.4 million.

Leadership. In 1984, Leslie Klevay was named Acting Center Director, replacing Dr. Harold Sandstead, who moved to the Human Nutrition Center for Aging at Tufts University. In June 1985, the duties of the Center Director were transferred from Dr. Klevay to Forrest Nielsen, Ph.D. In December 1986, Dr. Nielsen was appointed Center Director.

History of Appropriated Funding for GFHNR

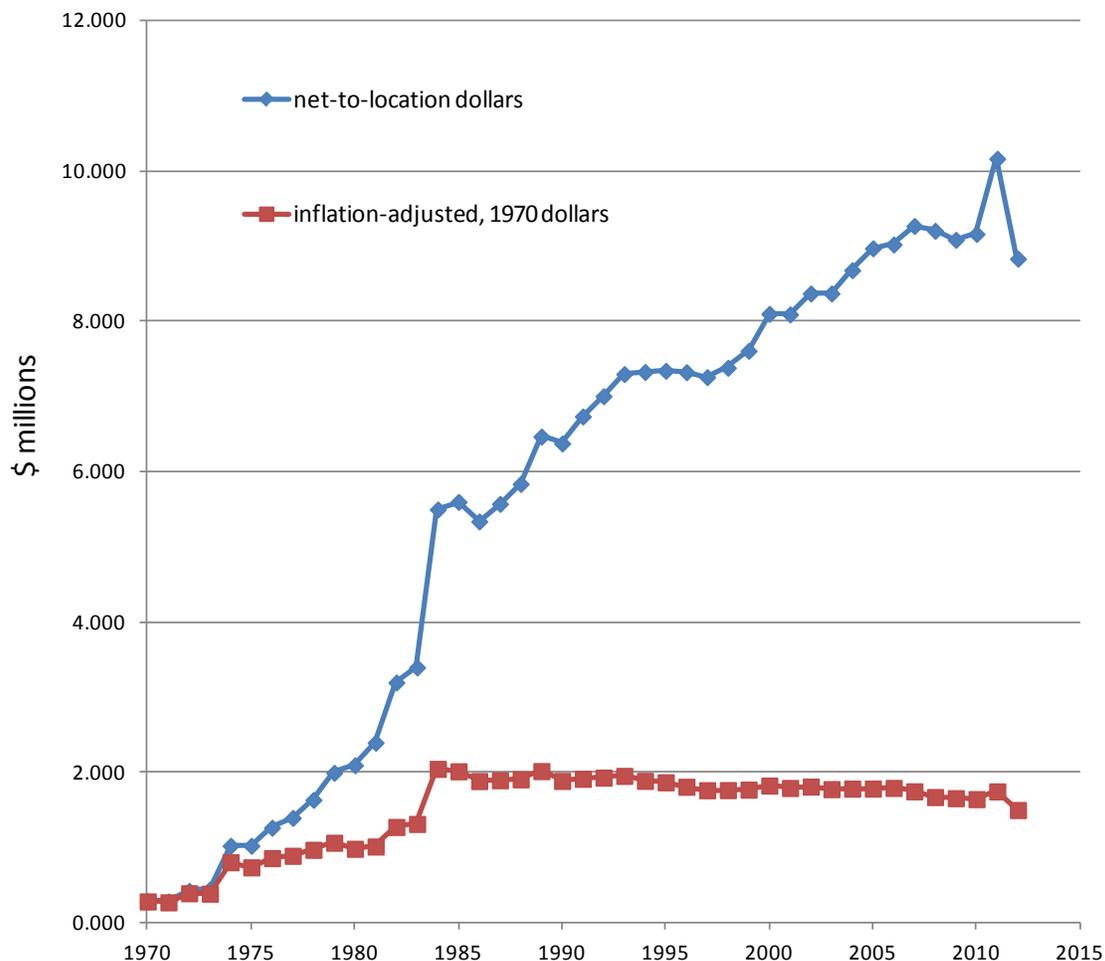


Figure 1. History of Grand Forks Human Nutrition Research Center appropriated funding.

Facilities. In 1984, an empty west-end shell was constructed for future development. In 1987, this was incorporated into the remodeling of first-floor laboratories. During this time, two shared research cores were created: a cell culture facility and a mineral analysis laboratory. Also in 1984, the second floor of the original building was remodeled to provide a nurses station and kitchen area for community-based studies, and a psychological testing suite. In 1986, a mainframe computer was acquired. By 2000, this system had been rendered obsolete by the migration to personal computers. In 1995, three parcels of land adjacent to the Center were purchased. The houses on two of the parcels of land were removed to build a parking lot for volunteers, handicapped employees, and

Center vehicles. The remaining house has been retained for low-priority storage.

In April 1997, a devastating flood inundated Grand Forks, ND, covering 85 percent of the city, forcing an evacuation of the city and severely damaging the facility. Flood waters destroyed the ground floor and basement, most of the scientists' offices and laboratories, and the vivarium. ARS considered not rebuilding the facility; however, the North Dakota Congressional delegation—Representative Earl Pomeroy (D-ND), Senator Byron Dorgan (D-ND), and Senator Kent Conrad (D-ND)—strongly opposed this action, and funds were obtained to repair the damage. The repairs took 2 years and involved removing and rebuilding the entire basement (including

vivarium) structure, repairing the entire first floor, and replacing the HVAC system and much of the electrical system. While this was being done, most employees were dealing with the same kinds of damage to their own homes.

The Center continued to function while the facility was being restored. Administrative people worked first out of motel rooms and then from their homes. People doubled up in second-floor laboratories, and mobile housing units were leased to serve as animal quarters. Finally, after 2 years and at a cost of some \$6.5 million, the restoration was complete. A rededication of the facility was held in June 1999.

In 2000, the Center purchased a custom-built mobile research laboratory at a cost of some \$400,000 provided by the Congress for that purpose. This unit, the only one of its kind, would facilitate nutrition research beyond the walls of the Center.

Staffing development. By 1984, the only full-time Federal scientists at the GFHNRC were Canfield, P. Johnson, Klevay, Kramer, Milne, Nielsen, and Henry C. Lukaski, Ph.D. (hired in January). In 1985, two University of North Dakota employees were hired into Federal scientist positions: Psychologist James G. Penland, Ph.D., and Biochemist Eric O. Uthus, Ph.D. The Center recruited additional scientists: Biochemist W. Thomas Johnson, Ph.D., Nutritionist Janet (Mahalko) Hunt, Anatomist Curtiss D. Hunt, Ph.D., Physiologist Jack T. Saari, Ph.D., and Nutritional Biochemist Philip G. Reeves, Ph.D., in 1987; Nutritionist John W. Finley, Ph.D. (replacing P. Johnson) in 1992; Nutritionist Cindy Davis, Ph.D., in 1998; and Molecular Biologist Huawei Zeng, Ph.D., and Nutritionist Fariba Roughead, Ph.D., in 2001. Departures from the Federal senior scientist staff during this period were Wallwork (1984), Tucker (1984), Canfield (1986), Lykken (1988), Halas (1988), Kramer (1989), P. Johnson (1991), and Milne (retired

1999). In 1990, when appropriated funds peaked based on inflation, the GFHNRC had 42 Federal employees consisting of 12 scientists, 5 post-doctorates, 14 laboratory technicians, 2 nurses, and an administrative staff of 9. A Research Support Agreement staff of 138 provided nurses, dietary technicians, clinical chemists, recruitment personnel, and psychologists for metabolic unit studies; service personnel for the vivarium, data processing, custodial duties, and building maintenance; and students (25 part-time) serving as chaperones for metabolic unit studies and/or helping in research laboratories.

Relationship with the University of North Dakota. In 1985, the Center was directed to replace the Broad Form Cooperative Agreement (BFCA) with the University of North Dakota with a contract for personnel services by using A-76 contracting guidelines. This contract was not completed before the Center was directed to replace the BFCA with a newly authorized instrument, a Research Support Agreement (RSA). This affected some 130 full-time employees and 30 part-time students then employed by UND in support positions (nurses, dietary technicians, chaperones, clinical chemists, recruitment personnel, psychologists, animal care, data processing, custodial work, and building maintenance). The transition was made in such a way that most UND employees continued in their positions at the GFHNRC. However, 17 positions were deemed unsuitable for the RSA, and those employees were given Federal positions. The following year, the Center executed a second agreement with the UND School of Medicine to provide medical services for human studies.

Research program. By 1985, the Center's work units had expanded to 30, although they were implemented by only 7 scientists. Thus, with the help of ARS Human Nutrition National Program Leader Gerald F. Combs, Sr., Ph.D., these were collapsed into 11

projects arrayed in 2 management units. Dr. Klevay was appointed Research Leader of the Human Subjects Research Unit, and Dr. P. Johnson was appointed Research Leader of the Animal Models Research Unit. The names of these management units were later changed to “Clinical Nutrition” and then “Mineral Nutrient Requirements” and “Nutrition, Biochemistry and Metabolism” and then “Mineral Nutrient Functions,” respectively.

With this reorganization, a formal mission statement was adopted: “To plan, develop, and implement research that is designed to produce new knowledge about human nutrient requirements with emphasis on minerals.” In 2000, the mission statement was changed: “To serve the public through research to determine nutrient needs for humans and to provide information concerning healthy food choices and a healthful food supply, with emphasis on determining mineral requirements that prevent disease and promote health and optimal function throughout life.”

The availability of the new metabolic research unit in 1985 enlarged and improved the facilities to conduct tightly controlled human feeding studies, including metabolic balance trials for trace elements. The new community studies kitchen and dining area advanced tightly controlled feeding studies with participants not residing in the metabolic unit.

Between 1985 and 2001, unique human studies that followed long-term, controlled feeding/metabolic balance designs were conducted at the GFHNRC. Participants typically spent 6 months under carefully controlled conditions in the metabolic research unit where they remained under close supervision and were chaperoned when outside the unit. They were trained to consume only those foods and beverages provided by dietary staff, who could assess compliance by performing weigh-

backs. Experimental diets were based on common, Western-type foods and were usually presented in a 3-day rotating menu cycle to provide some variety while being relatively consistent in nutrient composition. Participants’ body weights were maintained within $\pm 2\%$ of their respective starting weight through the use of individualized dietary formulations and exercise prescriptions that were adjusted as necessary.

Research accomplishments. Research accomplished at the GFHNRC during 1984-2001 was among the primary data used by the Food and Nutrition Board of the Institute of Medicine to establish the Dietary Reference Intakes (DRIs). The sections on trace elements cited more than 50 GFHNRC publications (30). In addition, the Center’s metabolic balance studies (31) were instrumental in the setting of Recommended Dietary Allowances (RDA) for calcium in 2010 (32), and suggesting a new RDA for magnesium (33). GFHNRC studies of human trace element absorption/retention were key to establishing DRIs for zinc (34-37), iron (38,39), and manganese (40-42).

Other significant research findings included—

- That boron may be beneficial for humans. Supplementation of a low-boron diet with an amount of boron commonly found in diets high in fruits and vegetables induced changes in postmenopausal women consistent with improved bone health and cognitive function (43-48). Boron supplementation modified concentrations of calcium metabolism hormones calcitonin and 25-OH-vitamin D₃ in serum, and enhanced the response to estrogen therapy in postmenopausal women. Boron supplementation improved mental alertness, improved motor speed and dexterity, and improved cognitive processes of attention and short-term memory in older men and women

- (47,48). These findings were cited by the World Health Organization in setting a suggested safe and adequate intake for boron (49).
- That magnesium deprivation of postmenopausal women can produce electroencephalographic changes indicative of central nervous system hyper-excitability (47), heart rhythm abnormalities (50), energy inefficiency (51), and increased calcium retention (52).
 - That a high intake of zinc (53 mg/d) can depress magnesium balance, apparently inducing undesirable changes in bone turnover markers in postmenopausal women (53).
 - That combined marginal intakes of zinc and copper induced heart rhythm abnormalities, increased serum cholesterol, and induced changes in oxidative stress markers indicating increased oxidative stress in postmenopausal women (54,55). These findings suggested that low zinc intake may increase the dietary need for copper, as has been shown for high-zinc intakes.
 - That the supplement chromium picolinate is ineffective in promoting weight loss and increasing strength (56,57).
 - That cadmium is very poorly bioavailable from sunflower seeds. Consumption of sunflower seeds relatively high in cadmium at a rate of 3-4 times normal for 48 weeks showed no measurable signs of toxicity and no significant uptake of the element as evidenced by cadmium levels of urine, erythrocytes, or hair (58-61). These findings informed a pending decision potentially affecting the importation of U.S. confectionary sunflowers into the European Union, allaying health concerns and, in effect, keeping that market open for U.S. producers. It was said that this research saved the sunflower industry in the Northern Plains.
 - That deprivation of nickel can affect the utilization of vitamin B12 (62), reduced sperm quantity and movement (63), exacerbated the response to a high salt intake (64), and impaired bone strength (65) in rats.
 - That deprivation of arsenic can affect single-carbon metabolism (66) in rats and chicks and cause DNA hypomethylation (67,68), which is associated with an increased risk of cancer in rats.
 - That exposure to diets modestly low in silicon can be beneficial for collagen formation and trabecular bone composition in the rat (69,70). These findings contributed to stimulating others to correlate increased silicon intakes with preventing bone loss in humans that could result in osteoporosis (71). Other findings suggested that silicon can enhance wound healing (72) and may be anti-inflammatory (73,74).
 - That boron can promote bone growth, strength, and maintenance (75-78), and the inflammatory response (79); that these effects may involve effects on S-adenosylmethionine utilization/formation (80,81).
 - That selenium is an effective anti-carcinogen agent. Selenium was found effective in the prevention of chemically induced aberrant colonic crypt (preneoplastic) foci (82,83), in the prevention of chemically induced cancers of the colon (84) and mammary gland (85), and in the prevention of spontaneous intestinal cancer in a high-risk, genetic mouse model (86). High-selenium broccoli and processed high-selenium wheat products were notably effective in protecting against colon cancer (87). These protective effects were associated with selenium inhibition of carcinogen-induced DNA-adducts formation (87).
 - That suboptimal dietary copper, manganese, or iron can increase susceptibility to chemically induced

colon cancer (89,90), and that copper deprivation can increase colonic tumorigenesis in a high-risk mouse genetic model (91).

- That copper-deficient animals are vulnerable to oxidative stress (92,93), and that rodents fed a high-sucrose diet marginally restricted in copper exhibit cardiomyopathy (94) reversible by copper supplementation (95).

Innovative research tools developed included—

- Computer-based systems for assessing a large number of cognitive processes and psychomotor skills in adults and children. These tests were instrumental in showing that zinc supplementation could improve cognitive function in children consuming low-zinc diets (11,12,96).
- A sensitive and accurate method for the determination of boron and other trace elements in low concentrations in biological samples (97). This method has been used to determine the boron content of a large number of foods (98); these determinations are a major source of data for the boron contents of foods.
- Bioelectrical impedance established for the determination of body composition (99-106).
- AIN-93 Rodent Diet—the standard diet used in virtually all nutritional studies with rodents today (107-109).
- Techniques developed for the state-of-the-art human whole-body radiometer were used to determine the metabolism of several minerals, including zinc and iron (34,37,39).

Nutrition Research at Grand Forks: the Recent Years, 2001-2012

Budget. By 2001, the GFHNRC appropriated budget was \$8.4 million. Through the efforts of the North Dakota Congressional

2002



Gerald Combs, Jr., was appointed Director of the Grand Forks Human Nutrition Research Center. In December 2004, he became the first appointment to the new Senior Scientific Research Service.

delegation, the budget increased incrementally to \$8.8 million in 2005, to \$9.0 million in 2006, and to \$9.2 million in 2007.

Leadership. In 2001, Dr. Nielsen stepped down as Center Director. For 2 years, he was replaced with a series of ARS scientists each detailed to serve on an “acting” basis: Dr. Robert Jacob, Dr. Wayne Wolf, and Dr. Henry Lukaski. In January 2002, that position was filled by Gerald F. Combs, Jr., Ph.D., a professor in the Division of Nutritional Sciences at Cornell University who served through an Interagency Personnel Agreement between ARS and Cornell University. In December 2004, Dr. Combs became the first appointment to the new Senior Scientific Research Service, which had been authorized by the Farm Bill of that year. He has continued to serve in that capacity as Center Director through the time of this writing. In 2004, Dr. Henry Lukaski was designated as Assistant Center Director, serving in that capacity until his retirement in 2009.

Facilities. During 2003-2004, 6,000 sq ft of space on the second floor was remodeled at a cost of some \$700,000 to add a multi-user laboratory and offices for scientists. In the same year, the Center’s outside-access

smoking room was closed, later to be offered for employee daytime bicycle storage. In 2006, a Human Performance Core was created by remodeling existing space and consolidating body composition and other human performance instrumentation. In 2008, a new rear entrance was added to facilitate volunteer access to the lobby from the rear parking lot. Major improvements in the Center's HVAC, windows, lighting, and roofing were made 2009-2011. In 2011, the Cell Culture Core was expanded, a dark room was remodeled to serve as a centrifuge room, and the former psychology testing area (second floor) was remodeled into a Behavioral Laboratory Suite consisting of three monitored eating laboratories, two monitored multi-purpose activity laboratories, and two control rooms.

Major instrumentation purchased during this period included nuclear magnetic resonance imager for the live assessment of body composition of small rodents; inductively coupled plasma emission mass spectrometer in tandem with a liquid chromatograph (LC-ICP-MS); isotope ratio mass spectrometer (IRMS); ion-trap, time-of-flight mass spectrometer in tandem with a liquid chromatograph (LC-IT-ToF); low-angle X-ray fluorescence spectrometer; automated nucleic acid processor; automated clinical chemistry analyzer; dual-energy X-ray whole-body scanner; plethysmograph; echo sonograph; Endopat vascular flow monitor; flow cytometer; Seahorse extracellular flux analyzer; micro-computed tomography (μ CT) scanner for analysis of rodent bone microarchitecture; multi-sizer adipocytes-counting flow cytometer; microarray reader; cavity ring-down spectrophotometer; Raman effect laser scanner; infrared imaging system; and pyrosequencer.

Staffing. In 2004, Jack Saari, Ph.D., and Janet Hunt, Ph.D., were appointed Research Leaders of the Center's research management units (MUs), which had been renamed "Nutritional Determinants of

Health" and "Micronutrient Absorption and Metabolism," respectively. Scientists hired during this period included Community Nutritionist Sarah E. Colby, Ph.D., and Clinical Investigator Wesley K. Canfield³, M.D., in 2005; Molecular Biologist Jay J. Cao, Ph.D. (replacing Davis) in 2006; Nutritional Biochemist Lin Yan, Ph.D., in 2007; Epidemiologist Lisa A. Jahns, R.D., Ph.D. (replacing Colby), Biochemist Matthew J. Picklo, Ph.D. (replacing Klevay) in 2008; Exercise Physiologist Pedro Del Corral, M.D., Ph.D. (replacing Finley), Clinical Nutritionist Susan K. Raatz, R.D., Ph.D. (replacing Penland), and Nutritionist Leah D. Whigham, Ph.D. (replacing Lukaski) in 2009; Nutritional Immunologist Kate J. Claycombe, Ph.D. (replacing Reeves) in 2010; and Exercise Physiologist James N. Roemmich, Ph.D. (replacing J. Hunt) in 2011. Departures from the senior scientist staff during this era were Davis (2002), Klevay (retired 2004), Finley (2005), Roughead (2005), Saari (retired 2006), Colby (2007), Reeves (retired 2007), Penland (retired 2007), J. Hunt (retired 2008), C. Hunt (retired 2008), Lukaski (retired 2008), Canfield (2009), Del Corral (2010), W.T. Johnson (retired 2010), and Nielsen (retired 2011). By early 2012, the GFHNRC had a total of 95 full-time employees, including 11 senior scientists, 2 retired scientists active through cooperative agreements (W.T. Johnson and Nielsen), and 4 open scientist positions.

Research Program. In 2002, the Center reorganized its research work units based on scientist teams. This resulted in collapsing the 11 units into 5 based on 3 programmatic pillars: obesity prevention, nutrients and other bioactive factors in foods, and mineral nutrition and metabolism. This plan was followed when Center scientists wrote their first Research Proposals for the newly implemented process of external review through the ARS Office of Scientific Quality Review (OSQR).

In 2006, the Center held a retreat of the senior scientists to discuss how to enhance the quality and relevance of the Center's research program. An outcome from those discussions was the adoption of "Food Factors and Health" as an organizational theme, with the mission statement "A leading nutrition research center providing trustworthy information about healthy choices of diet and physical activity."

In 2009, ARS directed the GFHNRC to pursue a program comprised of research addressing the prevention of obesity prevention and related disorders. The Center responded by developing a new array of five projects in two management units: the Healthy Body Weight Research Unit (projects—"Dietary Guideline Adherence and Maintenance of Healthy Body Weight," and "Biology of Obesity") ultimately led by Dr. Roemmich, Research Leader, and the Dietary Prevention of Obesity-Related Disease Research Unit (projects—"Roles of Food Factors in Preventing Obesity-Related Disease," "Dietary Prevention of Cancer," and "Obesity and Bone Health") led by Dr. Picklo, Research Leader. These projects received the highest OSQR evaluations the Center has received to date.

Proposed closure. In February 2008, the Bush Administration proposed the closure of the GFHNRC. That proposal called for moving about half of GFHNRC employees to the ARS Western Human Nutrition Research Center on the campus of the University of California, Davis, and half to the ARS Beltsville Human Nutrition Research Center, Beltsville, MD. Then-Secretary of Agriculture Ed Schafer testified before the Senate Agriculture Appropriations Subcommittee that these moves would cost taxpayers only \$500,000. However, the UND School of Business and Public Administration determined that the cost of closure and proposed relocation of employees would exceed \$40 million. This latter cost analysis contributed to the efforts of North Dakota

Senator Byron Dorgan and Representative Earl Pomeroy and Connecticut Representative Rosa Delauro (D-CT) that ensured the continuation of the GFHNRC in Grand Forks. The continuation was specified in legislation passed into law in fall of 2008, which also provided a \$1 million increase in base funding for the Center.

The nearly year-long period of uncertainty, followed by the marked change in mission, led to remarkably few resignations or retirements of Center staff. Still, this period saw the retirements of Drs. Lukaski, J. Hunt, and C. Hunt in 2008, and W.T. Johnson in 2010.

Relationship with UND. In 2002, the Center was directed to reduce the scope of the Research Support Agreement (RSA), which by then was supporting some 65 UND support employees at the GFHNRC. Accordingly, a Specific Cooperative Agreement (SCA) was executed between ARS and UND in 2004; this agreement supported some 40 UND employees who provided support for the Center's human studies. At the same time, the RSA was reduced to support only those UND employees who provided animal care and facilities support. In 2009, the SCA was replaced with an Assistance-Type Cooperative Agreement, which did not require UND to provide partial matching funds, and a smaller SCA was executed between ARS and the UND School of Medicine and Health Sciences to collaborate in conducting clinical research and provide medical oversight for GFHNRC human studies.

Community relationships. In 2005, the Center led ARS into establishing a summer internship program for Native American students through collaborative agreements with United Tribes Technical College, Bismarck, ND, and the University of Arizona, Tucson, AZ. During 2005-2010, that program provided valuable learning

experience for 38 bright students at 5 ARS locations, half of which were at the GFHNRC.

In 2008, the Center executed a Specific Cooperative Agreement with the Grand Forks Park District to facilitate collaborative, community-based studies related to healthy body weight. This included establishing a GFHNRC presence in a 167,000-sq-ft community health and fitness center scheduled to open in September 2012. This is the first Federal-local partnership dedicated to community-based human experimentation.

Research accomplishments. Significant accomplishments during this era included the following findings:

- That high-meat-protein diets do not promote calcium losses in women at risk to osteoporosis (110). High-meat diets were found to enhance calcium net utilization particularly from low-calcium diets. These findings refuted the popular understanding that high-protein intakes might contribute to osteoporosis by increasing calcium loss.
- That high-protein diets support the up-regulation of protein synthesis to mitigate the otherwise inevitable loss of lean body mass during periods of energy deficit in exercising humans (111). This came from a study done in collaboration with the U.S. Army Institute for Research in Environmental Medicine.
- That subclinical magnesium status, which appears to be prevalent, has pro-inflammatory effects (112).
- That current copper recommendations for humans are insufficient to accommodate losses of that nutrient associated with moderate exercise (113,114).
- That humans can compensate for low intakes of zinc by increasing the fractional absorption of that nutrient (115,116), and that this compensation can be blocked by dietary phytate (117).
- That zinc supplementation may be beneficial to bone health in postmenopausal women consuming less than the RDA for that nutrient (118). This study also suggested that relatively low intakes of magnesium may compromise indicators of bone health.
- That prolonged physical exertion does not produce physiologically significant losses of zinc, iron, calcium, magnesium, or phosphorus via sweat because loss of these elements in sweat declines as the exertion progresses (113,114).
- That supplementation of cancer-preventive doses of selenium to non-deficient adults produces increases only in non-specific fraction of plasma selenium, and that glutathione peroxidase (intracellular) genotype is a useful predictor of plasma selenium concentration and selenium balance (119).
- That the selenium metabolite, methyselenol, inhibits secondary carcinogenesis, as assessed in an animal model by the migration and invasion of transplanted tumor cells (120).
- That increased adiposity induced by a high-fat diet can reduce bone volume (121,122). This finding indicates that increased weight in obesity resulting in an increase load on bones (stimulates bone formation) may not prevent bone loss leading to osteoporosis. An obese mouse model also was used for the discovery that adipose protein redox status is altered in obesity (123).
- That perinatal copper deprivation can increase the expression of fibulin-5 and reduce the expression of a specific, nuclear encoded subunit of cytochrome c oxidase in the fetus, which results in impaired cardiac function in offspring (124). Evidence for cardiac impaired function and increased oxidative stress was shown by adult offspring of copper-deficient dams; they exhibited decreased cytochrome c oxidase activity, increased mitochondrial hydrogen peroxide generation, and enhanced formation

of intracellular residual bodies in their hearts (125). Maternal copper deprivation also impaired vascular function in offspring (126).

- That a low-protein diet for dams can change the expression of genes in pups, such that they develop more and larger fat cells and become obese (127).
- That impaired methylation, which occurs in obesity-related conditions, reduces expression of the major selenium transporter, selenoprotein P (128).
- That copper deficiency reduces iron absorption and retention (129).
- That elemental iron powders are 50-85% as bioavailable as ferrous sulfate (130,131).
- That the anemia produced by the deprivation of copper reduces expression of the iron metabolism regulatory molecule hephaestin in the rat (132,133).

Innovative research tools were developed, including—

- A method to sample transcellular/interstitial fluids and regional sweat (114,134).
- Robust animal models of secondary carcinogenesis. These models involve the implantation of cultured malignant melanoma cells, which ultimately metastasize to the lung (120).

Summary

The human nutrition program that became the GFHNRC was envisioned in the early 1960s by University of North Dakota biochemist William Cornatzer. Dr. Cornatzer's vision was picked up by U.S. Senator Milton R. Young, whose efforts led to a self-study by ARS of human nutrition research needs and, ultimately, to the founding of the Grand Forks Human Nutrition Laboratory in 1970. The facility, renamed the "Grand Forks Human Nutrition Research Center" in 1972, became the prototype for the subsequent founding of five

additional USDA Human Nutrition Centers comprising what became a robust national program of human nutrition research.

Over its 42 years of operation, GFHNRC has contributed significantly to scientific knowledge in human nutrition. Since 1971, over 1,700 scientific articles have been published by Center scientists. The Center became an international leader in conducting metabolic studies of trace elements in healthy volunteers; those studies produced key information that was used in establishing Dietary Reference Intakes (DRIs). The Center also pioneered in researching the nutritional roles of bioactive trace elements and so-called "ultra-trace elements," for which nutritional essentiality was not clear.

The redirection of the GFHRNC program to research addressing the prevention of obesity and related disorders represents a huge frame shift in the deployment of facilities and expertise. It presents the GFHNRC with the challenge to develop preeminence in this area comparable to that which it enjoyed in researching trace elements.

Acknowledgments

We thank Gerald F. Combs, Sr., Patricia Swan, and Donna Porter for sharing copies of relevant documents.

Author Contributions

Forrest Nielsen edited the Introduction and wrote Sections II-IV; Harold Sandstead wrote the Introduction and contributed material to Section II; Gerald Combs, Jr., edited the entire chapter and contributed material to Section IV.

Notes

1. In ARS parlance, these were Current Research Information System (CRIS) work units.
2. This finding appears to have prompted Mary Andrews, the wife of U.S. Senator Mark Andrews, to include Waldron hard red spring wheat bran in her homemade muffins. When her serum cholesterol level was found to have dropped, the Senator is said to have shared the wheat bran with several of his colleagues whose similarly favorable responses are said to have been instrumental in convincing the North Dakota Congressional delegation to promote human nutrition research in North Dakota.
3. Dr. Canfield had served on the GFHNRC scientific staff in 1979-1981.

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Appendix 1. ARS scientists at the Grand Forks Human Nutrition Research Center

Scientist	Years of service	Scientist	Years of service
Wesley K. Canfield, M.D.	1979-1986, 2005-2009	Henry C. Lukaski, Ph.D.	1984-2008
Jay J. Cao, Ph.D.	2006-current	David B. Milne, Ph.D.	1977-1999
Kate J. Claycombe, Ph.D.	2010-current	Juan M. Munoz, M.D.	1976-1977
Sarah E. Colby, Ph.D.	2005-2007	Forrest H. Nielsen, Ph.D.	1970-2011
Gerald F. Combs, Jr., Ph.D.	2002-current	Robert S. Pekarek, Ph.D.	1974-1977
Cindy D. Davis, Ph.D.	1998-2002	James G. Penland, Ph.D.	1985-2007
Pedro Del Corral, M.D., Ph.D.	2009-2010	Matthew J. Picklo, Ph.D.	2008-current
Gary W. Evans, Ph.D.	1971-1982	Susan K. Raatz, Ph.D., R.D.	2009-current
John W. Finley, Ph.D.	1992-2005	Philip G. Reeves, Ph.D.	1987-2007
Gary J. Fosmire, Ph.D.	1972-1979	James N. Roemmich, Ph.D.	2011-current
Carol H. Hahn, Ph.D.	1975-1976	Fariba (Z.K.) Roughead, Ph.D.	2001-2005
Edward S. Halas, Ph.D. (50%)	1974-1988	Jack T. Saari, Ph.D.	1987-2006
Janet R. (Mahalko) Hunt, Ph.D.	1987-2008	Harold H. Sandstead, M.D.	1971-1984
Curtiss D. Hunt, Ph.D.	1987-2008	Donald M. Tucker, Ph.D.	1977-1984
Robert A. Jacob, Ph.D.	1974-1976	Eric O. Uthus, Ph.D.	1985-current
Lisa A. Jahns, Ph.D.	2008-current	Kim Vo-Khactu, Ph.D.	1971-1974
Phyllis E. Johnson, Ph.D.	1979-1991	James C. Wallwork, Ph.D.	1979-1984
W. Thomas Johnson, Ph.D.	1987-2010	Leah D. Whigham, Ph.D.	2009-current
Leslie M. Klevay, M.D., S.D.	1972-2004	Lin Yan, Ph.D.	2007-current
Tim R. Kramer, Ph.D.	1979-1989	Huawei Zeng, Ph.D.	2001-current
Glen I. Lykken, Ph.D. (20%)	1977-1988		

Appendix 2. Post-doctorates and their mentors at the Grand Forks Human Nutrition Research Center

Name	Mentor	Year Started
Yacoub Y. Al-Ubaidi	Sandstead	1972
Carol J. Hahn	Evans	1973
John J. Doyle	Sandstead	1973
Robert A. Jacob	Klevay	1974
Duane R. Myron	Nielsen	1974
Phyllis E. Johnson	Evans	1975
Kenneth G.D. Allen	Klevay	1976
W. Thomas Johnson	Evans	1978
Henry Lukaski	Klevay	1979
Curtiss D. Hunt	Nielsen	1979
Brad W.C. Lau	Klevay	1980
Mary Davis	Kramer	1981
Eric O. Uthus	Nielsen	1982
Thomas L. Starks	Johnson, P.	1984
Mary A. Stuart	Johnson, P.	1984
Doh-Yeel Lee	Johnson, P.	1985
Robert J. Moore	Klevay	1986
Richard A. Vanderpool	Johnson, P.	1988
Dennis J. Bobilya	Reeves	1988
Sean M. Lynch	Klevay	1989
Carol D. Seaborn	Nielsen	1990
Scott M. Smith	Lukaski	1990
John W. Finley	Johnson, P.	1991
Corrie B. Allen	Saari	1991
Lori J. Pellet	Milne	1992
Susan Sergeant	Johnson, W.T.	1992
Elizabeth E. Droke	Lukaski	1993
Yisheng Bai	Hunt, C.	1994
Cindy D. Davis	Nielsen	1996
Boris G. Zaslavsky	Uthus	1998
Nicholas V.C. Ralston	Hunt, C.	1998
Z.K. (Fariba) Roughead	Hunt, J.	1998
Katsuhiko Yokoi	Nielsen	1999
James H. Swain	Hunt, J.	2001
Jacque Gray	Penland	2001
Kevin B. Hadley	Hunt, J.	2003
Jeanmarie Beisiegel	Hunt, J.	2004
Jennifer C. Watts	Combs	2005
Kimberly Schafer	Lukaski	2005
Matthew I. Jackson	Combs	2007
Jennifer Follet	Combs	2007
Emile Dekrey	Picklo	2010

Appendix 3. Graduate students of the University of North Dakota (UND) and North Dakota State University (NDSU) whose advanced-degree research was partially or fully performed at the Grand Forks Human Nutrition Research Center

Graduate student	University	GFHNRC research mentor
Sharon Greeley, Ph.D.	UND	Fosmire/Sandstead
Steven J. Buell, M.S.	UND	Fosmire
Christopher L. Dvergsten, Ph.D.	UND	Sandstead
Michael L. Jones, Ph.D.	UND	Sandstead
A. Suwarnasarn, Ph.D.	UND	Lykken/Wallwork
Peter C. Peterson, M.A.	UND	Halas/Sandstead
Paige M. Lokken, M.A.	UND	Halas/Sandstead
Mark J. Hanlon, M.A.	UND	Halas/Sandstead
Michael C. Rowe, M.A.	UND	Halas/Sandstead
Gail M. Reynolds, Ph.D.	UND	Halas/Sandstead
Marie Heinrich, M.A.	UND	Halas/Sandstead
Patricia A. Burger, M.A.	UND	Halas/Sandstead
J.C. Kwamamoto, Ph.D.	UND	Halas/Sandstead
R.A. Swenson, M.A.	UND	Tucker/Sandstead
James G. Penland, Ph.D.	UND	Tucker/Sandstead
James W. Penland, Ph.D.	UND	Tucker/Sandstead
Curtiss D. Hunt, Ph.D.	UND	Nielsen
Eric O. Uthus, Ph.D.	UND	Nielsen
Gro Thorne-Tjomsland, Ph.D.	UND	Sandstead/Nielsen
Naomi Bakken, M.S.	UND	Hunt, C.
Jeannine Matz, Ph.D.	UND	Saari
Yan Chan, Ph.D.	UND	Saari
Zhou Zhengi, M.S.	NDSU	Finley
Anne Thomas, M.S.	UND	Johnson, W.T.
Yan Chan, Ph.D.	UND	Saari
Patricia Moulton	UND	Penland
Laurie (Sumner) Raymond, Ph.D.	UND	Johnson, W.T.
Qiang Rong Liang, Ph.D.	UND	Saari
Kory J. Hintze, Ph.D.	NDSU	Finley
Kevin Miller, Ph.D.	NDSU	Finley
K Wald, Ph.D.	NDSU	Finley
Peter Leary, M.S.	UND	Finley

CHAPTER 10

Establishment of the Children's Nutrition Research Center at Baylor College of Medicine and Texas Children's Hospital in 1978

Buford L. Nichols

Buford L. Nichols, M.D., is Emeritus Director and Professor of Pediatrics, Baylor College of Medicine, Houston, TX.

“By mutual confidence and mutual aid, Great deeds are done, and great discoveries made; The wise new prudence from the wise acquire, And one brave hero fans another's fire.”

The Iliad of Homer, Book X,
translated by Alexander Pope, 1715-1720



Introduction

The Children's Nutrition Research Center (CNRC) is a unique cooperative venture between Baylor College of Medicine, Texas Children's Hospital, and the U.S. Department of Agriculture, Agricultural Research Service (USDA-ARS). The CNRC is dedicated to defining the nutrient needs of children, from conception through adolescence, and the needs of pregnant women and nursing mothers. Scientific data from the Center enables healthcare providers and policy advisors to make dietary recommendations that improve the health of today's children and that of generations to come. CNRC research has already impacted feeding guidelines for normal U.S. children and all children of the world.

Prologue

After completing my pediatric residency at Yale University, I was recruited to join the Pediatrics Department at Baylor College of Medicine (BCM) in 1964 with the understanding that as Associate Director of the National Institutes of Health's (NIH) General Clinical Research Center, I could do research in nutrition and gastroenterology and direct the house staff at Texas Children's Hospital (TCH). I participated, with Dr. Harold Sandstead, as a clinical examiner in the Texas Nutrition Survey in 1967. My primary BCM research was with malnourished infants with persistent diarrhea and clinical carbohydrate intolerance. The development of total parenteral nutrition (TPN) in 1968 proved to be life saving for these infants suffering from secondary malnutrition due to severe mucosal damage and persistent diarrhea. This clinical success with TPN led to the establishment of the Section of Pediatric

Gastroenterology and Nutrition on January 1, 1970.

Between 1968 and 1971, NIH grant funding was secured for clinical research on altered energy metabolism and body potassium in infants with primary malnutrition living in Jamaica, Mexico, and Guatemala. These international investigations allowed collaboration with some of the leading human-nutrition scientists of the day: John Waterlow, Sylvestre Frenk, and Fernando Viteri. I also had an NIH training grant for Clinical Fellows in Pediatric Gastroenterology and Nutrition. In 1971, these NIH resources became unavailable, and I began to examine alternative concepts for nutrition research and training support.

Founding of the Children's Nutrition Research Center

The legal authorization for establishing the Children's Nutrition Research Center (CNRC) was Senate Report 35, which was published on September 12, 1963. This report prepared by USDA-ARS was entitled "Proposed Plan for Expanded Research in Food and Nutrition." It reviewed the previous 70 years of human nutrition research in the USDA and recommended expansion of human nutrition research by construction and funding of three regional laboratories. Senate Report 35 was brought to my attention by Dr. Harold Sandstead in 1973, and as a consequence, a proposal was prepared and submitted to the Agriculture Rural Development and Related Agencies Subcommittee of the House Appropriations Committee in 1974. The application, sponsored by Rep. Bob Casey (D-TX), was based on the proposition that the scientific support for nutritional recommendations for infants and children needed to be strengthened and expanded. The focus was on normal children from conception to adolescence and mothers during pregnancy and lactation. Non-invasive approaches

were envisioned that included body composition, calorimetry, and stable isotope measurements. This initial application was unsuccessful.

We began another cycle of application, sponsored by Rep. Bob Gammage (D-TX), in 1976, which was administratively supported by Dean Joseph Merrill at BCM and Board Member George Bellows at TCH. This time, the House Agriculture and Related Agencies Subcommittee of the Appropriations Committee, chaired by Jamie Whitten (D-MS), requested a feasibility study. Dr. Jack Iacono, from the USDA-ARS National Program Staff, organized a site visit by ARS and external nutritional scientists, including Dr. Harold Sandstead, which was held on January 27, 1977. The site visit report was submitted to the House Agriculture and Related Agencies Subcommittee.

On March 16, 1977, I received a telephone call from Dr. Jean Mayer, President of Tufts University, informing me that Tufts was seeking to establish a Human Nutrition Laboratory on Aging and that appropriate enabling language had been added to the 1977 Farm Bill. In 1977, the House marked up appropriations for both BCM and Tufts Centers, but the Senate Agriculture Subcommittee only included Tufts. This turn of events led to a rallying of support by the full Texas Congressional Delegation in House and Senate in 1978. In the House, leadership was from Rep. Jack Hightower (D-TX) and Rep. Bill Archer (R-TX). Leadership was from Senator Lloyd Bentsen (D-TX) in the Senate. On February 21, 1978, I appeared before the McGovern Senate Select Committee on Nutrition, where I reported on the legal authorizations for our request and our proposed program objectives. I was introduced by Rep. Bob Gammage.

In 1978, the House Agriculture Subcommittee again marked up funds for the Tufts and BCM laboratories, but

the Senate did not. I was present on September 15, 1978, when the House/Senate Agriculture Appropriations Conference Committee met and accepted the House recommendations. The Dean of the Texas Delegation, Chairman of House Appropriations George Mahon (D-TX), walked over to the gallery and reported: "Well Doc, you got your center."

The conferees directed that the centers maintain close cooperation with NIH. Creation of the USDA-ARS CNRC at BCM and TCH was announced on November 2, 1978, by Senator Lloyd Bentsen. Dr. Iacono from ARS attended and reported that the House Agriculture Subcommittee had referred more than 40 competing requests to establish human nutrition centers at other institutions for his ARS review. The CNRC programs began in temporary facilities. Increased 1979 appropriations allowed establishment of a Stable Isotope Laboratory.

On July 27, 1984, in response to leadership by Rep. Jack Hightower and Speaker Jim Wright (D-TX), the House Agriculture Rural Development and Related Agencies Subcommittee marked up funds for the construction of a facility for the CNRC. The facility was to be used for research on the nutrient needs and nutritional status of mothers, infants, and children. The Committee justified this appropriation "based upon proximity to Baylor College of Medicine and Texas Children's Hospital," noting that "these institutions had conducted nutrition research for the past 20 years and will provide ready access to newborn and maternity care and to pregnant and lactating women and their unborn and newly born children."

The Agriculture Appropriations Conference Committee approved this recommendation in Public Law 98-396 on August 22, 1984. On April 13, 1985, groundbreaking occurred on a 1-acre site adjacent to TCH. Orville

G. Bentley, USDA Assistant Secretary of Science and Education, announced the \$49 million appropriation for constructing and equipping of the CNRC building. He reported that the CNRC "is already employing some of the most advanced research methods of their kind in the world, with emphasis on determining protein and energy requirements of women for pregnancy and lactation and of infants and children for growth and development. Safe, non-radioactive isotopes are being used as tracers of individual nutrients to determine their absorption and utilization."

The completed facility for the CNRC was dedicated October 7, 1988. Chairman of the House Agriculture Committee, Eligio "Kika" de la Garza (D-TX), was the keynote speaker. He envisioned "the impact of the important research contributions of the CNRC to USDA programs for child nutrition" and expanded his view of the Center's remit to "all children of the world."

A cooperative agreement between BCM and ARS that formalized the CNRC management system was signed on October 1, 1985. This stated that the mission of the CNRC is "to conduct research that will lead to a definition of the nutritional requirements needed to assure health in children from conception through adolescence, and in pregnant and lactating women." The agreement 58-7MN1-6-100 has been renewed every 5 years, maintaining the same mission statement.

Integration of CNRC with ARS National Nutrition Research Program

In contrast to the investigator-initiated research management system of NIH and the National Science Foundation (NSF), ARS research is oriented toward solution of problems of importance to U.S. agriculture, nutrition, and health policies. Goals for nutrition are described below along with key CNRC performance measures (1).

ARS Goal 1. Scientific Basis for Dietary Guidance for Health Promotion and Disease Prevention

“Dietary guidance focuses on identification of dietary (foods, nutrients, and bioactive components) and physical activity practices linked to maintaining health and preventing specific diseases. Such guidance is used as the basis for Federal food and nutrition policy which, in turn, has significant economic and societal impacts. To be of greatest use, dietary guidance should be based on appropriate scientific evidence. This includes not only identifying potential factors of interest, their molecular and cellular mechanisms of action, but also substantiating such effects in controlled intervention trials. ARS research will elucidate the roles of food components in minimizing the risk of diseases such as cardiovascular disease and cancer, as well as maintaining physiological functions necessary for optimal health and well-being, including sensory systems (such as vision), immune competence, brain function, reproductive systems, gastrointestinal health, bone health, and muscular function. ARS research will focus on increasing the certainty and specificity of information about the health impacts of foods, nutrients, and bioactive food components, as well as physical activity, to allow the development of dietary guidelines based on a firmer scientific base. This will enhance the usefulness of such guidance in programs that rely upon them.”

ARS Goal 2. Prevention of Obesity and Related Diseases

“The prevalence of obesity and overweight continue to increase and currently an estimated 66% of adult Americans fit those categories. Among children and adolescents aged 2-19 years, the prevalence of overweight increased from 13.9% to 17.1% just during the short period 1999-2004. These trends are unprecedented

in U.S. history and are an important underlying cause of many related disorders, including cardiovascular disease, Type 2 diabetes and several cancers, as well as escalating health care costs. ARS research will explore dietary, biological, behavioral and environmental factors influencing the development and consequences of obesity and related disorders across the lifespan. ARS research is needed on food choices and physical activity behaviors, what influences them, as well as development and evaluation of innovative measurement and intervention strategies that will promote healthy weights at the individual, family and community levels.”

ARS Goal 3. Life Stage Nutrition and Metabolism

“The metabolism, nutrient requirements and health effects of food components vary across stages of the life span. Early dietary intake including before, as well as, at conception, during pregnancy, lactation and infancy, has major effects on development, child health, and disease prevention later in life. The increased prevalence of chronic disease and disability among older people may be modified by improved nutrition. Mammalian development is intimately reliant upon nutrients and other food components, which serve as building blocks, signaling molecules, and enzyme cofactors. “Nutritional programming” occurs during critical periods of development when nutrition affects developmental processes to result in permanent or long-term changes in structure, function, gene expression, and consequently, disease susceptibility. ARS research to improve metabolic and physiologic function and health is needed at each stage of the life span. Increased knowledge is required of relevant basic and fundamental processes of development and aging, how they are influenced by diet and nutrition in order to identify nutrient requirements, appropriate dietary composition and patterns, and other lifestyle

strategies. ARS research in nutritional programming will lead to nutritional recommendations during critical periods of development in order to optimize long-term as well as short-term health. This will be achieved through in vitro, animal, and human studies.”

Performance Measures for the ARS Strategic Plan

To visualize progress toward the above ARS Goals, performance measures have been established as follows (1).

Performance Measure 5.2.1

“Monitor food consumption/intake patterns of Americans, including those of different ages, ethnicity, regions, and income levels, and measure nutrients and other beneficial components in the food supply. Provide the information in databases to enable ARS customers to evaluate the healthfulness of the American food supply and the nutrient content of the American diet. CNRC scientists have focused upon the dietary intakes of infants, children, and mothers as highlighted above and as is described below.”

Performance Measure 5.2.2

“Define the role of nutrients, foods, and dietary patterns in growth, maintenance of health, and prevention of obesity and other chronic diseases. Assess bioavailability and health benefits of food components. Conduct research that forms the basis for and evaluates nutrition standards and Federal dietary recommendations. CNRC scientists have focused upon the role of food intakes of infants, children, and mothers on growth and health as highlighted above and as is described below.”

Specific Contributions of CNRC to ARS Performance Measures

The following specific performance measures have made a profound impact on U.S. and international nutrition policies and recommendations for food intake of children. Parallel accomplishments in increased understanding of food needs of pregnant and lactating mothers have been omitted because of space.

Normal Child Bone Growth and Food Calcium Needs

The CNRC has established the norms for bone growth in healthy children. An example of this for girls is shown in figure 1. Bone dimension and density are measured with a minimally invasive procedure. In addition, CNRC scientists, using stable isotope technology, have determined the bioavailability and retention of calcium from foods during childhood (2-15). These studies have been incorporated into the Institute of Medicine (IOM) Dietary Reference Intakes (DRI) for Children (16).

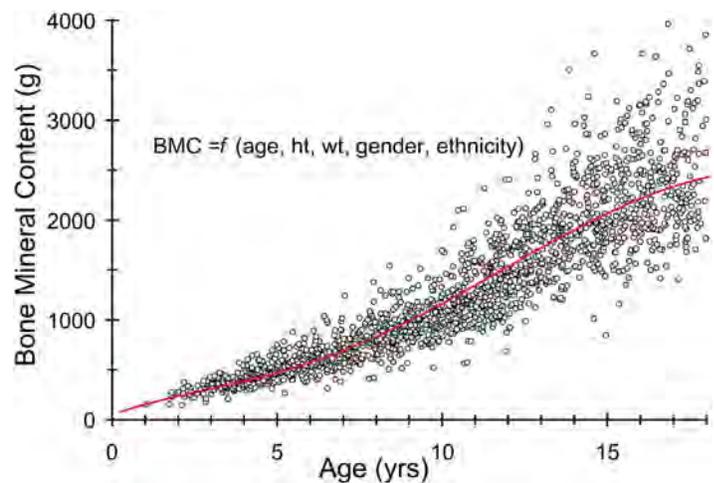


Figure 1. Children’s Nutrition Research Center reference bone mineral content as function of age. Reference values by height, weight, gender, and ethnicity are available on the Web site. This graph shows cross-sectional reference values from 2,100 healthy girls. Reference values for boys are also available. The individual values were determined by non-invasive DEXA measurements.

Normal Child Lean-Body Growth and Food Protein Needs

CNRC scientists have established the reference values for growth of lean (non-fat) tissues in the normal child (17-21). This was accomplished by measuring the total body potassium, located mostly in lean tissues, with a non-invasive technique. Estimates of rates of potassium deposition for infants from 9 months through 3 years of age (19) and total body potassium content from 4 through 18 years of age (21) were utilized to estimate rates of lean-body growth and protein deposition (protein deposition = total potassium accumulated (mmol/d) ÷ 2.15

(mmol potassium/g nitrogen) x 6.25). The 40K analyses that formed the basis for the computed protein depositions shown in figure 2 are given in the figure.

It is clear that the CNRC has contributed to the estimation of protein requirements for U.S. children by determining the rates of potassium and hence protein deposition in normal children. These CNRC studies were the basis for increasing the protein allowance for children by about 25% in the 2002 IOM DRI (22) and have been adopted as international standards by the Food and Agriculture Organization (FAO) and the World Health Organization (WHO) (24).

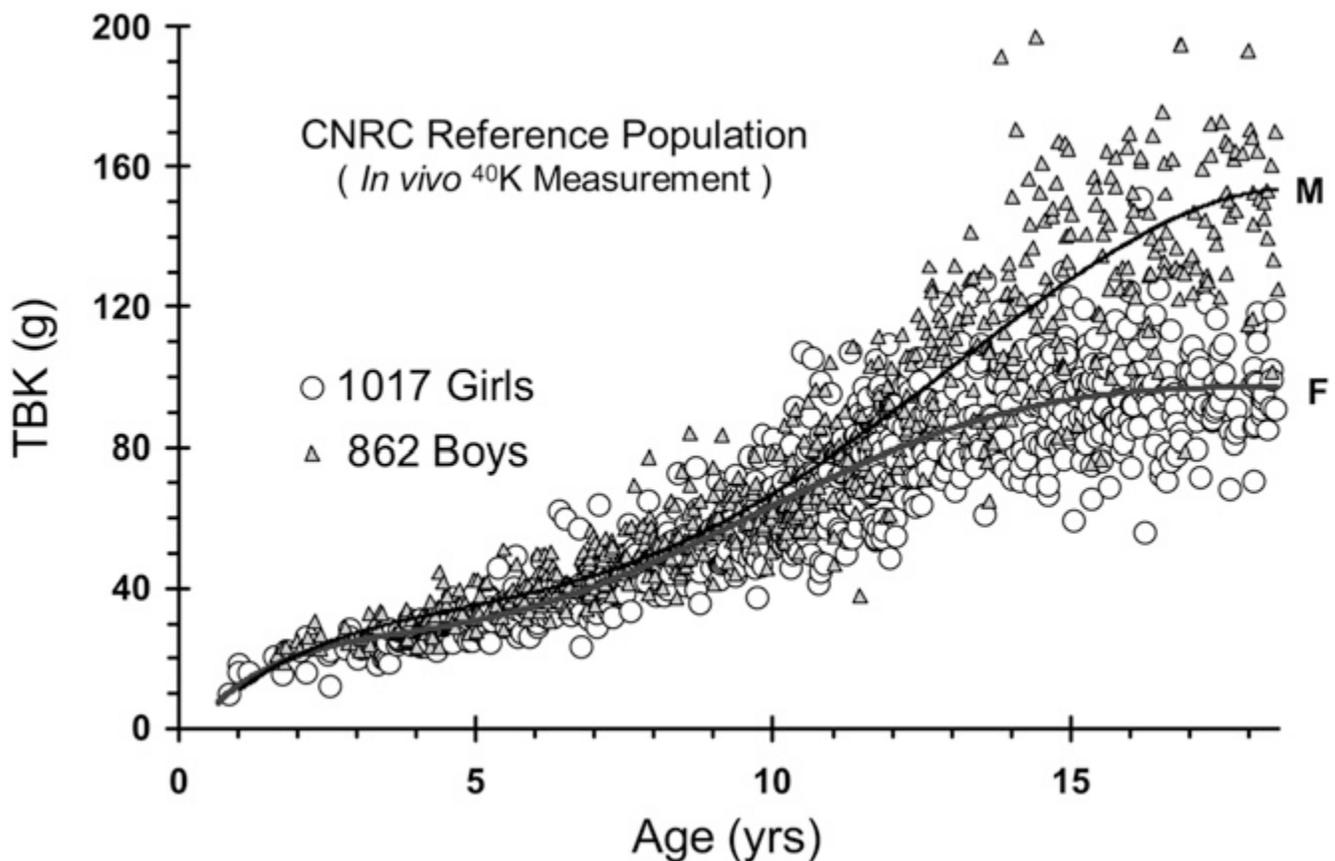


Figure 2. Children's Nutrition Research Center reference lean body mass in normal children by non-invasive measurements of total body potassium in a whole-body ⁴⁰K counter. A total of 862 boys and 1,017 girls were studied in a cross-sectional design. Because of the constant relationship between potassium and nitrogen in lean body mass, the growth of total body nitrogen can be computed.

Normal Child Energy Expenditures and Food Energy Needs

CNRC scientists have undertaken the direct measurement of total energy expenditure (TEE) by the doubly labeled water (DLW) method perfected in the Stable Isotope Laboratory (25-28). The method represented a distinct advantage over previous TEE evaluations that had to rely on a factorial approach and/or on food intake data, both of which have limited reliability. CNRC investigators submitted almost all of the individual infant and child TEE and ancillary data (figure 3) including age, gender, height, weight, basal energy expenditure, and descriptors for each individual in the data set. The measurements were obtained from infants and children whose ages, body weight,

height, and physical activities varied over wide ranges, so that they could provide an appropriate base to estimate energy expenditures and requirements at different life stages in relation to gender, body weight, height, age, and for different activity estimations. This data was used to estimate the current energy recommendations and also has been used to refine WHO childhood energy intake recommendations. The consequences of this normative CNRC data are shown in figure 3, where child energy intake is reduced by about 20% in the 2002 IOM RDI (22) and has been adopted internationally by FAO/WHO/ UN University (UNU) Committees (24). It is anticipated that this reduction of recommended energy intake can play a role in the prevention of childhood obesity.

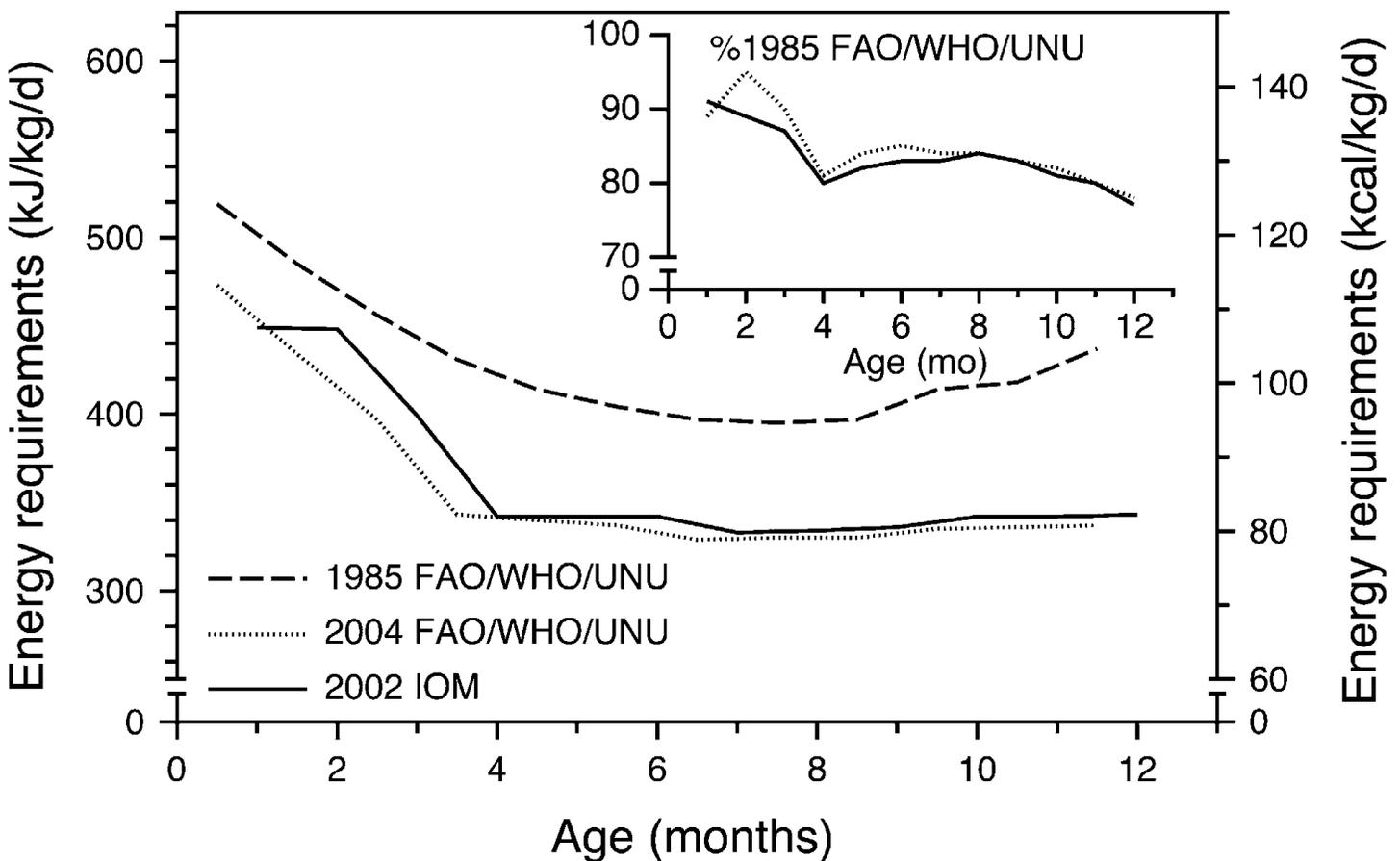


Figure 3. Energy requirements of boys 0-12 months of age based on total energy expenditure (TEE) measurements. The estimated requirements of male infants as recommended by the 1985 international FAO/WHO/UNU groups are compared with 2002 IOM and 2004 FAO/WHO/UNU recommendations. The 20% reduction of the current recommendations from those by the 1985 FAO/WHO/UNU Committees is shown in the upper right corner (28).

Contributions of the CNRC to Understanding of Food Needs of Children and Mothers

ARS Performance Measure 5.2.3 reads: “Publish research findings not encompassed under the other performance measures for this objective likely to significantly advance the knowledge of human nutrition, extensively influence other researchers in the same or related field, or yield important new directions for research citation rates.”

CNRC scientists published 2,775 peer-reviewed papers and invited reviews from 1978 through 2005. Led by Dr. Dennis Bier since July 1, 1993, there are currently 42 CNRC scientists in 8 research clusters: 5 groups on normal development or prevention of obesity; 1 on mineral

absorption; 1 on nutrient-gene interactions; and 1 on phytonutrient biochemistry. Under Dr. Bier’s leadership, CNRC scientists have successfully implemented the 1978 Congressional Mandate to integrate with NIH by matching the ARS research budget with NIH-funded nutrition research programs. Figure 4 is a photograph of the current CNRC scientific staff.

Working to provide better scientific information about body growth and food needs, CNRC scientists have made progress in fulfilling the vision of Chairman of House Agriculture Committee Kika de la Garza on October 2, 1988, when he predicted “the impact of the research contributions of the CNRC on food guidelines for USDA programs for child nutrition” and “all children of the world.”



Figure 4. Children’s Nutrition Research Center (CNRC) scientific staff as of 2006 in the lobby of the facility. Dr. Dennis Bier, CNRC Director, is in the center of the first standing row. The Emeritus Director (and present author) is standing to his right.

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CHAPTER 11

History of the Jean Mayer Human Nutrition Research Center on Aging at Tufts University

Irwin Rosenberg

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The Jean Mayer U.S. Department of Agriculture (USDA) Human Nutrition Research Center on Aging at Tufts University (HNRCA), while quite a mouthful, is aptly named, because it has contributed substantially to the legacy of Jean Mayer, to the scientific stature of the USDA and, in Atwater's tradition, to USDA's contributions to human nutrition, to the embedding of concepts of aging in the human nutrition and health agenda, and certainly to the stature of Tufts University, which has a signature program in nutrition and health science.

The events leading to the establishment of HNRCA—with its 15 stories of research space on the health sciences campus of Tufts University in Boston, MA, and with its scientific staff of 300 and more than 7,000 alumni, thus making HNRCA the largest center for nutrition and aging in the world—have a history that is embedded in both domestic and international developments, especially in the 1960s and the 1970s. Those were rich decades in the history of nutrition and nutrition science in this country, and in many ways the

establishment of the HNRCA in 1978 was a culmination of some of those events.

To tell the HNRCA story, let me start with a narrative about hunger in America, recorded also by Donna Porter. In the tumultuous decade of the 1960s, one of the most active and productive elements of the U.S. Government in nutrition was the work of the Interdepartmental Committee on Nutrition for National Defense (ICNND), whose history has been well recorded in a previous symposium in the Experimental Biology meetings and published in the *Journal of Nutrition* (1). For our purposes, it is worth noting that the ICNND was a prominent nutrition survey and research program that evolved during the Ten-State Survey in this country. That survey demonstrated emphatically that poverty and hunger existed in unacceptable dimensions in this country (2), not just in developing countries in the third world.

The report of the Ten-State Survey on hunger in America forged an important relationship between Jean Mayer and the Kennedy brothers Robert and Edward.

Mayer, then a professor in the department of nutrition in Harvard's School of Public Health, utilized his participation in a National Coalition Against Hunger, which involved 66 million citizens, including labor unions, welfare rights organizations, etc., to persuade President Richard Nixon, who had marginally defeated Hubert Humphrey in the 1968 election, to improve his credentials with domestic liberal and social causes by hosting the first—and to this day only—White House Conference on Nutrition in 1969. Mayer was seconded to the government to chair and plan that conference, which arguably has had a greater impact on the nutritional policy history of this country than any other single event. Out of that conference came social programs like Food Stamps, a sharp enlargement of the Special Supplemental Program for Women, Infants, and Children, nutrition labeling with a sharply increased attention to the relationship between nutrition and chronic disease, such as heart disease, and an increased realization that nutrition research could play a major role in health sciences and disease prevention, as well as in the fight against poverty and hunger.

A major vehicle for the translation of some of the 800 recommendations of the 1969 White House Conference on Nutrition was the Senate Select Committee on Nutrition and National Needs, which was chaired by Senator McGovern, with a minority co-chair, Senator Robert Dole—both of whom would later run for president of the United States (3). This effort was another means of enlarging the nutrition science and research capability of the U.S. Government. At that time, nutrition research in the U.S. Government was represented by the Beltsville Human Nutrition Laboratory within the USDA, a small intramural program in human nutrition research at the NIH (mostly in the National Institute of Arthritis and Metabolic Diseases), and small laboratories in the U.S. Food and

Drug Administration (FDA) Food Division. The USDA had responded to mandates from Congress to establish a second human nutrition research center in the wheat-growing heartland, and that became the laboratory in Grand Forks, ND. Harold Sandstead, the center's first director, can also take credit for later advising Jean Mayer on some of the pathways and mechanisms that could lead to enlargement of the USDA nutrition centers program.

As the interest in human nutrition science and its potential benefits to human health was still very strong, especially in the Senate Select Committee, the Committee produced a report on national nutrition goals (4), which roiled the food and nutrition policy landscape (a history worthy of its own symposium). The report has been succeeded by the Dietary Guidelines for Americans and the Food Guide Pyramid.

Let me return to some personalities in addition to Senators McGovern, Dole, and Kennedy who would play important roles in the evolution and reorganization of the concept of a human nutrition research center on aging. The two enthusiastic and idealistic staff members of the Senate Select Committee were Jerry Cassidy, a young lawyer, and Ken Schlossberg, a young political activist. Schlossberg was from Massachusetts, and both he and Cassidy had become familiar with Jean Mayer and his efforts with the White House Conference and his insistent advice to the Senate Select Committee. The increasingly powerful Speaker of the House at the time, also from Massachusetts, was Thomas P. (Tip) O'Neill, who is widely quoted as having coined the phrase "all politics is local."

The stars were in alignment during the Carter Administration when Claude Pepper, then the most senior senator from Florida, with Senator Hubert Humphrey, championed the concerns of the elderly, including research on aging. This alignment

included McGovern, who was advised by D. Mark Hegstead, another Massachusetts nutrition scientist seconded to the USDA Science and Education Administration. Jean Mayer would become President of Tufts University in 1976 and the first client of the legislative advisory firm formed by Schlossberg and Cassidy after they left the government. This alignment would persuade Speaker O'Neill and the sympathetic senators that another center for human nutrition research should be established, that it should be mandated to be built in Boston, MA, and that it should have a focus in nutrition and aging (and by implication, chronic disease). This was translated into legislative language in the 1977 Farm Bill (5).

In the Food and Agriculture Act of 1977, Congress directed the Secretary of Agriculture to establish a comprehensive human nutrition research program and to study the potential cost and value of regional research centers for nutrition. The act stated in part: "Congress hereby finds that there is evidence of a relationship between nutrition and many of the leading causes of death in the U.S.; that improved nutrition is an integral component of preventive health care; that there is a serious need for research on the effects of diet and degenerative diseases and related disorders."

The Agriculture Appropriations Bill, passed later in 1977 (6), instructed the USDA to establish an "adult human nutrition research facility at Tufts University in Massachusetts," and provided planning funds for that facility. Facility and programmatic planning had been initiated by representatives of the USDA and Tufts University.

Stanley Gershoff, who had come from Harvard University with Mayer to be head of a Tufts Institute of Nutrition, led a team to write the proposal. In 1978, Congress

committed funds for construction and placed the center under the direction of the newly created Science and Education Administration of USDA. The conferees stipulated in their agreement that the center's programs should complement those of the NIH and should be conducted in close collaboration with NIH's National Institute on Aging. On August 1, 1979, a cooperative agreement between Tufts University and the USDA was signed; and on October 23 that same year, the National Institute on Aging and the USDA signed a memorandum of understanding detailing their mutual interest in the Human Nutrition Research Center on Aging at Tufts University. Tufts University donated land from its Boston campus for the new center.

Prior to the passage of the act, Agriculture Secretary Robert Bergland and Joseph A. Califano, Jr., Secretary of the U.S. Department of Health, Education, and Welfare, had signed an agreement for sharing their nutrition research responsibilities. It was expected that the management of the HNRCA would be an executive committee consisting of the two Secretaries and the president of Tufts (or the president's designees), and that the director of the HNRCA would report to the executive committee. In reality, the relationship would be between Tufts and the USDA.

There would be many things that were unique about this new center. It would be run by a cooperative agreement with Tufts, much along the lines of the Jet Propulsion Laboratory at the California Institute of Technology. At some point, there had been some possibility that this laboratory would be affiliated with Boston University, Harvard University, Massachusetts Institute of Technology (MIT), and Tufts; but in the end, the decision was made to accept the donation of land on the Health Sciences campus of Tufts University in downtown Boston to build the \$30 million, 15-story building.

Center Directors of the Jean Mayer USDA Human Nutrition Research Center on Aging

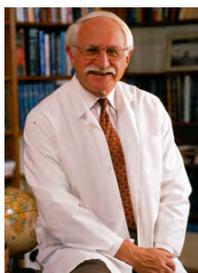
Hamish N. Munro
1982-1984



Harold H. Sandstead
1984-1985



Irwin Rosenberg
1986-2000



Robert (Rob) Russell
2001-2008



Simin Meydani
2009-present



Groundbreaking was celebrated on December 14, 1979. Therein lies another unique feature of the Human Nutrition Research Center on Aging: its establishment on a health sciences campus, thus declaring unequivocally that the orientation would be toward human nutrition and the human health sciences. Much of the previous research in nutrition had taken place on agriculture campuses of colleges and universities with Hatch Act funding.

The other unique feature of this new center is that it would have a human lifespan theme: that of nutrition and aging and the nutritional needs of a growing aging population. The Grand Forks Human Nutrition Research Center in Grand Forks, ND, was established with the theme of trace mineral research. Shortly thereafter, the Children's Nutrition Research Center in Houston, TX, also would be chartered with an earlier lifecycle theme.

Stanley Gershoff was the principal investigator of this center grant through USDA. The scientific stature of this new center was sealed with the appointment of the eminent scientist in protein metabolism, Hamish Munro, who moved from MIT to be the first director of the HNRCA. Scientific programs began in rental space in 1979-1980, the first scientists were recruited at that time, and the building opened to considerable fanfare and pride in 1982. The rest, as they say, is history.

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CHAPTER 12

History of the Western Human Nutrition Research Center

Robert A. Jacob

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Abbreviations

ARS	Agricultural Research Service
DOD	Department of Defense
EEG	Electroencephalography
FY	Fiscal Year
LAIR	Letterman Army Institute of Research
LAMC	Letterman Army Medical Center
MOU	Memorandum of Understanding
RDA	Recommended Dietary Allowance
SEA	Science and Education Administration
USAMRDC	U.S. Army Medical Research and Development Command
USDA	U.S. Department of Agriculture
WHNRC	Western Human Nutrition Research Center

The history of human nutrition research in the U.S. Department of Agriculture (USDA) dates back to the 1890s with the Congressional mandate of a program and the legacy of USDA nutrition research pioneer Wilbur O. Atwater. This laid the basis for later Congressional mandates that the USDA be the lead agency to conduct human nutrition research in the United States. The Food and Agriculture Act of 1977 mandated that the USDA “establish research into food and human nutrition as a separate and distinct mission” and “assess the potential value and cost of establishing regional food and nutrition research centers in the United States.”

By the late 1970s, centers in the Midwest (the Grand Forks Human Nutrition Research Center in Grand Forks, ND), the Northeast (the Human Nutrition Research Center on Aging in Boston, MA), the South (the Children’s Nutrition Research Center in Houston, TX), and the West (the Western Human Nutrition Research Center) were in operation or development. Within USDA, the program in human nutrition research was to be administered by the Agricultural Research Service (ARS). Upon reorganization of the USDA during the Carter Administration (1977-1981), this responsibility shifted to the Science and Education Administration (SEA), then back to ARS during the succeeding Reagan Administration.

The Role of the U.S. Army in Establishment of the Western Human Nutrition Research Center

In 1974, the U.S. Army Medical and Nutrition Research Laboratory moved from Fitzsimons General Hospital in Denver, CO, to the newly built Letterman Army Institute of Research (LAIR) in the Army's Presidio of San Francisco, CA. Adjacent to the Letterman Army Medical Center (LAMC), the 3-story LAIR building was designed to resist earthquake damage, and it contained state-of-the-art facilities to conduct Army research programs. Facilities for nutrition research included a 12-bed metabolic unit with a kitchen, analytical laboratory, and capabilities for research involving experimental animals and radioactive isotopes. The mission of LAIR was to conduct research to benefit the soldier, and it included programs in shock and trauma, blood replacement, wound healing, ocular and cutaneous hazards, and nutrition. The nutrition component served all of the Armed Forces and was tasked to evaluate the nutritional status of military personnel and conduct nutrition research to improve military personnel's health and fitness for combat.

The Nutrition group in Denver was well known for its expertise in assessing the nutritional status of populations, having participated in the Interdepartmental Committee on Nutrition for National Defense's 35 Country Nutrition Survey for 1956-1967, and the Ten State Nutrition Survey for 1968-1970. At LAIR, the group continued research in experimental human nutrition with investigations into the metabolic fate and human requirement for vitamins A and C and B vitamins. The availability of clinical and metabolic ward facilities at both Denver and LAIR allowed pursuit of clinical nutrition goals including understanding the role of diet in muscle metabolism and physical endurance, stress fractures associated with training,

the effects of nutrients on gastrointestinal function, and the occurrence of non-infectious diarrhea. Transferees from the Denver laboratory that assumed leadership positions at LAIR included Colonel Edward Canham, M.D., Commander; Colonel Robert Herman, M.D., Director, Department of Medicine; and Howerde Sauberlich, Ph.D., Director, Department of Nutrition. In 1976, the total staff authorized for food and nutrition research at LAIR included 74 military and 49 civilian positions.

Due to cutbacks in military spending after the Vietnam War, the U.S. Army evaluated its priorities for funding research. Within the U.S. Army Medical Research and Development Command (USAMRDC), nutrition research received low priority scores. Subsequently, a series of cuts were made to the LAIR budget in the late 1970s, with most of the cuts being applied to the nutrition research program. Responding to a 1977 Office of Management and Budget request to cut manpower spaces, the USAMRDC applied all but 4 of 166 cuts to LAIR, effectively eliminating the Army's nutrition research program there and threatening the existence of LAIR (what with the building just being completed and occupied in 1974).

The looming closure of the nutrition research program at LAIR captured the attention of the scientific community and the U.S. Congress. In July of 1977, Arnold Schaefer of the Swanson Center for Nutrition in Omaha, NE, and LaVell Henderson, President of the American Institute of Nutrition, spoke publicly against the possible loss of the Army's nutrition research program at LAIR and suggested that it might be transferred to the USDA to form a Western Human Nutrition Research Laboratory. San Francisco Representative John Burton (D-CA), Senator George McGovern (D-SD), Chairman of the Senate Select Committee on Nutrition and Human Needs, and other legislators found the

cuts to the LAIR nutrition program and facility to be disturbing considering that LAIR was a new facility, and in light of increased funding to the USDA to create human nutrition research centers including a location in the West. At the same time, hearings before the House Committee on Government Operations resulted in the recommendation that if the Army did not fully utilize LAIR's facilities and technical capabilities, especially in nutrition research, all or part of the facility should be transferred to USDA as part of the proposed Western Human Nutrition Research Center. The Conference report for the Fiscal Year (FY) 1979 (October 1978 through September 1979) Department of Defense (DOD) appropriations bills designated \$1.8 million as the last year of funding for the Army nutrition research program and stated that "the program shall be transferred to the USDA."

Through FY 1979, it was not clear to what extent the Army would divest of its nutrition research program, and negotiations between the Army and USDA did not successfully resolve the questions about the fate of the nutrition research program at LAIR. At this early stage, the two agencies were sometimes far apart in regard to the possible use of LAIR facilities for USDA nutrition research. A June 1979 proposal from Anson Bertrand, Director of the USDA's Science and Education Administration (SEA), suggested four options, requiring from 40 to 100 percent (83,000 to 200,000 square feet) of the LAIR facility to house 26 to 64 research scientists. In September Lt. General Charles Pixley of the Surgeon General's Office replied that the Army currently occupied 75 percent of LAIR, with plans to fully utilize the building within 2 years, but that a maximum of 3,000 square feet of space could be allocated in LAIR for up to 25 USDA employees.

However, in the FY 1980 USDA and DOD appropriations bills, Congress provided

USDA with \$1 million to develop a Western Nutrition Research Center at LAIR and directed the Army to transfer 19 personnel and facilities devoted to nutrition at LAIR to the USDA. The Army was further directed to negotiate with USDA so that USDA could perform the Army's mission-essential nutrition research on a reimbursable basis. By April of 1980, a memorandum of understanding (MOU) between the USDA and the Army provided the basis for the transfer of the Army's LAIR nutrition research program to USDA, thereby creating the USDA Western Human Nutrition Research Center (WHNRC)—the fifth USDA human nutrition research center, after the centers in Beltsville, Grand Forks, Boston, and Houston. The MOU was signed by Anson Bertrand for USDA/SEA, and by Joseph H. Yang, Assistant Secretary of the Army. The MOU specified that transfer of the Army's nutrition research program at LAIR was to be effective beginning April 6, 1980. It did not involve transfer of funds, but it included 19 permanent full-time staff positions and equipment and supplies associated with LAIR's nutrition research activities. Also specified was assignment of nutrition-associated space totaling most of the third floor of the building—including the metabolic ward and kitchen, associated analytical facilities, and laboratory and office space to support 19 personnel—and some 30 rooms in a separate but contiguous building for animal housing. The USDA would reimburse the Army for their floor space and shared support facilities and services such as animal care, use of radioisotopes, library, auditorium, and shipping/receiving via an Interagency Support Agreement. To help complete ongoing Army nutrition projects, some employees who transferred to USDA would continue work on the projects until September 30, 1980, with some associated DOD funds to reimburse the USDA for completing the work. The basic arrangement laid out in the 11-point MOU of April 1980 served the needs of both the Army and the

USDA, and allowed their respective research programs to co-exist productively at LAIR for nearly two decades.

Legislative language related to establishment of the human nutrition research centers (HNRCs) in the 1960s and 70s often suggested affiliation of the centers with nearby universities. The benefits derived from interaction with university facilities and research expertise had long been realized by the USDA's agricultural research establishment; hence, the formal affiliation of the Grand Forks, Boston, and Houston HNRCs with the University of North Dakota, Tufts University, and Baylor University, respectively. Establishment of the Western Center on a campus of the University of California (UC) at Berkeley, Davis, or Los Angeles made good sense in that all three campuses had nationally prominent nutrition departments. In July of 1978, Professor William Weir, Chairman of the Nutrition Department at UC Davis, submitted a proposal to the USDA to establish the Western Human Nutrition Research Center on the Davis campus—a campus strong in agricultural sciences as well as nutrition.

In the end, the availability of the excellent LAIR nutrition research facilities precluded the selection of a UC site for the WHNRC in 1980. However, productive collaborations of the WHNRC with all three UC campuses continued throughout WHNRC's tenure in the Presidio of San Francisco, the LAIR era ending with the closure of the Army's Presidio base in 1994, the subsequent closure of LAMC and LAIR, and the Center's eventual move to the UC Davis campus in 1999.

The WHNRC in the Presidio of San Francisco (1980-1999)

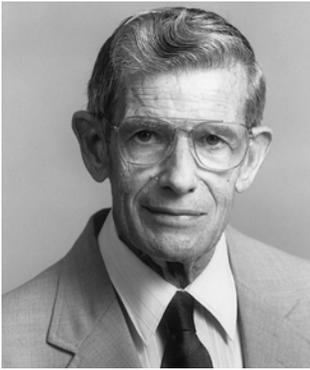
One of the unique features of the new WHNRC was its location in the Presidio of

San Francisco, a park-like military base first occupied by the Spanish in 1776 and bordered by the Pacific Ocean and San Francisco Bay. Visitors to the Center were always taken through the third-floor hallway, where they marveled at a panoramic view of the Bay, the Golden Gate Bridge, and the Marin Headlands in the background.

The new WHNRC was to be administered through the Human Nutrition Center of the USDA/SEA in Washington, DC, by D. Mark Hegsted, Administrator, and James "Jack" Iacono, Associate Administrator. The mission of the Center, as stated by USDA Assistant Secretary Mary Jarratt before the House Committee on Science and Technology in June 1981, was to "improve methodology for assessing nutritional status" and "design and evaluate nutrition intervention programs." While the Center's mission statement has changed somewhat over the years, the goals of determining nutrient requirements, improving nutritional assessment methods, and testing nutritional interventions for promoting health have remained.

Initially, some 10 DOD civilian employees at LAIR converted to USDA positions at the WHNRC. These included four research scientists: Howerde Sauberlich, Mary "Molly" Kretsch, James Skala, and Herman Johnson. Dr. Sauberlich, formerly Director of the Department of Nutrition at LAIR, became the first Director of the WHNRC.

One of the key leaders and nutrition research scientists at LAIR in 1980 was Colonel Robert Herman, a physician who was Director of the Department of Medicine at LAIR and Chief of Endocrine and Metabolic Services at the adjacent Letterman Army Medical Center (LAMC). A highly respected nutrition research scientist, educator, and administrator, Dr. Herman was in charge of clinical nutrition research and the metabolic unit at LAIR, was



Howerde Sauberlich, formerly Director of the Department of Nutrition at Letterman Army Institute of Research (LAIR), became the first Director of the Western Human Nutrition Research Center.

President of the American Society of Clinical Nutrition, Editor of the *American Journal of Clinical Nutrition*, and recipient of numerous medals and awards for his work in nutrition. Dr. Herman's untimely death on Christmas Day 1980, at the age of 55, cut short his illustrious career and any potential role in the new USDA nutrition research effort at LAIR. A part of his legacy remained with the WHNRC, however, as his substantial collection of nutrition-related books and journals were later gifted to the Center by his widow and scientific colleague, Yaye (Tokuyama) Herman.

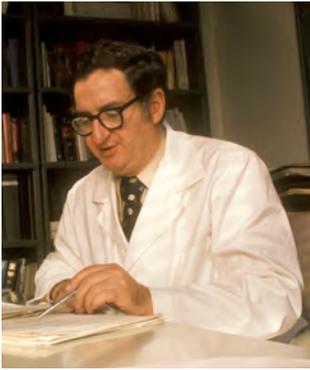
An Inaugural Symposium was held at the fledgling WHNRC on August 13-14, 1981. The symposium was sponsored by the USDA Agricultural Research Service (ARS)—again charged with the USDA's human nutrition research program in the new Reagan Administration—in cooperation with the University of California. The Symposium focused on two themes: "Evaluating Human Nutrition Intervention Programs" and "Assessing Nutrient Adequacy of Food as Consumed." The program included representatives of U.S. Government agencies involved in food and nutrition programs and national and international speakers with expertise in the chosen themes. (One of the few difficulties of the USDA being co-

located with the Army at LAIR was obtaining advance permission for foreign national visitors to enter a U.S. military research facility.)

Transition: Army to USDA Nutrition Research Center

Howerde Sauberlich was the first of several nationally recognized nutrition scientists to be appointed Director of the WHNRC. A pioneer in developing laboratory methods for assessing human nutritional status, Dr. Sauberlich had earlier published the widely acclaimed compendium of methods "Laboratory Tests for the Assessment of Nutritional Status" (1). Along with co-author and biochemist colleague, James Skala, he established the Center's Bioanalytical Support Laboratory, which became the Analytical Biochemistry Section of the WHNRC's nutritional assessment armamentarium.

Two other scientists who transferred from LAIR to USDA began work on establishing the dietary intake and body composition sections of the Center's nutritional assessment capability: Research Nutritionist Molly Kretsch and Research Physiologist Herman Johnson. In addition to her research assignment, Dr. Kretsch served as Director of the Center's Human Metabolic Research Unit from 1980 to 1983. Like Dr. Sauberlich, Drs. Kretsch and Johnson brought methods used in the Army's nutrition research studies to the new WHNRC and began to integrate them into the Center's program. Dr. Kretsch helped to establish computerized methods for accurately estimating food intakes and determining the nutrient content of foods. The inaccuracy of the methods in those days led Dr. Kretsch to develop a new computerized approach to dietary intake assessment that utilized bar codes to identify food items and portable electronic weight scales to measure the quantities of each food consumed.



James "Jack" Iacono was appointed Director of the Western Human Nutrition Research Center.

Comparison of the results against carefully weighed foods provided to volunteers in the Center's metabolic unit demonstrated the increased accuracy of the technique over the commonly used food diary and recall methods (2). Among body composition methods, Dr. Johnson helped set up methods for determining lean body mass by ^{40}K counting and body water by D_2O (heavy water) dilution and bioelectrical techniques (3).

The Role of Fats in Chronic Disease and Immunocompetence

In 1982, Dr. Sauberlich left the WHNRC and returned to Alabama to join the newly organized Department of Nutrition Sciences at the University of Alabama, Birmingham. The ARS, now managing the USDA HNRCs after the Carter to Reagan transition, appointed James "Jack" Iacono as Center Director. Within ARS, Dr. Iacono had experience as an administrator as well as a research scientist. He had directed a successful nutrition research program at the USDA-ARS Beltsville Human Nutrition Research Center (BARC) and was later appointed as Associate Administrator of SEA's Human Nutrition Center during the Carter Administration. A nutritional biochemist, Dr. Iacono's research interests

were primarily on the effects of fat intake on an individual's risk of developing chronic disease, especially heart disease and stroke. A key member of his research team, Rita Dougherty, made the move from Beltsville to San Francisco with him, providing some continuity for his research program during the transition.

Dr. Iacono's research on the effects of fat intake included study of populations in Finland and Italy, as well as in the United States. This allowed study of different types of fat, e.g. the higher saturated fat (in meat and dairy products) of the Finnish diet versus higher monounsaturated fat (in olive oil and nuts) in Italy and polyunsaturated fat (in soybean, corn, and seed oils) in the United States. (4). Like many of the WHNRC scientists, Dr. Iacono took advantage of the Center's metabolic unit to conduct human nutrition studies, where the diet and lifestyle of volunteer subjects were precisely controlled and studies could extend to 3 months or more. This was especially important when sensitive and slow-changing end-points such as blood pressure, coagulation, and immune function were measured. While operation of the Center's 12-bed metabolic unit was complicated and expensive, the results of such studies were regarded as unique in terms of their quality and relevance to human nutrition. At a time when dietary fat was largely considered as harmful, Dr. Iacono's research helped to show that some types of fat have beneficial effects on health, such as his findings that replacing some saturated fat in the diet with polyunsaturated fat lowers blood pressure in normotensive as well as hypertensive individuals (5). Stemming from his research results and broad knowledge of the effects of dietary fat intake, Dr. Iacono contributed to public health recommendations on the kinds and optimal amounts of dietary fat to help prevent degenerative diseases (6).

In 1983, Dr. Iacono recruited Gary Nelson, a lipids biochemist from the

NIH National Heart, Lung, and Blood Institute, to provide further expertise in lipid analysis and expand the Center's research on physiologic effects of dietary fat intake, especially as related to blood clotting and risk of stroke. Later in 1983, Dr. Nelson recruited Darshan Kelley to begin tissue culture studies. Dr. Kelley's research later evolved into a program on nutritional immunology, a discipline believed important to understanding the diverse effects of fat and other nutrients on health. During his first few years at the WHNRC, Dr. Nelson set up lipid analysis methods and conducted several studies on fat metabolism in experimental animals. In 1989, he conducted the first of several human studies, a 100-day metabolic unit study in which the effects of a high salmon intake (about a pound a day) in nine healthy men were compared to those of a similar diet without the salmon. The study was conducted because health benefits were being alleged to consumption of fish oil capsules, yet a guiding tenet of the USDA's human nutrition research program was to understand and publicize the health benefits of foods rather than supplements.

While some of the blood fat measures improved (decreased triglycerides and increased HDL "good" cholesterol), few of the health-related measures, including blood coagulation tests, were affected significantly by the high salmon intake (7). The results also indicated that the short-term consumption of a high fish (salmon)-containing diet does not adversely affect the immune system, as had been reported with fish oil supplements. (It was anecdotally reported that the volunteer subjects were not inclined to eat any kind of salmon for some time after they completed the study.)

Dr. Nelson collaborated with Drs. Iacono and Kelley to conduct human feeding studies in men and women of other highly unsaturated fatty acids (alpha-linolenic, docosahexaenoic, conjugated linoleic acid)

that had shown some health benefits in animal models but had not been studied much in humans. Found in some fatty foods, especially fish, flaxseed, cheese, and dairy products, their ingestion was purported to provide an array of health benefits, mostly related to heart disease, stroke, and immune function. The study findings showed that high intakes of these fatty acids, or foods that contain them, provided little or no anti-thrombotic or immune function benefits, important information at a time when the over-the-counter market for supplements of such was booming (8,9).

Darshan Kelley's research program on the effects of fats and other nutrients on immune function was seen as a key element for attaining the Center's goal of understanding the roles that foods and specific nutrients play in preventing chronic diseases such as heart disease, cancer, arthritis and diabetes. While Dr. Nelson studied effects on blood clotting, Dr. Kelley focused on the immune and inflammatory responses that are closely related to risk of heart disease and arthritis. In collaboration with Drs. Iacono and Nelson, Dr. Kelley conducted controlled human studies of the fatty acids mentioned above to determine their effect on the body's immunocompetence and inflammatory status. A study that varied the consumption of total fat and linoleic acid (a fatty acid found in soybean and other seed oils) showed that reduction in total fat intake enhanced several indices of human immune response and contributed to the Recommended Dietary Allowances (RDA) for total fat (not to exceed 30% of energy) and for linoleic acid (not to exceed 10% of total energy) (10). Dr. Kelley also conducted several studies of the effects of dietary omega-3 polyunsaturated fatty acids (alpha-linolenic and docosahexaenoic acids) and showed that the non-marine sources of these fats (such as flaxseed) are safe and have substantial anti-inflammatory effects

similar to those observed with fish oils. An increase in the consumption of foods rich in these types of fatty acids is now recommended to help prevent and manage a number of chronic inflammatory diseases including arthritis, type 2 diabetes, and heart disease (11).

Subsequent studies by Dr. Kelley demonstrated that one of the trans fatty acids, conjugated linolenic acid, caused the development of insulin resistance and nonalcoholic fatty liver disease in animal models, and that both these metabolic disorders could be prevented simultaneously by increasing the intake of omega-3 fatty acids (12). These results suggest that an increase in the intake of trans fatty acids and a reduction in the intake of omega-3 fatty acids is one of the major causes for the rapid increase in the incidence of insulin resistance, diabetes, and fatty liver. Evidence from Drs. Nelson's and Kelley's studies showing that arachidonic and docosahexaenoic acids did not provoke blood clotting or inflammatory problems in humans contributed to the decisions to add these two fatty acids to infant formulas in more than 100 countries.

The large number of publications resulting from each of the above human studies (from five to eight for each study) is somewhat typical of the live-in metabolic unit studies conducted at the WHNRC. This reflects not only the research goals of multiple investigators but also the intention to obtain the most pertinent findings from difficult, time-consuming, and costly studies.

Research on Mineral Nutrients

In the early 1980s at the USDA-ARS Western Regional Research Laboratory in Albany, CA, Judy Turnlund was developing a new methodology for studying the body's metabolism of essential minerals using stable isotopes. Because the isotopes were not radioactive, they could be used safely

in humans to track a dose of a mineral in accessible body compartments such as the blood, urine, and feces. The method required a sophisticated mass spectrometer and human studies where the diet could be controlled and all excreta collected. Dr. Turnlund met the latter need by collaborating with scientists in the Nutrition Department of the University of California at Berkeley who operated an active metabolic unit ("the penthouse") for controlled human nutrition studies. The closure of the unit in the mid-1980s led to Dr. Turnlund's move across the Bay to the WHNRC, where the 12-bed metabolic unit and other resources allowed her to continue to refine the methodology and utilize it to study human mineral metabolism and requirements. As copper was being revealed as an essential nutrient for the formation and health of bones, the nervous system, heart, and blood vessels, Dr. Turnlund conducted studies in men and women that allowed her to map the metabolism of copper in the body and more reliably estimate the human dietary copper requirement. The studies resulted in the first RDA for copper (13) and provided data to more reliably estimate the safe upper limit for copper intake (14).

Since little was known about human metabolism and requirement for the essential minerals molybdenum and magnesium, Dr. Turnlund conducted studies to fill the knowledge gap on these nutrients (15,16). The molybdenum studies provided the data needed to establish the first RDA for molybdenum (17). She also utilized her knowledge of mineral nutrition and stable isotope methodology in collaborations with other WHNRC scientists, studying zinc, calcium, and iron. Starting with mathematical modeling programs from other scientific institutions, Dr. Turnlund applied data from her human studies to develop the first-ever computerized models of how copper and molybdenum are metabolized in healthy people (18). This allowed unique predictions of such things



Janet King was appointed Director of the Western Human Nutrition Research Center.

as intestinal absorption, excretion, body turnover, and even tissue concentrations of the minerals at a given intake. A pioneer and international authority on mineral nutrition, Dr. Turnlund was a member of the National Academy of Sciences expert panel that formulated the year 2000 RDAs for many essential minerals including copper, iron, molybdenum, and zinc (19). Dr. Turnlund served as Acting Center Director during the period 1992-1994, while Dr. Iacono was assigned to ARS Headquarters in Beltsville, MD, and the ARS Western Regional Research Center in 1992-1993, and after his retirement in 1994. In recognition of her outstanding accomplishments in human nutrition, she received the American Institute of Nutrition's Lederle Award in 1996.

In July of 1994, the WHNRC and the UC Davis Department of Nutrition co-hosted a symposium "New Approaches to Define Nutrient Requirements." Held at the WHNRC, the symposium explored the evidence for estimating nutrient requirements based on physiologic functions as well as traditional biochemical measures such as balance studies and blood concentrations. Attended by scientists from academia, government, and industry, the proceedings of the symposium were

published in the *American Journal of Clinical Nutrition* with Dr. Turnlund of the WHNRC and Dr. Barbara Schneeman of UC Davis as Scientific Editors (20).

After Dr. Iacono's retirement and a nationwide search for a new Center director, ARS appointed Janet King to the position in January 1995. Previously Chair of the Department of Nutritional Sciences at nearby UC Berkeley, Dr. King was internationally recognized for her research on maternal nutrition and human zinc requirements. Testament to her accomplishments and standing in the field of nutrition is her election to the National Academy of Sciences in 1994, leadership on national and international committees such as the USDA/HHS Dietary Guidelines Advisory Committee, the National Academy of Sciences' Food and Nutrition Board (which established a new paradigm for U.S. Dietary Reference Intakes), and the United Nations Committee on International Harmonization of Dietary Standards. She also served as President of the American Society of Nutritional Sciences and an Associate Editor for the *American Journal of Clinical Nutrition*. At the WHNRC, Dr. King continued to pursue her research interests in zinc and maternal nutrition, sometimes extending her studies by collaborating with other WHNRC scientists. Dr. King, herself a pioneer in the use of stable isotopes to study and model mineral metabolism, collaborated with Dr. Turnlund on human studies of zinc deficiency and metabolism (21). Dr. King developed a kinetic model of zinc metabolism and showed that the size of exchangeable pools of zinc in the model are sensitive measures of zinc status (22). The pools are good reference points for the zinc status of vulnerable population groups, i.e. pregnant women, children fed cereal diets, and the elderly. Collaborations with Dr. Kelley and Dr. Marta Van Loan showed that mild zinc deficiency in healthy men did not alter immune function (23), but more severe zinc deficiency impaired skeletal muscle

capacity (24), while collaboration with Dr. Chris Hawkes showed that lower selenium status during pregnancy is associated with greater glucose intolerance (25).

After gaining interest and expertise in selenium nutrition at UC Davis, Dr. Chris Hawkes joined the WHNRC in 1984. Dr. Hawkes's interest in the mechanisms by which selenium might help prevent cancer added to the Center's growing program on the roles of micronutrients in preventing chronic disease. When the occurrence of congenital malformations in ducks was attributed to high selenium concentrations in a California wildlife refuge, Dr. Hawkes collaborated with WHNRC researcher Stanley Omaye to study selenium toxicity in pregnant monkeys. They showed that, unlike birds, primate fetuses are well protected from selenium and are only at risk if the mother herself is poisoned by too much selenium. This work demonstrated that pregnant women needn't be concerned about eating foods from high selenium areas, which are common in major agricultural production areas of the Western United States (26).

While previous studies of selenium nutriture in humans were more pharmacologic than nutritional, Dr. Hawkes conducted a 4-month metabolic unit study in which the selenium intake of healthy men was varied by feeding foods that were naturally high or low in selenium. The study provided valuable new information on biochemical measures of selenium status and how the body adapts to high or low selenium intake (27). Since previous studies in rats showed that selenium may have either beneficial or deleterious effects on sperm function depending on the amount and form of selenium fed, Dr. Hawkes measured sperm properties during the study. The finding that the high selenium intake decreased sperm motility raised concern about the increasing frequency of selenium supplementation in the U.S. population and the need for

further studies to evaluate this effect (28). Collaboration with WHNRC colleague Nancy Keim showed that selenium intake can modulate energy metabolism, i.e. high selenium intake produced a hypothyroid response and subsequent body weight gain, while low selenium intake produced a hyperthyroid response accompanied by loss of body fat and weight (29). Collaboration with Dr. Kelley showed that the higher selenium intake enhanced some aspects of cell mediated immunity (30). Dr. Hawkes is continuing his research into the role of selenium in helping to prevent hormonally related cancers, recently identifying a selenoprotein in breast and prostate epithelial cells that may be involved in protecting against breast and prostate cancer.

Vitamins and Phytonutrients

Since consumption of fruits and vegetables is strongly associated with health benefits in the population at large, the WHNRC developed research programs to determine specific nutrients in plant foods that promote health and their mechanisms of action. Micronutrients believed to modulate oxidative damage, inflammation, and immune function were examined, often via well-controlled human studies carried out in the Center's metabolic unit.

Bringing a background in biochemical methods for assessing human nutritional status, Robert Jacob joined the WHNRC in 1983 and assumed responsibility for the Center's Bioanalytical Support Laboratory. With an interest in micronutrients that provide antioxidant protection, Dr. Jacob conducted two 3-month-long metabolic unit studies of vitamin C depletion and repletion in healthy men (the first study in collaboration with WHNRC colleagues Drs. James Skala and Stanley Omaye). These studies established plasma and leukocyte vitamin C as the best tests for assessing body vitamin C status (31), and showed that

even moderate vitamin C deficiency lowers antioxidant defense and increases oxidative damage in the body (32). This information was used by the Institute of Medicine's Panel on Dietary Antioxidants (of which Dr. Jacob was a member) in 2000 as part of the justification for increasing the RDA for vitamin C based on the need to provide cellular antioxidant protection as well as prevent scurvy (33).

In the 1980s and 1990s, Dr. Jacob conducted three metabolic unit studies of B vitamins in collaboration with Dr. Marian Swendseid, a Professor of Nutrition in the UCLA School of Public Health. Results from a study of niacin depletion and repletion established red blood cell nicotinamide dinucleotide concentration as the first blood and functional measure of niacin status (34) and provided data on urinary excretion of niacin metabolites that was part of the information used to set the RDA for niacin in the 1989 publication of Dietary Reference Intakes for B Vitamins (35). Studies that varied folate intake in healthy men and postmenopausal women showed that even mild folate deficiency may increase risk of developing vascular disease by elevating plasma homocysteine, and that folate deficiency can cause DNA and chromosome aberrations and increased DNA repair activity, conditions which increase the risks of developing cancer and the occurrence of birth defects (36,37).

In 1996, Dr. Jacob chaired a five-member ARS panel that developed the first nutrient standards for Public Law-480 Title II grain blend commodities used for supplemental and emergency feeding throughout the world. The Panel's report provided the first nutrient standards for Food for Peace grain-soy blends, which are the primary commodities the United States ships overseas for food relief. The new standards, which also included guidelines for extrusion processing that provides a pre-cooked "instant" product, are used by the USDA

Farm Service Agency as the basis for contracts of the foods used for relief work that are improved in their nutritional value and ease of use by the recipient.

To extend his studies on health-promoting micronutrients beyond vitamins to lesser known phytonutrients, Dr. Jacob collaborated with Drs. Shin Hasegawa and Gary Manners of the ARS Western Regional Research Center across the Bay, who had perfected methods for isolating triterpene limonoids from citrus molasses. Found in citrus juice and tissues, limonoids had been shown to provide anti-cancer activities in laboratory animals and human breast cancer cells in culture but had not been studied in humans. The appearance of limonin in the blood after doses of pure limonin glucoside were given orally showed that limonoids are absorbed systemically in humans and therefore may provide anticancer protection to body tissues (38).

Since polyphenols from cherries and other bright-colored fruits showed anti-inflammatory effects in animal studies, Dr. Jacob collaborated with Dr. Kelley and Dr. Adel Kader, of the UC Davis Pomology (fruit science) Department, to conduct a cherry feeding experiment in healthy women. They found that cherry consumption displayed an acute anti-inflammatory effect within 5 h of a single serving of cherries (39). Dr. Kelley followed this up with a long-term cherry consumption study and found that consumption of Bing sweet cherries by healthy adults for 4 weeks significantly reduced circulating concentrations of several markers of inflammation (40). These results may explain the long-held anecdotal belief that consumption of cherry products can reduce the symptoms of gout and arthritis.

Carotenoids are a family of over 600 plant pigments that are strongly associated with cancer and heart disease prevention through epidemiological studies, but whose health benefits in humans have not been

established experimentally. Betty Burri joined the WHNRC in 1985 and became interested in the body's metabolism of carotenoids and their nutritional value beyond serving as vitamin A precursors. Dr. Burri addressed these questions by developing new methods for assessing vitamin A status and blood carotene concentrations (41). She then conducted two metabolic unit studies with healthy women in which she varied the carotene intake by feeding a low carotene diet and one replete with beta-carotene. To precisely measure beta-carotene absorption and conversion to vitamin A, she collaborated with UC Davis Nutrition Professor Dr. Andrew Clifford and perfected a dual tracer-stable isotope technique that allowed metabolic tracing of deuterated vitamin A and beta-carotene isotopes in the study subjects (42). These studies showed that some measures of antioxidant defense decreased and increased during periods of carotene depletion and repletion, respectively (43), and that carotene depletion induced changes in thyroid hormones and menstrual cycles (44). These results suggest that carotenoids have physiological roles independent of their function as precursors of vitamin A. Measurement of the conversion of beta-carotene to vitamin A was studied in both men and women and showed that the conversion was lower and more variable between individuals than previously believed. This helps explain the generally poor results from public health programs that attempt to improve vitamin A status through the incorporation of beta-carotene rich foods in the diet (45).

By the late 1980s, WHNRC scientists were examining nutritional correlates of many biochemical and physiological functions; however, no research on neural and behavioral pathways had been established. In 1986, Monica Schaeffer began a program to measure indicators of neural functions, including sensory, motor, and cognitive functions. Since both deficient and excess

vitamin B₆ had been shown to result in nervous system abnormalities, she set up methods to study sensory and motor functions in the rat model. In several studies, she found that both deficiency and excess of vitamin B₆ resulted in decreased startle response, while deficiency also resulted in gait abnormalities (46,47). These results represent early evidence of a nutritional principle that was increasingly documented over succeeding years: that body functions operate optimally over a range of nutrient intakes and may be compromised at either low or high nutrient intakes.

Also interested in studying nutrition-behavior correlates, Molly Kretsch set up sensory deprivation and testing rooms at the WHNRC where cognitive function tests could be reliably administered to nutrition research subjects. In collaboration with Herman Johnson, Dr. Kretsch tested cognitive functions in healthy, premenopausal women involved in WHNRC energy-weight loss studies. The findings from one study showed a decline in iron status of dieting women that correlated with poor performance on a measure of sustained attention (48). This was among the first evidence that one of the most common nutritional deficiencies of young women, mild iron deficiency short of anemia, may have adverse physiologic consequences, i.e. cognitive impairment. With help from the nearby Letterman Army Medical Center, Dr. Kretsch also set up equipment to take electroencephelographic (EEG) tests as measures of brain activity. Her use of the tests in a vitamin B₆ study provided the first clinical evidence of EEG abnormalities with short-term vitamin B₆ deficiency in women (49). Linkage of this information with biochemical status measures played an important role in setting the 1998 U.S. RDA for vitamin B₆.

In 1998, the WHNRC received a boost to its program on nutrition and immune function

with the addition of Charles Stephensen. He joined WHNRC from the School of Public Health at the University of Alabama, Birmingham, where he had participated in studies that showed important links between vitamin A and infectious disease. His principal focus was to determine the role of nutrients that act via nuclear receptors (including vitamins A and D and some fatty acids) in maintaining a healthy immune system. Dr. Stephensen's WHNRC research has demonstrated that vitamin A, and other nutrients that act via the retinoid X receptor, can directly promote survival of T lymphocytes and development of Th2 memory cells, which mediate immune responses that protect against mucosal and parasitic infections (50). Dr. Stephensen and collaborators have also shown that adolescents and young adults with HIV infection have poor-quality diets and low intake of many micronutrients, resulting in poor status of vitamins E and D (51). Since recent evidence indicates many potential benefits for vitamin D nutriture beyond bone health, Dr. Stephensen has begun work on studies to develop and validate methods that quantitatively assess the contribution of sun exposure, diet, and skin pigmentation to vitamin D status in free-living individuals, and to determine the prevalence of vitamin D deficiency in infants and their mothers in the Sacramento, CA, area.

Body Weight, Nutrition, and Health

Critical to the study of nutrition and health is development of methods and research on body composition and energy metabolism. With a Ph.D. degree in exercise physiology and background in body composition methodologies from the University of Illinois, Marta Van Loan joined the WHNRC in 1982. Her responsibilities at the new Center included the development of a body composition laboratory for the assessment of human nutritional status as well as a research assignment on nutrition and body composition. Dr. Van Loan conducted

numerous studies to validate new body composition methods, including total body electrical conductivity (TOBEC) for measuring fat-free mass, dual energy x-ray absorptiometry (DEXA) for measuring bone mineral density, and bioelectrical impedance spectroscopy (BIS) for determination of total body water and extracellular fluid (52,53). These methods featured improved reliability and ease of use, thus making them suitable for use in controlled human studies at the Center and in studies that involved large numbers of men and women.

Having validated a full range of body composition methods, Dr. Van Loan began studies on the influence of eating behaviors and dietary patterns on bone health. In studies of premenopausal women, she found that women who restricted their food intake to lose weight ("dieting") had a lower bone density than women who did not engage in dieting. This suggested that chronic dieters are at greater risk of developing osteoporosis in later life and should monitor their bone density, calcium intake, and increase weight-bearing physical activity to maintain bone health (54,55). Findings from Dr. Van Loan's collaboration with scientists at Iowa State University indicated that women who minimize weight gain during the menopausal transition may optimize appetite hormones, thereby facilitating appetite control and weight maintenance (56). Currently, Dr. Van Loan is participating as a Co-Investigator in a 3-year, multi-center trial on the efficacy of soy isoflavones as an alternative to hormone replacement therapy for minimizing bone loss in postmenopausal women. She is also the lead scientist, in collaboration with others at the WHNRC, in an investigation of the effect of dairy products on weight and fat loss during dietary restriction and the underlying mechanism (57).

In 1985, Nancy Keim joined the Center from the University of Wisconsin. With a background in dietetics and human nutrition, Dr. Keim began a research

program to determine how dietary recommendations and practices affect energy metabolism and to delineate beneficial versus harmful effects of dieting on health and performance. She conducted a 4-month metabolic unit study to determine whether meal ingestion pattern (large morning meals vs. large evening meals) affects changes in body weight, body composition, or energy utilization during weight loss. Ingestion of larger morning meals resulted in slightly greater weight loss, but ingestion of larger evening meals resulted in better maintenance of fat-free (lean body) mass. Thus, incorporation of larger evening meals in a weight loss regimen may be important in minimizing the loss of fat-free mass (58). In a study of restrained eating behavior and the metabolic response to dietary energy restriction in women, Dr. Keim showed that the metabolism of dieting women is geared toward using carbohydrate for energy with decreased capability to burn fat. This finding suggests an alteration of metabolism that favors storage of fat and may contribute to weight regain in women who are chronic or “yo-yo” dieters (59).

Transition: Leaving the Presidio of San Francisco

The recommendations of the 1988 U.S. Base Realignment and Closure Commission included closure of the Army base at the Presidio of San Francisco. For some years thereafter, the fate of LAMC and LAIR was still uncertain. The cost of retrofitting the 1968-era LAMC hospital to modern earthquake and egress standards was too great to save it from closure; however, the more modern LAIR research building, home to the Army’s “research-for-the soldier” program and the now-mature WHNRC, had no such liability. After much discussion at local, city, and national levels about the fate of this jewel of a property bordering the Pacific Ocean and San Francisco Bay, the U.S. Congress directed that the National Park Service take over the property and

add it to the U.S. National Park System as part of the existing Golden Gate National Recreation Area. As per Congressional directive, the Army would abandon all its Presidio property, including LAMC and LAIR. (A more detailed history of the Letterman properties in the Presidio of San Francisco is available at <http://www.militarymuseum.org/LettermanAMC.html>.)

While the Presidio property was officially transferred from the U.S. Army to the National Park Service in October 1994, the status of the LAIR building, as well as WHNRC’s occupancy, was still unknown when Janet King joined the Center as Director in 1995. As the Army moved out of the LAIR building, Dr. King and the Center’s administrative staff faced the challenges of operating the Center as a tenant of the National Park Service but without the Army’s shared support facilities and services. In August 1996, the National Park Service notified Dr. King that the WHNRC’s scientific research program did not fit the theme of the Presidio Park that was being envisioned and thus the Center would have to leave the Presidio. At this time, the National Park Service did not give Dr. King a leave-by date but assured her that the Center would have plenty of time to plan for the transition once a firm date was provided.

In late 1996, knowing that the WHNRC would have to move out of the Presidio but not knowing exactly when, the ARS and Dr. King faced the challenge of planning for the future of the WHNRC. Over the years, the Center and its scientists had established collaborations and contacts with UC Davis, UC Berkeley, UCLA, and the ARS Western Regional Research Center across the Bay in Albany, so these were all possible sites to which the WHNRC might relocate. Finding space for a research center with 14 scientists, some 80 total staff, and substantial laboratory and animal facilities was a daunting task. Since the WHNRC was the only one of the ARS HNRCs without its

own building, ARS was looking for a site where it could construct a building for the Center and purchase or lease property on a long-term basis. The lack of property space was a problem for all of the potential sites except the UC Davis campus, located on the farm acreage of Davis in the Central Valley of California, about 75 miles northeast of San Francisco. While the other two UC campuses also had nationally ranked nutrition departments, UC Davis was stronger in agricultural sciences, especially plant and animal sciences, and thus a good fit for the Center's mission of understanding the relations among farm, food, and health.

The U.S. Congress appreciated the plight of the WHNRC and began designating funds for construction of a building for the Center, although the total amount was appropriated over 4 years (1996-1999) due to tight Federal budgets and the need to cut costs. This piecemeal and protracted funding process delayed planning for the building, because plans could not be finalized until the amount funded was known. With the help of colleagues at UC Davis, the USDA and the University of California eventually formulated an MOU (memorandum of understanding) that designated a long-term lease to property on the west end of campus for the new WHNRC building. The last portion of funds for the new building was appropriated with the help of a Davis area congressman, Rep. Victor Fazio (D-CA). One of the key figures in the negotiations between ARS and UC Davis was Charles Hess, a plant scientist and administrator who had served UC Davis as Dean of the College of Agricultural and Environmental Sciences for the period 1975-1989 and USDA as Assistant Secretary of Science and Education for the period 1989-1991. Many other individuals at UC Davis also contributed to bringing the WHNRC to the campus, including Robert Grey, Provost, M.R.C. Greenwood, Dean of Graduate Studies, and Carl Keen, Chair of the Nutrition Department.

In August 1998, Dr. King received word from the National Park Service that the WHNRC must vacate the Presidio—and within 30 days. Meeting this deadline was impossible for a number of reasons, one being that arrangements for WHNRC space on the UC Davis campus had not been completed. Dr. King and the Center's Administrative Officer Leo Rachel then negotiated with the National Park Service for a 6-month extension of the leave-by date. Now assured of funding for a new building, and knowing where (and when) they were going, Dr. King and the WHNRC staff began planning for the move. Committees were formed to work on the design and specifications for the new building under the leadership of Research Scientist Nancy Keim.

The WHNRC at the University of California Davis (1999-Present)

In the spring of 1999, the WHNRC began moving to the UC Davis campus. Since existing office and laboratory space on the campus was largely occupied, and no single campus building or department could house the WHNRC in its entirety, the Center's research program was partitioned to several campus departments where space could be allocated and complementary research was being conducted. Thus, WHNRC scientists' laboratories were relocated to various locations on campus, including the Departments of Nutrition, Pomology (fruit science), Food Science, and Medicine. Likewise, the administrative and support functions were relocated where space was available on campus, with some of the former finding space in a nearby USDA administrative building in Davis. In hindsight, this arrangement had the advantage of allowing a 7-year period of close contact between WHNRC scientists and their UC Davis colleagues, stimulating a variety of interactions that would benefit the Center's research program.

Having successfully led the WHNRC into the new millennium and met the challenge of moving the WHNRC to its permanent location on the UC Davis campus, Dr. King left the Center and ARS in 2003 to continue her nutrition research career at the Children's Hospital Oakland Research Institute in Oakland, CA. In 2007, Dr. King was inducted into the ARS Science Hall of Fame, the third nutrition scientist to be so honored (after Drs. Hamish Munro and Walter Mertz).

After a nationwide search for a new Center Director, ARS selected Lindsay Allen to be Center Director in 2004. A Professor of Nutrition at UC Davis, Dr. Allen is an accomplished research scientist in the area of micronutrient nutrition and a leader in the nutrition science profession. She served as President of the American Society for Nutrition and the Society for International Nutrition Research, and is Vice-President of the International Union of Nutritional Sciences. Dr. Allen has been a member of many Institute of Medicine committees, including the Food and Nutrition Board, and the Standing Committee on the Scientific Evaluation of Dietary Recommended Intakes. She has worked to raise awareness and improve micronutrient nutrition worldwide through food-based, supplementation, and/or food-fortification interventions (60,61). Dr. Allen discovered that vitamin B12 deficiency was highly prevalent in developing countries due to a low intake of animal-source foods (62) and was associated with impaired function. One of the important findings from her collaborative study with colleagues at UC Davis and the University of Michigan was that both low folate and vitamin B12 nutriture are associated with dementia and cognitive impairment in elderly Mexican Americans, and that higher plasma vitamin B12 levels may reduce the risk by lowering plasma homocysteine (63,64).

The New Millennium—at UC Davis

Groundbreaking for the WHNRC's new building at UC Davis took place in 2002; however, the building was not dedicated and occupied until 2006. Upon occupancy of the 2-story, 49,000-square-foot structure, the WHNRC staff numbered about 100 and included 15 lead scientists, as well as post-doctoral researchers and pre-doctoral students. Support facilities included a 12-bed metabolic unit, research kitchen, Bioanalytical and Physiological Support Laboratories for conducting carefully controlled nutrition studies of a few hours to months in duration. An indirect calorimeter for measuring human energy expenditure was completed in 2008.

While maintaining the overall goal of improving the health of Americans through nutrition, the mission of the WHNRC at the turn of the century had been extended to emphasize two issues that had been coming to the forefront of nutrition science. These were (1) the role of nutrition in maintaining a healthy body weight, a reflection of concern over the growing incidence of obesity in the United States; and (2) the mechanisms by which food constituents affect health and how these are influenced by an individual's genetic makeup and environment. This led Center Directors King and Allen to recruit research scientists who had interest and background in these areas. Important to progress in the second area above was the understanding and utilization of emerging technologies in molecular biology, genomics, and metabolomics.

Since consumption of fructose-sweetened beverages in the United States has increased greatly over the past three decades, concomitant with increased obesity and diabetes, Nancy Keim teamed with UC Davis scientist Peter Havel to conduct a series of studies to assess the effects of higher fructose consumption on energy and lipid metabolism. They found that

beverages sweetened with fructose and high fructose corn syrup resulted in alterations in hormones associated with hunger, including insulin, leptin, and ghrelin, elevated circulating blood triglyceride concentrations, reduced ability to burn fat for energy, decreased resting metabolic rate, and evidence of insulin resistance (65). The results suggest that long-term consumption of diets high in fructose may contribute to increased risk of obesity, diabetes, and heart disease.

In 2000, Liping Huang joined the Center as a research geneticist. She began a program to identify the genetic influences on zinc homeostasis at the molecular and cellular levels in humans. Dr. Huang identified zinc transport proteins whose biosynthesis is under genetic control and showed that alteration of genetic expression of some of these proteins may play a role in the progression of prostate cancer (66). Since sensitive measures of human zinc status had not been identified, Dr. Huang studied the potential of tests for the genetic expression of the zinc transport proteins as markers of zinc status. From lymphocyte cell culture and human studies, she found that the level of genetic expression (mRNA) of the ZIP1 zinc transport protein was inversely related to zinc availability (67). This suggests a potential application of ZIP1 as a biomarker of zinc status in humans.

Previously a professor at the Pennington Biomedical Research Center at Louisiana State University, Molecular Biologist Daniel Hwang joined the WHNRC in 2002. Dr. Hwang studies the molecular mechanisms by which different types of dietary fatty acids and phytochemicals modify risks of chronic diseases. He has shown that saturated fatty acids stimulate but polyunsaturated fatty acids and some plant polyphenols inhibit recognition receptors (TLRs and Nods) involved in the body's immune and inflammatory responses (68,69). These results indicate that saturated fatty acids

promote inflammation linked to chronic diseases while polyunsaturated fatty acids and plant polyphenols inhibit this process. Ongoing research to validate and extend these findings uses transgenic animal models to determine whether dietary n-3 polyunsaturated fatty acids and plant polyphenols inhibit tumorigenic potential as a result of suppression of TLRs or Nods-induced inflammation.

In 2003, Molecular Biologist Susan Zunino joined the Center's research program to study the mechanisms by which phytochemicals in fruits and vegetables promote immune function and protect against chronic disease. Using healthy and cancerous cells as laboratory models, Dr. Zunino showed that phytochemicals, including resveratrol from grapes and quercetin from strawberries, can kill acute lymphoblastic leukemia cells, possibly by interfering with energy production in subcellular mitochondria (70). In collaboration with WHNRC scientist Charles Stephensen, Dr. Zunino found that a freeze-dried powder form of table grapes fed to diabetic mice prevented the progression of diabetes and increased survival time (71).

Three scientists who joined the WHNRC research program in 2005-2007 are attacking the growing problem of obesity in the United States by investigating the biochemical, genetic, and behavioral aspects of nutrition-obesity connections. Research Physiologist Sean Adams investigates the etiology of obesity and associated disorders such as diabetes, determines how specific foods and food components modify these parameters, and searches for molecular biomarkers reflective of a healthy or disordered metabolism. Studies designed to understand how fat tissue size and physiology are controlled led to the discovery of unique proteins robustly expressed in adipocytes (fat cells) and peripheral neurons and that are controlled by diet, metabolically relevant cues, and obesity (72). Since

peripheral neurons transmit metabolic and sensory information (temperature and pain, for example) to the brain, these findings shed light on mechanisms by which diet and fat tissue influence nervous system function and neuropathy development.

Other ongoing efforts in Dr. Adams's laboratory focus on the influence of dietary calcium (Ca) on inflammatory and immune cell patterns in the fat tissue of animals and humans, since low Ca intake has been associated with increased inflammation in adipose tissue. More recently, as a result of collaborations between John Newman of the WHNRC and colleagues at the University of Alabama Birmingham, Case Western Reserve University, UC Davis, and the University of Ottawa, metabolomics technologies have been applied to identify metabolite biomarkers of fat metabolism in diabetics and in isolated mitochondria (energy-generating organelles) from muscle tissue. In addition to providing insights into the etiology of metabolic disease, these efforts should provide useful clinical tools for predicting diabetes risk and for tracking how dietary and physical activity interventions prevent or thwart progression of disease.

Research Chemist John Newman brings expertise in state-of-the-art analytical instrumentation to apply metabolomics to determine the impact of diet and dietary components on human health and obesity. Special emphasis is given to the obesity problem and its complications associated with the high-fat "Western" diet. While Dr. Newman collaborates with researchers within the WHNRC, the United States, and abroad, his primary focus is on the impact that the content and composition of dietary fat has on the levels of lipid metabolites that regulate cellular growth, inflammation, blood pressure, and satiety, with experiments to delineate how differences in individual responses to dietary fat might manifest in risks for obesity and

health complications. Using newly developed tools, Dr. Newman recently demonstrated subtle changes in lipoprotein structure and function with associations to dyslipidemia-associated cardiovascular disease (73). Current studies are exploring how omega-6:omega-3 ratios of high-fat diets derived by blending butter fat, corn oil, olive oil, flax oil, and/or fish oil influence these structural aspects of circulating lipoproteins, as well as the molecular responses of peripheral tissues. These research goals extend and complement the WHNRC's impact in the area of dietary fats on health accomplished by Drs. Iacono, Nelson, Kelly, and Hwang.

Nutritionist Kevin Laugero studies neurobehavioral aspects of eating behavior and nutrition-based interventions aimed at facilitating long-term adoption of the Dietary Guidelines for Americans. The primary objective of Dr. Laugero's research is to understand the impact of stress on food choice, and how foods switch off the response to psychological stress. Dr. Laugero's research also aims to understand the role and underpinnings of chronic psychosocial stress in dysfunctional eating behaviors, particularly as they relate to obesity and the metabolic syndrome. He is currently testing whether increased physical activity in obese persons reduces the effects of chronic stress on eating behavior and energy metabolism, and identifying metabolic profiles that relate to weight loss or gain (74).

Acknowledgments

The assistance of David D. Schnakenberg, LTC, U.S. Army, in supplying information on the role of the U.S. Army in the establishment of the WHNRC in the Presidio of San Francisco is greatly appreciated.

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CHAPTER 13

Inception and History of the Arkansas Children's Nutrition Center

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Abstract

Arkansas Children's Nutrition Center (ACNC) was realized from the vision of individuals who understood the importance of providing good nutrition to the children of Arkansas. The work and research of ACNC has expanded since its beginning in 1994, thanks to the support of Arkansas Children's Hospital, the U.S. Department of Agriculture, and many government officials including Senator Dale Bumpers (D-AR). Led by Thomas Badger, Ph.D., ACNC currently receives approximately \$5.2 million in annual funds from USDA. Arkansas Children's Nutrition Center is truly carrying out its mission to maximize the health of children from conception through adolescence and their health as adults, especially during aging.

The Beginning

Arkansas Children's Nutrition Center is located on the grounds of Arkansas Children's Hospital (ACH), one of the top pediatric hospitals in the United States, according to *U.S. News and World Report* (1). ACH was founded outside the small

Arkansas town of Morrilton in 1912 as the Arkansas Children's Home Society, a branch of the National Children's Home Society. It was created "to care for Arkansas' orphaned, neglected, homeless and poverty-stricken children." By 1926, the facility had moved to its current location in Little Rock following a fundraising campaign that garnered more than \$200,000 in building funds. Today, ACH is a private, non-profit institution. It is the only pediatric medical center in Arkansas and the most comprehensive in the region (2). ACH houses its own pediatric research facility: Arkansas Children's Hospital Research Institute (ACHRI). ACH also works collaboratively with the State's only medical school, the University of Arkansas for Medical Sciences (UAMS).

At its inception, Arkansas Children's Nutrition Center (ACNC) was initially the vision of Dr. Robert Fiser, a pediatric endocrinologist and chair of the Department of Pediatrics for the UAMS. His understanding of the importance of providing good nutrition to children planted seeds for the developments that would lead to ACH's relationship with USDA and its Agricultural Research Service (ARS). Dr. Fiser intended to accomplish his goal and vision for the development of a

History of USDA-ARS Human Nutrition Research



Dr. Thomas M. Badger moved to Little Rock, AR, to help Dr. Robert Fiser build a nationally competitive pediatric research program. Dr. Badger worked with Dr. Fiser and Senator Dale Bumpers to win funding for the establishment of a USDA-funded Human Nutrition Research Center—the Arkansas Children’s Nutrition Center.

nutrition center by recruiting Dr. Thomas M. Badger, then an associate professor at Harvard Medical School and director of the Vincent Memorial Research Laboratories at Massachusetts General Hospital.

Dr. Badger earned a Ph.D. in nutrition and biochemistry from the University of Missouri-Columbia and conducted postdoctoral work in neuroendocrinology at Washington University School of Medicine in St. Louis, MO. His National Institutes of Health (NIH)-funded research program in Boston focused on the interactions of nutrition, reproductive neurobiology, and development, and Dr. Fiser learned of Dr. Badger through his colleagues at Harvard.

In 1986, Dr. Fiser convinced Dr. Badger to move to Little Rock and help him build a nationally competitive pediatric research program. Dr. Badger was charged with helping ACH and the UAMS Department of Pediatrics develop and establish the Arkansas Children’s Hospital Research Institute (ACHRI), an institute established by the Board of Trustees of Arkansas Children’s Hospital in 1989 exclusively for UAMS researchers on the ACH campus, and with working with Dr. Fiser and Senator Bumpers to win funding for the establishment of a USDA-funded Human Nutrition Research Center (HNRC).

The Foundation

The ACHRI was established as a private, not-for-profit corporation owned by the ACH. It has a separate board of trustees and president/chief executive officer. The first ACHRI board, led by Chair Charles Whiteside III of Merrill Lynch and Company, recognized the need for a building to house the pediatric research facility. At the time, even though the UAMS Department of Pediatrics and nearly all of Arkansas’ major pediatric care providers were housed on the ACH campus, most pediatric research was being conducted on the UAMS campus, nearly a mile from ACH. Thus, in 1990, the ACHRI Board recommended the purchase of the original Baptist Hospital of Little Rock, which was immediately adjacent to the ACH campus. ACH imploded all the buildings except for two and then deeded the 130,000-square-foot Surgery and Radiology Building to ACHRI with the idea of renovating it for research. Funds were raised and a state-of-the-art animal research facility was built on the ground floor to house both typical research animals and larger animals such as pigs, sheep, and calves. In 1991, ACH and UAMS reached an agreement to combine the strengths to enhance the capabilities of ACHRI (3), and research began in the new ACHRI animal facility in 1992. The ACHRI building provided the much-needed space for basic animal research to be conducted on the ACH campus, and this was an important first step in building future research programs, since all developmental animal research at that time was performed several miles away in an old, outdated barn on the campus of the Veteran’s Administration Hospital. Furthermore, before ACHRI was established at ACH, research and clinical chemistry laboratories were combined, and thus laboratories devoted exclusively to researchers were limited on the ACH campus and were mostly housed at UAMS.

The Human Nutrition Research Center

Drs. Fiser and Badger worked closely with Senator Bumpers and Mr. Chuck Culver, an attorney and the former campaign manager for Senator Bumpers, to draft initial exploratory language about the development of a human nutrition research center (HNRC) on the ACH campus. Congress appropriated \$100,000 and directed the ARS to determine the feasibility of establishing an HNRC devoted exclusively to research into the nutritional status and needs of infants and children. This resulted in a site visit committee being sent from the ARS in January of 1994 to review the Congressional request and to make a recommendation. Arkansas was not alone in its request, and other universities had similar proposals for establishment of an HNRC on the campuses of their respective facilities. The site committee concluded that ACH possessed all of the necessary components that would support a children's nutrition center.

Arkansas was and remains an ideal location to house the newest of the six HNRCs. Its stable rural population allows longitudinal studies to be conducted with low attrition rates. Arkansas also has a metropolitan component in its capitol city, Little Rock. These two diverse settings, rural and metropolitan, provide researchers with excellent opportunities to conduct clinical studies. Furthermore, Arkansas has traditionally ranked as either first or second in the prevalence of obesity in the Nation, making it a fertile area to study overweight and obesity. Moreover, the high rate of poverty in the State makes the issue of nutritional status even more important, as good nutrition leads to good overall health and lower healthcare costs. Arkansas is also an agricultural State with several food processing firms and a business force interested in nutrition and diet. These factors give Arkansas Children's Nutrition Center the opportunity to be on the cutting edge of exploring the effects of

diet and nutrition, developing prevention interventions and educational components for improving nutritional status for children.

In 1994, Congress appropriated \$1.2 million and directed the ARS to establish the sixth human nutrition research center at Arkansas Children's Hospital. Thus, the Arkansas Children's Nutrition Center (ACNC) was born with a mission to investigate dietary factors that will maximize the health of children from conception through adolescence, as well as their health as adults, especially during aging. In accomplishing this mission, children and their families are studied relative to commonly consumed foods, and animal and cellular models are used to address questions not possible in children. Animal studies are used to establish new hypotheses, test existing ones, and clarify basic metabolic functions of nutrients and dietary factors in common foods. Controlled dietary, metabolic, and behavioral studies are conducted to obtain data on which dietary strategies can be developed for healthy and safe human development, healthy maturation of the American populace, and guidance for improving the nutritional policy on the quality and safety of the Nation's food supply.

Before any of the appropriated funds could be released, however, research proposals and budgets were drafted, and an agreement was established between ACH and the ARS. Beginning in December of 1994, Dr. Badger, Dr. Charles Onstad, and Dr. Roscoe Dykman drafted two proposals that laid the groundwork for future development of the Center, "Psychological and Psychophysiological Functioning of Children With Failure to Thrive" and "Exposure to Dietary Factors Early in Human Development: Long-Term Health Consequences of Phytochemical Intake." The objectives were to determine the effects of diet on cognitive and behavioral development and brain function; cellular

and metabolic imprinting; development and function of metabolic, endocrine, and immune systems; child health and development; their long-term health as adults, concentrating especially on bone (skeletal) development and adipogenesis as it relates to osteoporosis and obesity, respectively; and cancer risks (4,5). Research began in August of 1995. In October of 1995, Congress appropriated an additional \$300,000, bringing the yearly total in appropriated funds to \$1.4 million.

Also in 1995, the ACHRI completed renovation of the second floor of the ACHRI Research Building (35,000 sq. ft.). This new ACHRI space, combined with the previously developed animal facility on the first floor, allowed the ACNC investigators to move from the UAMS campus to the ACH campus. This presence on the ACH campus signified the beginning of a new focus on pediatric nutrition in Arkansas; however, the need for a separate ACNC building remained a priority. This ACHRI space would be the home of the basic ACNC research for a few years, while the clinical studies were conducted in the main hospital one block away. All previous HNRCs had Federal buildings to house their research. In an interesting twist, however, Congress had restricted the use of Federal funds for new buildings during the initial period in which the ACNC funds were appropriated, leaving the ACH to guarantee a private building to house the program. Without a major donor, the ACHRI and ACH began fundraising efforts to build a single-story, 25,000-square-foot building to house all clinical studies for ACNC, with the idea of structuring the building for the future addition of four floors. In 1997, Arkansas Children's Nutrition Center opened its doors, making it the only HNRC not housed in a Federal building. The building contained a 6-bed live-in facility, a 100-subject-per-day outpatient facility, a clinical nutrition laboratory, a human brain function laboratory, a recruiting center, and a

psychological evaluation unit. Also in 1997, funding was increased by an additional \$500,000, bringing the yearly total in appropriated funding to \$1.9 million.

Major foci of ACNC research are the long-term health consequences of early nutrition and diet, the health effects of dietary factors other than traditional nutrients, and prevention of chronic diseases that have their origins during early development. The Center conducts work in five primary areas: brain development, cognition, and behavior; phytochemicals and peptides; immunology, food allergies, and food safety; bone development and structural integrity; and adipogenesis, fat metabolism, and obesity.

In 2002, ACNC began one of the most comprehensive prospective, longitudinal studies of infant feeding that also embodies all five focus areas of the ACNC mission areas mentioned above. This study addresses the effects of diet on metabolism, body composition, and brain function in infants and children. It is referred to as the "Beginnings Study." This study follows 600 children who were breastfed or fed milk-based formula or soy-based formula. Healthy participants are studied from age 1 month through age 6 years to determine developmental factors of feeding on growth and cognition. Extensive longitudinal studies in food intake, nutritional status, body mass and composition, metabolism, organ development, and brain development and function are conducted in these children. This study will have a significant impact on our understanding of potential child health differences between breast and formula feeding and on the effects of soy-formula.

The Beginnings Study is a high-profile study, because it specifically addresses the controversial issue of the health effects of soy formula, which has been severely restricted in France, the United Kingdom, and Israel, primarily because

of potential adverse estrogenic effects of soy phytochemicals known as isoflavones. In fact, France also recommends that soy foods not be fed to children younger than 3 years. Since more than 1 million American infants consume soy formula each year, this is an important infant nutrition issue to research. Furthermore, the National Institutes of Health's (NIH) National Toxicology Program (NTP) and the National Institute for Environmental Health Sciences (NIEHS) held a workshop to discuss potential effects of soy formula and genistein (the major isoflavone in soy protein) on the reproductive system and concluded that more research was needed on soy formula. This has led to a new NIEHS study similar to the Beginnings Study, which began in 2010.

This study points out several important issues related to the HNRCs in general and the ACNC in particular. First, a longitudinal study of this type requires a team of experts and a unique facility that is typical of the HNRCs but not typical of other research facilities. One of the most important features of the HNRC program is its abilities to conduct important and needed research studies that have either not been possible in other facilities or for which funding has not been possible. Second, longitudinal studies such as the Beginnings Study require a team of highly qualified pediatricians, neuroscientists, nutritionists, endocrinologists, psychologists, toxicologists, immunologists, radiologists, and others, plus a dependable study population that is stable and diverse. Arkansas has both the team of investigators and the study population necessary for such prospective, longitudinal studies.

At the time of writing this chapter, the Beginnings Study is about 60 percent complete, thus results are preliminary. However, this study is part of a large translational program within the ACNC involving studies in developing pigs fed the same infant formula employed in clinical

studies, in rodents fed the same soybean components used to make soy formula, and in cell cultures to study specific serum metabolites from infants and animals fed various diets.

Longitudinal study of the same infants at 6 years shows that regardless of the feeding type (breastfeeding or formula feeding), the child grows within the national norms established years ago, and this includes the well-known and subtle difference between breastfed and formula-fed infants. Results from the Beginnings Study and the related pig, rodent, and cell culture research suggest that (1) the developing body reflects the diet being consumed; (2) infants and animals fed soy tend to be leaner; (3) dietary factors, especially phytochemicals, alter gene expression and metabolic profiles; (4) there are slight differences in brain development and function of infants fed breast milk or formula—in most cases, milk formula is less like breast milk than soy formula; however, children score within normal limits on all standardized behavioral tests; (5) differences in brain function noted very early in life tend not to be present later in life; and (6) no adverse effects of soy formula were observed in development, including in the reproductive tract.

In 2004, ACH and ACHRI broke ground for a \$17.1 million expansion and appointed Dr. Richard F. Jacobs as president of ACHRI. During this expansion, a second floor was added to the current ACNC building. This floor added sufficient laboratory and office space to house the ACNC basic research team that had been housed in the ACHRI facilities since 1995. Importantly, the combination of basic and clinical investigators in the same building added strength to the translational research that began in 2000. From that point forward, the vast majority of research projects within the ACNC are translational, meaning that important clinical problems are tackled by studies in children, where possible, but are

taken to animal and cell models to learn more about mechanisms and to study issues not possible in children. The important basic information can then be used to develop further and more indepth clinical studies in children, thus making maximal use of basic and clinical studies.

The ACNC grew from an initial appropriation of \$1.2 million to an annual budget of more than \$6.2 million in USDA funds, which is also matched by approximately the same amount in NIH funding. From the inception of the Arkansas Children's Nutrition Center, the ACH has provided more than \$25 million in building and renovation costs and more than \$17 million in indirect costs. Furthermore, the UAMS Departments of Pediatrics, Physiology/Biophysics, Pharmacology/Toxicology, Microbiology/Immunology, and Neurology have provided academic appointments to the ACNC investigators. Thus, the ACNC is truly a partnership between Federal and State governments and private business.

Scientific advancements from ACNC research have come in our understanding of the effects of soy infant formula on child growth, development, and health; the significant role of phytochemicals in gene expression and the subsequent changes in metabolism; and brain development over the first several years of life (6).

It took real leadership and vision of Dr. Robert Fiser and Senator Dale Bumpers to get the Center started, and many other people worked very hard as a team to see it grow. Among those who were particularly instrumental were ACHRI Chairman Charles Whiteside and his board; several of the ACH boards; former Senator David Pryor (D-AR) and his staff; Congressman Ray Thornton (D-AR) and his staff; Chuck Culver; ACH President/CEO Dr. Rand O'Donnell; ACH President/CEO Jon Bates; Senator Blanche Lincoln (D-AR); Senator Mark Pryor (D-AR); Congressmen Vic Snyder (D-AR), Mike

Ross, John Boozman, and Marion Berry; and UAMS Department Chair and ACHRI President/CEO Richard Jacobs.

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Index

1963 Report to Congress, "Proposed Program for Expanded Research in Food and Nutrition" 68, 124

A

Achterberg, Cheryl 228, 251
Adams, C.F. 133, 134, 135
Adams, Georgian 31, 44, 133, 156
Adams, Mildred 101, 156
Adams, Sean 319
Alford, John 93
Allen, Lindsay 318
Anderson, Barbara 137
Anderson, Richard 86, 87
Andrews, Karen 153, 156
Andrews, Mary 277
Andrews, Senator Mark 266, 277
Appel, Lawrence 225, 228, 251
Archer, Representative Bill 290
Arkansas Children's Hospital 326
Atkinson, Edward T. 6, 240
Attaya, Margaret 41, 42
Atwater, Helen 10, 200, 201
Atwater, Wilbur O. 2, 3, 4, 6, 7, 8, 9, 10, 11, 21, 52, 66, 73, 122, 126, 128, 131, 137, 150, 171, 173, 199, 200, 240, 242, 243, 244, 259, 303

B

Badger, Thomas M. 326
Baer, David 93, 97
Bailey, Ben 265
Baker, Doris 140, 143
Baker, Gladys 16, 35
Baker, O.E. 23
Balls, A.K. 32
Bane, Lita 44
Bankhead Jones Act of 1935 2
Barnes, Lewis 213
Batchelder, Esther 51, 123
Bates, Jon 331
Bauman, Carl 86
Bayley, Ned 244, 246
Baylor College of Medicine 289, 291
Beck, Melinda 88
Beecher, Gary R. 65, 79, 93, 100, 121, 125, 141, 142, 143, 146, 147, 154, 156, 239

Behall, Kay 81, 82
Bellows, George 290
Bentley, Orville G. 291
Bentsen, Senator Lloyd 290
Berdanier, Carolyn 76, 80
Bergland, Secretary Robert 210, 246, 301
Berlin, Elliot 82
Berry, Representative Marion 331
Bertrand, Anson 305
Bevier, Isabel 21
Bhagwat, Seema 139
Bhathena, Sam 80
Bialostosky, Karil 223
Bier, Dennis 223, 296
Bieri, John 95
Birdseye, Clarence 20
Birdseye, Miriam 20, 21, 31, 38
Blanton, C.A. 186
Block, Secretary John 211, 247
Bodwell, C.E. 73, 78, 79, 92, 94
Bogle, Margaret 245, 254
Booher, Lelia 28, 29, 30, 31, 77, 85, 101, 132, 156, 243
Booth, Sarah 150
Boozman, Representative John 331
Borum, Peggy 213
Bowen, Phyllis 98
Bowman, Shanthy 224
Britz, Steven 74
Bronner, Yvonne 225
Buege, Dennis 156
Bumpers, Senator Dale 326, 331
Burdick, Senator Quentin 267
Burkitt, Denis 81
Burri, Betty 314
Burton, Representative John 304
Bush, President George W. 202
Butler, Roy E. 31
Butrum, Ritva 135, 136, 137, 140
Byrdwell, W. Craig 148

C

Caballero, Benjamin 225
Caldwell, Alvin 45
Caldwell, Charles 74
Califano, Secretary Joseph A., Jr. 301
Callaway, Wayne 213
Callison, Elizabeth C. 28, 29, 77, 85, 132
Calloway, Doris 223

- Camargo, Carlos 225
 Canfield, Wesley K. 266, 269, 273
 Canham, Edward 304
 Cannon, Helen 265
 Cao, Jay J. 273, 286
 Carpenter, Rowena 33
 Carter, President Jimmy 209, 246
 Casey, Representative Bob 290
 Cassidy, Jerry 300
 Cavin, J.P. 32
 Chang, Florence 156
 Chang, Mei Ling 80
 Chatfield, Charlotte 31, 133
 Chen, Pei 148
 Child Nutrition Act of 1966 208
 Citizens' Food Committee (CFC), 1947 44
 Clark, Faith 31, 42, 49, 56, 68, 123, 124, 134, 244
 Claycombe, Kate J. 273, 286
 Clemens, Roger 228, 251
 Cleveland, President Grover 6
 Clevidence, Beverly 70, 74, 82, 96, 97, 148
 Clifford, Andrew 98, 306
 Clinton, President Bill 224
 Clydesdale, Fergus 225
 Colby, Sarah E. 273, 286
 Combs, Gerald F., Jr. 272, 276, 286
 Combs, Gerald F., Sr. 70, 73, 74, 125, 138, 239, 245, 247, 252, 269, 276
 Conrad, Senator Kent 268
 Conway, Joan 93, 94, 95, 100, 186
 Coons, Callie Mae 44, 51, 58, 101, 123, 156, 264
 Cornatzer, William E. 255, 268
 Corson, H.T. 24
 Craft, Neal 95
 Cronin, Fran 223
 Cronister, Kathryn 46, 47
 Csonka, Frank 45
 Culver, Chuck 319, 322
 Cutler, Rupert 246
 Cutrufelli, Rena 137, 156
- D**
- Daniel, Esther Petersen 28, 31
 Davis, Carole 223, 224, 225, 226
 Davis, Cindy 269, 273, 286, 287
 Dawson, Harry 99
 Deckelbaum, Richard 224
 de Jesus, Vincent 156
 de la Garza, Representative Eligio "Kika" 291, 296
 Delauro, Representative Rosa 274
 del Collo, Peggy 259
 Del Corral, Pedro 273, 286
 Dickson, Mabel 28
 Dietary Reference Intakes 21, 75, 147, 172, 177, 182, 199, 205, 230, 270, 276, 293, 311, 313
 Dietary Supplement, Health and Education Act of 1994 95
 Dietz, William 223
 Doherty, Robert 102, 145, 157
 Doisy, Edward 265
 Doisy, Richard 265
 Dole, Senator Robert 241, 300
 Dorgan, Senator Byron 268, 274
 Dougherty, Rita 308
 Douglass, Larry 156
 Dupont, Jacqueline 1, 70, 74, 125, 245, 253
 During, Alexandrine 96
 Dutcher, Rodney 25
 Dwyer, Johanna 156, 224, 245, 256
 Dykman, Roscoe 319
- E**
- Edminster, T.W. 241, 244
 Eitenmiller, Ron 150
 Elias, Megan 3, 15, 66, 76
 Elliot, Martha 22
 Ellis, Rex 86
 Ellsworth, Henry Leavitt 1
 Ellwood, Kathleen (Kathy) 71, 74, 126, 245, 255, 259
 Enns, Cecilia Wilkinson 191
 Ershow, Abby 149
 Escobar, A.J. 226
 Evans, Gary W. 266, 286, 287
 Exler, Jacob 127, 137, 139, 157
 Expanded Food and Nutrition Act of 1969 208
- F**
- Failla, Mark 91, 92
 Farioletti, Marius 32
 Farm Bill of 1977 282, 293, 296
 Fazio, Representative Victor 317

Federal Agricultural Improvement and Reform Act of 1996 254
Feeley, R.M. 134
Feinberg, Matthew 156
Ferretti, Aldo 82, 147
Fields, Meira 91, 92
Fincher, Lillian 49
Finley, John 71, 75, 127, 245, 257, 258, 269, 273, 286, 287
Fiser, Robert 326
Fisher, Katherine 44
Fjeld, Carla 71, 74, 126, 245, 255
Flannagan, Vincent 82, 147
Flannagan-Hope Act of 1947 43
Food and Agriculture Act of 1977 3, 290, 301, 303
Food and Agriculture Organization of the United Nations (FAO) 24, 42, 43, 77, 100, 153, 154, 294, 295
Food Quality and Protection Act of 1996 172
Food Security Act of 1985 3
Food Stamp Act of 1964 181, 208
Food, Conservation, and Energy Act of 2008 208, 257
Fosmire, Gary J. 266, 286
Fredrickson, Donald 241
Frenk, Sylvestre 290
Friend, Breta 56
Fukagawa, Naomi K. 228, 251

G

Galton, Francis 56
Gammage, Representative Bob 290
Ganther, Howard 257
Garrison, Y.J. 134
Garza, Cutberto 223, 224
Gebhardt, Sue 135, 137, 139, 157
Gershoff, Stanley 301, 302
Gladwell, Malcolm 220
Glickman, Secretary Dan 223, 224
Go, Van Liang 225
Gorseline, Harry 32
Gortner, Willis 66, 67, 68, 69, 72, 76, 78, 86, 101, 124, 140, 243, 244, 245, 257, 265
Greenfield, Heather 154
Greenwald, Peter 86, 149
Greenwood, M.R.C. 317
Grey, Robert 317

Grundy, Scott 224
Guthrie, Barbara 87
Gutierrez, Jose 140

H

Hahn, Carol J. 266, 286
Halas, Edward 266, 286
Hallfrisch, Judith 81, 82
Halsted, James A. 89, 265
Hambridge, K. Michael 89
Handler, Phil 246
Hanna, Agnes 22
Hansen, Carl 79
Hardin, Secretary Clifford 244
Harding, President Warren G. 11
Harnly, James 126, 138, 140, 145, 146, 147, 148
Harper, Alfred E. 21, 22, 27
Harris, Ellen 71, 76, 126, 138, 139
Harris, Suzanne 125, 138
Harrison, Earl 74, 96
Hartzler, E.R. 132
Hasegawa, Shin 313
Hatch Act of 1887 1
Hathaway, Millicent 85, 101
Havel, Peter 318
Havel, Richard 223
Hawkes, Wayne Chris 312
Hay, William Howard 56
Haytowitz, David 136, 137, 139, 156, 157
Healthy Hunger-Free Kids Act of 2010 213
Heckler, Secretary Margaret 211
Hegsted, D. Mark 69, 72, 73, 125, 241, 245, 246, 247, 259, 265, 306
Henderson, LaVell 304
Hepburn, Frank 125, 136, 137, 154
Herman, Robert 304, 306, 307
Herman, Yaye Tokuyama 307
Hess, Charles 317
Hightower, Representative Jack 290
Hitchens, Anthony 93
Hoekstra, William 86
Hoke, Marge 137
Holden, Joanne 126, 135, 139, 140, 144, 146, 149, 154, 156, 157
Hollings, Senator Ernest 241
Holsinger, Virginia 100
Hoover, Loretta 136
Hoover, President Herbert 23

Hope, Representative Clifford R. 24, 25
Hopkins, Leon 67, 68, 86, 124
Horn, Floyd 256
Horn, Mildred J. 77, 156
Hornstein, Irwin 79, 93
Houston, Secretary David F. 10
Howe, Juliette 82, 156
Howe, Paul 26, 27, 28, 31
Hrdlicka, Ales 56
Huang, Liping 311
Humphrey, Senator Hubert 292
Hunt, Caroline L. 10, 200, 201
Hunt, Curtiss D. 269, 273, 274, 286, 287
Hunt, Janet M. 269, 273, 274, 286, 287
Hwang, Daniel 319

I

Iacono, James (Jack) 67, 69, 72, 73, 82, 101, 125, 245, 246, 247, 290, 291, 306, 308
Interdepartmental Committee on Nutrition for National Defense 299, 304
Irish, Frederick W. 28, 30
Irwin, M. Isabelle 78, 89

J

Jacob, Robert A. 100, 266, 272, 286, 287, 312, 313
Jacobs, Richard F. 330, 331
Jahns, Lisa A. 273, 286
Jarratt, Mary 298
Jen, Joseph 256
Johnson, Herman 298, 299, 306
Johnson, LuAnn 266
Johnson, Phyllis E. 266, 286, 287
Johnson, Rachel 224
Johnson, W. Thomas 269, 286, 287
Jones, D. Breese 28, 45, 77, 132, 156
Joss, Edward 32
Judd, Joseph 82, 97, 98, 100

K

Kader, Adel 313
Kamin, Henry 211
Keen, Carl 317
Keim, Nancy 304, 312, 315-318
Kelley, Darshan 309
Kelley, Ernest 32
Kelsay, June 80, 81, 85

Kennedy, Eileen 223
Kennedy, President John F. 208
Kennedy, Robert 241, 299
Kennedy, Senator Edward 299
Key, Joe L. 246
Khachik, Fred 142, 143
King, Charles Glen 50
King, Janet 225, 311, 316-318
Kinney, Terry 247
Kinsella, J.E. 134
Kittrel, Flemmie 21
Klevay, Leslie M. 266, 267, 269, 270, 273, 286
Kline, O.L. 28, 29
Klurfeld, David 71, 75, 126, 245, 257, 258, 259
Kneeland, Hildegard 122
Knipling, Edward B. 256
Kott, Sally 223
Krainak, Jon 156
Kramer, Tim R. 90, 258, 266
Kretsch, Mary (Molly) 71, 75, 126, 127, 245, 257, 306, 307, 314
Kris-Etherton, Penny 225
Kritchevsky, David 211
Kumanyika, Shiriki 223, 224

L

Lahey, Edward 54, 55
Lakshmanan, Florence 93
Lamourex, Vincent B. 50
Langworthy, Charles Ford 7, 8, 9, 10, 11, 66, 122, 242, 243
Lanza, Elaine 137, 140, 143
LaRosa, John 213
Laugero, Kevin 320
Lawson, Roger 255
Le Bovit, Corinne 57
Lemar, Linda 139, 156
Lennartson, Roy 50
Letterman Army Institute of Research 304, 306, 314
Levander, Orville 74, 86, 87, 88, 89, 99, 101, 134
Leverton, Ruth 57, 58, 68, 101, 123, 156, 243, 244
Levin, Susan 48
Levy, Robert 140, 149, 211
Li, Betty 140, 143, 144, 157

Lichtenstein, Alice 224
Lichtenstein, H. 132
Lieber, Charles 213
Lincoln, President Abraham 199
Lincoln, Senator Blanche 322
Lipton, Sam 79, 93
Logan, George 266
Luecke, Richard 265
Lukaski, Henry C. 269, 272-274, 286, 287
Lupton, Joanne 225
Luthria, Devanand 148
Lykken, Glen I. 266, 269
Lynch, Marguerite 265
Lyng, Richard 247
Lyon, Joan 224

M

Madigan, Secretary Edward 220, 222
Mahon, Representative George 291
Malmberg, Carl 57
Manners, Gary 313
Marable, Nina 93
Marsh, Anne 85, 132, 137
Marsh, R.L. 132
Marshall, Mary 45, 76, 78, 102
Matthews, Ruth 125, 134, 137, 138, 139, 150
Mayer, Jean 241, 243, 290, 299
McCarthy, Marie 137
McCay, Jeanette 42
McClain, Phillip 79, 93
McDonough, Frank 93
McGovern, Senator George 209, 241, 300, 304
McLaughlin, L. 85
McMurry, Kathryn 224, 225
McNutt, Paul V. 33
Merrill, Annabel L. 52, 133
Merrill, Joseph 282
Mertz, Walter 67, 68, 70, 72, 73, 74, 85, 86, 95, 101, 124, 126, 149, 245, 265, 318
Meydani, Simin 302
Meyers, Linda 213, 223
Michaelis, Michael, III 79
Miles, Carolyn 93, 94
Miller, D.F. 133
Miller, Sanford 211
Miller-Ihli, Nancy 145, 147
Milne, David B. 266, 269, 286, 287

Milner, John 213
Mitchell, Helen 33, 56
Moe, Paul 93, 94, 100
Molyé, Karen 156
Morgan, Agnes Fay 44, 54
Morrill Act of 1862 1, 201
Morris, Eugene 86
Morton, Secretary J. Sterling 6, 7, 8, 240
Moshfegh, Alanna J. 171
Moss, Mary 140, 144
Mullis, Rebecca 213
Munoz, Juan M. 266, 286
Munro, Hamish N. 302, 318
Munsell, Hazel 19, 20
Murphy, E.W. 134, 137
Murphy, Patricia 146
Murphy, Suzanne 224

N

Nair, P.P. 84, 85
National Agricultural Research and Teaching Act of 1977 209, 249
National Defense Advisory Committee 204
National Nutrition Conference for Defense, 1941 33, 240
National Nutrition Monitoring and Related Research Act of 1990 183, 187, 213, 214, 253
National School Lunch Act of 1946 48, 206
Nelson, E.M. 28, 30, 31
Nelson, Gary 300
Nelson, Miriam 228, 251
Nesheim, Malden 213
Nestle, Marion 223
Newman, John 320
Nichols, Buford L. 289
Nicklas, Theresa 225
Nickle, Melissa 139
Nickols-Richardson, Sharon 228, 251
Nielsen, Forrest H. 89, 263, 265-267, 269, 272, 273
Nixon, President Richard 241, 244, 300
Norris, Karl 94, 143
Novotny, Janet 97, 98, 99, 148
Nutrition Labeling and Education Act of 1990 (NLEA) 141, 153, 252

O

Obama, Michelle 229
Obama, President Barack 213, 229
O'Brien, Ruth 34, 44, 46, 122, 123
O'Dell, Boyd 86
O'Donnell, Rand 331
O'Haver, Tom 145
Olson, Robert 211
Omaye, Stanley 312
O'Neill, Representative Thomas P. "Tip" 300
Onstad, Charles 328
Organic Act of 1862, amended 1977 242
Orr, M.L. 133, 137

P

Pabst, Anna 19
Page, Louise 52, 53, 206, 207
Park, Jae 75, 98
Parloa, Maria 9
Parrish, Thomas 34
Pate, Russell 225
Patterson, Kristine 139
Pawlosky, Robert 147, 148
Pearson, Thomas 228, 251
Pecot, R.K. 133
Pehrsson, Pamela 139, 225
Pekarek, Robert S. 266, 286
Penland, James G. 269, 273, 286, 288
Pepper, Senator Claude 300
Pérez-Escamilla, Rafael 228, 251
Perloff, Betty 137, 157
Perry, Michèle M. 317
Peterkin, Betty 213
Phillips, Kathryn 142
Phipard, Esther 27, 50, 52, 53, 56, 206, 207
Picklo, Matthew J. 273, 274, 286, 287
Pi-Sunyer, F. Xavier 225, 228, 251
Pixley, Lt. General Charles 305
Polansky, Marilyn 101, 132
Pomeroy, Representative Earl 268, 274
Porter, Donna 299
Posati, Linda 137
Prior, Ron 150
Pryor, Senator David 331
Pryor, Senator Mark 331
Public Law (PL) 480 of 1954 100, 254

R

Raatz, Susan K. 273, 286
Rachel, Leo 317
Rattay, Karyl 225
Reagan, President Ronald 247
Reed, Debra 223
Reeds, Peter 100
Reeves, James 137
Reeves, Philip G. 269, 273, 286
Reiser, Sheldon 67, 81, 90, 91, 255
Research and Marketing Act of 1946 2, 264
Reynolds, Robert 92, 100
Richards, Ellen 17
Richardson, Martha 137
Richmond, Surgeon General Julius 210
Rimm, Eric 228, 251
Ritchko, Sue Ann 125, 139
Rizek, Robert 68, 70, 124, 125, 134, 136, 139, 140, 156, 244, 246
Robbins, Rebecca 148
Roberts, Lydia 33, 34
Roemmich, James N. 273, 274, 286
Roosevelt, President Franklin D. 23, 33, 34, 173, 204, 240
Rose, Mary Schwartz 20
Rose, W.C. 78
Roseland, Janet 156
Rosenberg, Irwin 223, 299, 302
Rosenthal, Representative Benjamin 58
Ross, Representative Mike 331
Roughead, Fariba 269, 273, 286
Rumpler, William 93, 186
Russell, L. Faye 145
Russell, Robert 302

S

Saari, Jack T. 269, 273, 286
Salans, Lester 211
Sandstead, Harold H. 243, 265-267, 276, 286-290, 300, 302
Sauberlich, Howerde 247, 304, 306-308
Schaefer, Arnold 241, 304
Schaeffer, Monica 314
Schafer, Ed 266
Schlossberg, Ken 300
Schmidt, Claude H. 257
Schnakenberg, David 320
Schneeman, Barbara 213, 223, 245, 256, 311

- Schoene, Norberta 82, 84, 99
Scholfield, Daniel 82
Schwarz, Klaus 72, 86, 89
Schweigert, Bernard 211
Schwenk, Frankie 74, 245, 254
Scott, Milton 257
Scrimshaw, Nevin 154
Seale, James 93, 94
Sebelius, Secretary Kathleen 228
Sebrell, W. Henry, Jr. 31, 50, 52
Senate Select Committee on Nutrition and Related Needs 2, 241
Sendstrom, Marvin 48
Senti, Fred 68, 123, 243
Shalala, Secretary Donna 223, 224
Sharp, Paul 54
Shaw, Anne 223, 224
Sherman, Henry C. 20, 28, 36, 37, 86, 122, 131, 243
Showell, Bethany 139
Shuman, Clyde B. 21
Sims, Laura 125, 138
Skala, James 306, 307, 312
Slavin, Joanne 228, 251
Slover, H.T. 132, 140, 141
Smith, Allen 99
Smith, James C., Jr. 72, 86, 89, 90, 91, 95, 96, 100, 101, 102, 157, 239
Smith, Margaret Cammaek 28
Smith, Sybil L. 28, 29, 30
Smith-Lever Act of 1914 201
Smithson, James 1
Snyder, Dan 223
Snyder, Representative Vic 331
Solano-Aguilar, Gloria 99
Souders, Helen 52, 157
Southgate, David 154
Spence, Joseph 70, 71, 74, 75, 101, 126, 127, 245, 256, 257, 259
Spivey-Fox, Mattie R. 257
St. Jeor, Sachiko 223
Stampfer, Meir 224
Stanley, Louise 15, 16, 17, 18, 19, 20, 24, 25, 26, 35, 36, 101, 122, 123, 131, 243
Stare, Fredrick 211
Stephensen, Charles 307, 311
Stern, Judith 211
Stetka, Jill 259
Stewart, Jean 137
Stewart, Kent 72, 79, 93, 124, 140, 141, 142, 154
Stiebeling, Hazel 20, 21, 22, 23, 24, 26, 27, 31, 32, 33, 36, 37, 38, 39, 42, 43, 44, 46, 47, 50, 51, 54, 55, 56, 57, 58, 64, 101, 122, 123, 156, 201, 204, 243, 244
Stokes, Andrea C. 326
Sullivan, Secretary Louis 213
Suttie, John 223
Swan, Patricia B. 3, 6
Sweeney, James 85, 95, 132
Swendseid, Marion 305
Szepesi, Bela 80
- T**
- Texas Children's Hospital 289, 291
Thomas, Robin 139, 156
Thompson, Raymond (Rick) 141
Thompson, Secretary Tommy 225
Thornton, Representative Ray 331
Tinker, Lesley 224
Tippett, Katherine S. 191
Todhunter, E. Neige 34, 55
Toepfer, E.W. 86, 123, 132, 134
Trainer, Denise 139
Trout, David 80
Trowbridge, P.F. 18
Trowell, Hugh 81
True, Alfred C. 7, 8, 10
Truman, President Harry S. 44, 206
Tucker, Donald M. 266, 269, 286, 287
Tufts University 267, 290, 299
Turnlund, Judith 310
- U**
- Underwood, Eric 256
United Tribes Technical College 274
University of Arizona 274
University of Arkansas for Medical Sciences 326
University of California at Davis 317
University of North Dakota 263, 264, 266, 269
Urban, Joseph 71, 74, 99
Uthus, Eric O. 269, 286, 287

V

Vallee, Bert 265
Van Deman, Ruth 38
Van Horn, Linda 228, 251
Van Loan, Marta 311, 315
Vanderslice, Joseph 140, 144, 145, 154
Vaughan, David 67, 78, 93
Vaughn, F.V. 32
Veillon, Claude 87
Veneman, Secretary Ann 225
Vilsack, Secretary Tom 228
Viteri, Fernando 282
Vo-Khactu, Kim P. 266, 286

W

Wallace, Secretary Henry C. 10, 11, 15, 16
Wallwork, James C. 266, 269, 286
Wang, Guangya 154
Wang, Thomas T. 75, 98
Warden, Beverly 97
Waterlow, John 282
Watt, Bernice 41, 42, 52, 124, 133, 134, 137, 156
Weaver, Connie 225
Webb, Paul 92
Weihrauch, John 137
Weinsier, Roland 224
Weir, C. Edith 67, 68, 86, 123, 124, 156, 264
Weir, William 306
Weiss, Gertrude 51, 123
Welsh, Susan 199
West, Clive 154
Weswig, Paul 265
Whigham, Leah 273, 286
White House Conference on Food, Nutrition, and Health, 1969 3, 66, 241
Whiteside, Charles, III 327, 331
Whitten, Senator Jamie 290
Widdowson, Elsie 153
Wilder, Russell 33
Williams, Christine 228, 251
Wilson, President Woodrow 10
Winton, A.L. 131
Winton, K.B. 131
Wolf, Isabel 125, 138, 211, 247
Wolf, Wayne 87, 140, 141, 148, 152, 153, 156, 157, 272
Womack, Madelyn 45, 77, 78, 79, 93, 101

Wong, Noble 93
Woods, Charles D. 8, 131
World Health Organization (WHO) 24, 100, 101, 271, 294
Wright, Representative Jim 291
Wu, W.T. 133

Y

Yan, Lin 273, 286
Yang, Joseph H. 305
Yates, Allison 67, 71, 75, 76, 126, 127
Yeutter, Secretary Clayton 213
Young, Senator Milton R. 66, 241, 243, 255, 268

Z

Zeng, Huawei 269, 286
Ziesel, Steven 150
Zook, E.G. 132
Zunino, Susan 319