

## **Action Plan: National Program 107 – Human Nutrition 2014 – 2019**

**Goal:** National Program (NP) 107, *Human Nutrition*, will improve the nutrition and health of the American people by enhancing the quality of the American diet and improving health through research.

Hallmark aspects of NP 107 research include an emphasis on food-based approaches to improving health, the capacity of six, internationally-recognized Human Nutrition Research Centers with the core capability for long-term, multi-disciplinary, translational research in high priority areas to improve the Nation's health and the availability of premier scientists, state-of-the-science equipment and facilities for human research across the lifecycle. Unique national resources that are part of NP 107 include the National Nutrient Data Laboratory, the Food Surveys Research Group that conducts the What We Eat in America portion of NHANES, and a laboratory that develops and improves methods for food analysis. Partnerships with other federal, non-profit, and industry groups allow ARS to leverage funds and build upon common research goals.

Development of this Action Plan was informed by external review of the last 5 years' work in NP 107 (July 2012), the stakeholder workshop "Enhancing USDA's Contribution to Nutrition Monitoring in the 21st Century" (October 2011) and stakeholder feedback obtained online via the USDA Open website in September and October 2012.

**NP 107 addresses five over-arching components:**

- 1. Linking Agricultural Practices and Beneficial Health Outcomes**
- 2. Monitoring Food Composition and Nutrient Intake of the Nation**
- 3. Scientific Basis for Dietary Guidance**
- 4. Prevention of Obesity and Obesity-Related Diseases**
- 5. Life Stage Nutrition and Metabolism**

**Relationship of this National Program to the ARS and USDA/Research Education and Economics (REE) Strategic Plans:**

NP 107 research supports the following actions from the **ARS Strategic Plan for 2012-2017** under **Strategic Goal 1.1, Human Nutrition:**

**Performance Target 1.1A:** Monitor nutrient composition of the food supply and consumption by Americans.

**Performance Target 1.1B:** Strengthen the scientific basis for dietary guidance for health promotion and disease prevention.

**Performance Target 1.1C:** Develop strategies for prevention of obesity and related diseases.

**Performance Target 1.1D:** Conduct research on life stage nutrition and metabolism.

The **REE Action Plan Goal 4** entitled **Nutrition and Childhood Obesity** highlights these four aims:

- 1.** Link food systems to beneficial human health outcomes in the U.S. and internationally.
- 2.** Conduct nutrition monitoring of the American population and evaluate policies influencing nutritional health.
- 3.** Build the scientific basis for dietary guidance for health promotion and disease prevention across the life cycle.
- 4.** Develop and extend approaches to prevent obesity and related diseases, including translational activities to promote behavior change related to healthy eating and physical activity.

## **Component 1: Linking Agricultural Practices and Beneficial Health Outcomes**

The food in our diets is a product of agriculture; to this end agriculture is the basis for our nutritional status and nutritionally-related health status. Agricultural policies, decisions, and procedures determine the types and amount of foods available to the public; agricultural practices also may enhance the nutritional content and appeal of those foods. There is an urgent need to identify those agricultural practices/decisions that can promote optimal human nutrition and health. Within the ARS, cooperation between national programs in human nutrition and those oriented towards agricultural production provides the synergy to develop sustainable methods of producing foods that will contribute to optimal public health.

### **Problem Statement 1A. Determine Agricultural Practices that Influence the Nutritional Status of Americans**

Agricultural decisions may function as either facilitators or barriers to the consumption of healthy diets. Healthy diets depend on the selection of foods dense in nutrients and other health-promoting compounds. Agriculture may facilitate better nutrition and health by influencing food selection and/or by modifying the chemical composition of those foods. Food selection is determined in part by availability which is determined by broad agricultural policy as well as production decisions. Additionally, food selection may be influenced by quality which is determined by breeding and production management. The healthfulness of individual foods may be modified by agricultural decisions (breeding, environmental and production conditions, post-harvest practices) that affect the density of beneficial nutrients and bioactive components. Human nutritionists need to work in conjunction with agricultural scientists to determine agricultural decisions that lead to meaningful impacts on human health. Information generated by these studies is needed to develop public, private and scientific direction that will continue to optimize the healthfulness of our food supply.

### **Research Needs**

We need to identify nutritionally-related barriers to health that can be ameliorated by changing agricultural practices. Practices that may alter the availability/acceptability of foods, and therefore influence diet selection and quality, need to be identified and measured. Food production practices, including breeding, management and post-harvest activities, may alter food composition; the effects of these practices on food composition need to be quantified to determine if they have any effects on human health. Other practices may change the chemical composition of a food or alter the bioavailability of specific components. There is a need to determine whether these changes result in altered human body stores and/or changes in physiologic variables. In vitro and animal studies may be used to suggest effects and develop hypotheses. When possible, human studies are needed to establish proof of a meaningful effect on human nutrition and disease prevention endpoints. Research may be facilitated by collaboration with animal, plant, and food scientists.

### **Anticipated Products**

- Identification of agricultural decisions that make a meaningful difference in consumer acceptability and dietary choices.
- New information about the effects of agricultural production, post-harvest practices and environmental conditions on human nutrition and health status that can be used to make public, private, and scientific policy/decisions that improve the healthfulness of the nation's food supply.
- Information regarding the production, accumulation and bioavailability of nutrients and bioactive components, and how agricultural decisions may modify these attributes in a manner that affects human health.

- Information regarding how agricultural/post-harvest factors may impact nutritional status of humans.

### **Potential Benefits**

- Improved health resulting from increased consumption of fruits, vegetables, and other currently under-consumed food groups that are recommended in the *Dietary Guidelines for Americans*.
- Enhanced means of food production yielding foods with improved taste, nutritional value, and/or quality to drive consumer demand.
- Optimization of agricultural products and practices for nutritional and health-promoting value.

## **Component 2: Monitoring Food Composition and Nutrient Intake of the Nation**

Monitoring food composition and nutrient intake of Americans is foundational for promulgating public policy, developing dietary guidance, conducting nutrition research and making decisions regarding food production. The food choices Americans make are dynamic and reflect an ever-changing U.S. food supply and population, and vigilance, adaptability, and sophistication are needed to stay at the forefront of this endeavor.

### **Problem Statement 2A: Provide U.S. Food Composition Data**

Foundational to characterizing the nutritional intake of Americans is knowledge of the composition of the foods they eat; this has been a function of the USDA since the nineteenth century. The U.S. food supply is fluid and the task of providing timely and accurate food composition data is made complex by constant change in food regulations and policy, food choices and consumer preferences, food production and processing methods that induce compositional variability, and demographic changes in the American population. Data must also reflect increased research and consumer interest in components of foods that either positively or negatively affect health. Continued development of state-of-the-art analytical techniques is essential to providing accurate and reliable data.

### **Research Needs**

Food composition datasets must contain accurate and timely information for essential nutrients, non-nutritive bioactive compounds, components of concern such as *trans*-fatty acids and dietary supplements. There is a need for increased data for packaged foods and data that address the potential problem of component variability. Databases must use appropriate, standardized approaches for data acquisition, evaluation, compilation, and dissemination. There is a need for new approaches to acquiring, storing, and retrieving data as well as disseminating results. Public and private partnerships are essential for acquisition of new data and expansion/updating of legacy data. Development of state-of-the-art analytical methods is often a pre-requisite to acquiring additional data.

### **Anticipated Products**

- Food composition data that accurately reflect the extent and fluidity of the U.S. food supply.
- User-friendly, current, and accurate databases of essential nutrients, health-promoting components of foods, and dietary supplements consumed by Americans.
- New approaches to database architecture that allow for novel means of acquiring data, storage of very large data sets and retrieval of data in multiple formats.
- Data that can be used by the scientific community and federal regulatory and action agencies to generate relationships between food components and health outcomes.

- New and improved analytical methods for food constituents, essential nutrients and health-promoting compounds in whole foods.

### **Potential Benefits**

- An expansive, up-to-date knowledge of food and supplement composition that responds to the dynamic nature of the food supply is essential for illuminating the underpinnings of diet to maintain good health and prevent disease.
- The information derived will be used for formulating policy, informing regulatory agencies and consumers, designing food and nutrition-based interventions by health professionals, and directing future research needs for the agricultural industry, academic researchers, and government scientists.

### **Problem Statement 2B: Determine Food Consumption and Dietary Patterns of Americans**

“What We Eat in America (WWEIA), NHANES,” conducted in partnership with the Department of Health and Human Service’s National Center for Health Statistics, is the only nationally representative American dietary survey. The resulting data are used by a broad array of national and international government agencies, food industries and researchers for development of public policy and dietary guidance, guiding food product development and assessment, and for scientific research. ARS will continue to collect, disseminate, and evaluate the nutritional data. However, changing demographics and consumer choices, as well as new uses of, and demands for, data make it essential that ARS adapt new and improved methodologies and technologies for data collection, processing, quality control and dissemination.

### **Research Needs**

Because these data are critical to public policy and health assessment of Americans, the collection, analysis, and release of accurate and high quality data must occur on a timely basis; there is potential for improved means of data collection and faster analysis and dissemination of the data. Changing demographics and eating habits (such as increased use of dietary supplements) require expansion of the type and amount of data collected, and changes in the use of data may require changes in format and delivery.

### **Anticipated Products**

- Biennial release of nationally representative data on the food, nutrient and dietary supplement intake of Americans.
- Enhanced dietary assessment methods that improve the study of diet and health relationships.
- Increased knowledge of the nutrition of Americans in population subgroups.

### **Potential Benefits**

- Information from the dietary survey will be used for multiple purposes including developing national nutritional policy and guidelines, conducting nutritional epidemiology studies, providing foundational data for food and nutrition-based interventions, informing the food/agricultural industry and directing future research needs.

### **Component 3: Scientific Basis for Dietary Guidance**

Dietary Reference Intake values for individual nutrients and the *Dietary Guidelines for Americans* form the basis for federal, state, and local food and nutrition policies. These are used by researchers, health professionals, the food industry, and individual Americans. Strong scientific evidence is needed to provide accurate dietary guidance. Generating this evidence is challenging due to changes in the demographics of the U.S. population, changes in the food supply, changes in how and where food is prepared and consumed, inter-individual variability in responses to dietary differences, and environmental influences. This work is also challenged by publication of sometimes contradictory data regarding specific foods, micro/macronutrients, and disease prevention. ARS scientists will utilize population-based and clinical studies to provide evidence for dietary guidance and will utilize animal and cellular studies to examine specific mechanisms.

#### **Problem Statement 3A: Improve the Scientific Basis for Updating National Dietary Standards and Guidelines**

Our understanding of the physiologic processes underlying healthy development and aging and the prevention of disease is constantly expanding. We are faced with the need to accumulate new information relating how diets, foods, and bioactive food components, and physical activity influence these processes. There is increasing appreciation of individual genetic and epigenetic differences that influence how dietary intake and physical activity affect health.

#### **Research Needs**

More scientific evidence is needed to serve as the foundation for dietary recommendations as they relate to specific life stages, particularly for young children (birth to 24 months) and older adults (> 70 yrs). Researchers will evaluate the quantitative needs for bioactive food components and physical activity, the inter-individual variability in those needs, and how those needs change from birth to older age. Validated health biomarkers will be identified to address personalized needs for specific foods and components based on genetic profiles, ethnicity, lifestyle, and physical environment.

#### **Anticipated Products**

- Scientific basis for improving estimates of requirements and safe intake ranges of nutrients and other bioactive food components.
- Accurate estimates of inter-individual variation in nutrient and activity requirements, including the genetic and environmental foundations for such variation.
- More complete data on nutrient adequacy in specific population groups.
- Validated biomarkers for health outcome responses to dietary intake and physical activity.

#### **Potential Benefits**

- Enhanced evidence will lead to more accurate recommendations for diet and physical activity for maintenance of health and improved quality of life. These data will inform the *Dietary Reference Intakes* and the *Dietary Guidelines for Americans*. This information will also be used by the food industry, dietary professionals, health care professionals, and individual Americans.
- The development of more accurate information regarding nutrient needs, activity patterns, and consumer behavior of specific population groups and individuals, will allow policymakers to develop improved food and nutrition policies and programs, such as the *Dietary Guidelines for Americans*, *MyPlate*, and USDA food assistance programs, including the Supplemental Nutrition Assistance

Program (SNAP) and the Special Supplemental Nutrition Program for Women, Infants, and Children (WIC).

### **Problem Statement 3B: Identify Roles of Food, Food Components and Physical Activity in Promoting Health and Preventing Disease**

Diet-related chronic diseases such as type 2 diabetes, cardiovascular disease, osteoporosis, and cancer are major public health concerns in the United States. Population-based research links dietary patterns, the intakes of specific nutrients or other food components and physical activity with health maintenance and decreased risk of disease. However, rigorously-designed evaluations of the relationships and analysis of the physiologic processes underlying these effects are often lacking or are equivocal. Advances in technology have created new tools and opportunities that afford scientists a hitherto unprecedented ability to discern the mechanisms by which these factors promote health and prevent disease. Recently discovered physiologic relationships such as host-gut microbiome interactions or inter-organ microRNA-based signaling provide ARS scientists with potentially fruitful, high-impact lines of research.

#### **Research Needs**

Researchers will elucidate how foods and health-promoting bioactive food components, along with physical activity, affect metabolic and physiologic factors related to quality of life and longevity. This work will determine factors such as bioavailability and metabolism that influence the efficacy of nutrients and other food components. How these factors change as a result of physiologic state (e.g., pregnancy, aging and obesity) and are influenced by genotype and other environmental factors will be determined. ARS scientists will develop and utilize innovative tools for assessing impacts on molecular, cellular, and physiologic mechanisms.

#### **Anticipated Products**

- Improved knowledge of the mechanisms whereby foods, food components, and physical activity alter physiological function and promote health.
- Determination of how physiologic states modify these mechanisms.
- Measurement of bioavailability and metabolism of nutrients and food components and identification of factors that modulate these processes in the body.
- Demonstration through human studies that lifestyle factors improve health outcomes.

#### **Potential Benefits**

- Improved understanding of how foods, food components, and physical activity support health and reduce disease risk will lead to nutrition policies and government programs promoting better health outcomes.
- Knowledge of the relationships among nutrition, physical activity, and health will lead to better estimates of the requirements and recommendations for levels of optimal dietary intake and activity, and provide greater understanding of how to tailor recommendations to promote adherence to the *Dietary Guidelines for Americans*.

### **Component 4. Prevention of Obesity and Obesity-Related Diseases**

The high prevalence of obesity in the American population has major economic, social, and public health consequences. Because obesity is an underlying cause of many disorders, including cardiovascular disease, type 2 diabetes, nonalcoholic fatty liver disease, and several cancers, its increase fuels escalation

of health care costs. Diabetes alone costs > \$170 billion dollars annually in the U.S. A prevalence of obesity above the national average is found in higher risk groups including African-Americans, Hispanic-Americans, and nightshift workers. Because reduction of excess body weight is difficult to achieve and even harder to sustain, experts are increasingly aware of the critical need for effective, proven methods for the primary prevention of weight gain, particularly in children.

#### **Problem Statement 4A: Understand the Causes and Effects of Obesity and Obesity-Related Disorders**

The rise in obesity is the result of multiple factors, all with different degrees of impact. These factors include dietary, biological, behavioral, economic, and environmental. There is a need to further investigate the causal factors for obesity and sequelae such as heart disease and diabetes so that effective diet-, activity-, and science-based policy solutions to these problems may be developed.

#### **Research Needs**

Clearer understanding is needed of the integrated roles of physical activity, diet and dietary components in energy metabolism, eating behavior and timing, satiety, and health outcomes. We will employ innovative methods to explore physiologic mechanisms and genotypic influences that underlie obesity and its consequences. There is need to understand the impacts of obesity in an aging population with respect to development of neurological deficit, muscle loss, and bone loss. Other studies will investigate the mechanisms by which obesity negatively alters the metabolism and bioavailability of nutrients and other bioactives. Studies performed in animals and in cell culture will elucidate the role of specific processes that contribute to the development of obesity and obesity-related disorders.

#### **Anticipated Products**

- Identification of factors that sway eating behaviors, food choice, physical activity, and adherence to the *Dietary Guidelines for Americans*. This work includes recognition of dietary and biological contributors that influence eating behavior and satiety.
- Elucidation of the biological mechanisms underlying changes in energy metabolism, and the development and consequences of obesity and related disorders, including the role of food and food components, aging, gene-diet interactions, gut-derived signaling, neuroendocrine and metabolic pathways, inflammation, and microbial environment.
- Novel tools, methodologies, and applications for monitoring and modeling biological and behavioral responses, including the development of genomic and metabolomic biomarkers.
- New approaches to minimizing adverse effects of obesity and maximizing benefits of maintaining weight loss.

#### **Potential Benefits**

- Through increased knowledge of the integrated relationships that lead to obesity and its related diseases, it will be possible to design effective preventive strategies for Americans and provide more accurate dietary and health advice.
- Greater understanding of social and environmental influences will provide a firmer foundation for public policy and public health efforts at the federal, state, and local level to reduce obesity and related health problems in the U.S.

## **Problem Statement 4B: Develop and Evaluate Strategies to Prevent Obesity and Obesity-Related Diseases**

Greater efforts must be made that address individual variation in maintaining a healthy weight, achieving a healthy body weight, and preventing the development of obesity and its related diseases. To date, most interventions have generally not been effective or sustainable. Researchers must develop a better understanding of the social, environmental, and cultural processes that guide people to adopt and sustain healthful food choices, eating behaviors, and physical activity patterns such as those recommended in the *Dietary Guidelines for Americans*. Since maintaining healthy body weight and composition may not be possible for some people, dietary and activity-based measures are needed to prevent development of obesity-related diseases.

### **Research Needs**

ARS research will identify and evaluate methods of promoting change in diverse populations. There is a need for research on single and multi-component interventions to identify effective methods of change for healthier lifestyles. Scientists will develop a greater knowledge base of how obesity prevention solutions are influenced by socio-demographic, environmental, economic, psychological, and biological factors. Well-designed, controlled intervention studies are needed to define dietary and activity-based influences on energy metabolism. Personalized solutions for prevention of obesity-related diseases are also needed. Preclinical studies will identify and validate mechanisms of how foods and food components may prevent or alleviate obesity and its consequences. These data will provide the bases for solutions to mitigate obesity.

### **Anticipated Products**

- Recognition of how demographic, social, environmental, economic, behavioral and biological factors can be used to achieve and sustain a healthy body weight.
- Proven, effective, and sustainable methods for engaging social, community, and individual change to prevent obesity, including use of all forms of technology.
- Innovative and valid methods for better measures of food choices and intake, physical activity and related variables.
- Identification of foods and food components and their mechanisms of action in preventing obesity and its subsequent negative health outcomes.

### **Potential Benefits**

- Development of accurate measures of eating behaviors and physical activity in addition to generation of solutions for promoting change in these variables will allow policy makers to allocate and leverage resources effectively to reduce the obesity epidemic in diverse groups in the U.S.
- Enhanced understanding and accurate assessment of how foods, food components, the timing and amount of food intake and physical activity influence obesity prevention will be used by other federal agencies and for informing the *Dietary Guidelines for Americans*, and increasing compliance with these guidelines.
- Novel technologies and applications will provide innovative ways for the private sector to help prevent obesity through the development of new products that promote healthier food choices, food consumption patterns, and physical activity habits.
- Successful intervention strategies will enable individuals, families, and communities to sustain healthy behaviors, prevent obesity and its subsequent diseases in diverse groups, and reduce health care costs in the U.S.

## **Component 5. Life Stage Nutrition and Metabolism**

Three of the six ARS Human Nutrition Research Centers have Congressionally-mandated missions to focus their work on specific portions of life, namely pregnant and lactating women, children, and the elderly. In addition to determining nutrient and physical activity requirements for these groups, enhanced understanding of metabolic processes in early and late life that differ from usually studied young adults is essential to develop more relevant recommendations, government policies and programs, and to contain health care costs. One aspect of this is the concept of “nutritional programming” that occurs during periods of development and can result in long term alterations of gene expression and future changes such as the slow loss of muscle mass among the elderly that leads to reduced calorie needs, frailty, and higher medical costs.

### **Problem Statement 5A: Identify Dietary and Related Lifestyle Impacts for Healthy Development and Function from Conception to Old Age**

Food and its components are essential to the fundamental processes of healthy development and aging. There are multiple gaps in our knowledge of those relationships in humans. These gaps limit the ability to make authoritative recommendations for nutrient requirements, dietary composition and patterns, and lifestyles that lead to health. With expansion of the aged population in the U.S., there is greater demand for characterizing diet and lifestyle requirements that help maintain health and life quality. Other data are essential to define the mechanisms by which foods and food components regulate metabolism, development, growth, and senescence. In many cases, identifying specific mechanisms requires use of animal and cell culture models and it is important that appropriate models are utilized.

### **Research Needs**

ARS will discover the mechanisms by which maternal, antenatal, and postnatal health outcomes are influenced by maternal nutrition and lifestyle. We will investigate the fundamental mechanisms by which food components and physical activity influence growth, neurological development, and aging and how dietary requirements change throughout the life cycle. Studies will be performed in humans as well as in animal and cell culture models. The development of new models will assist with the discovery of the sites of action of bioactive food components. Given the increased prevalence of obesity among all age groups, there is a need to define changes in energy metabolism that occur throughout life and how energy intake alters developmental and aging outcomes. There is a need for solutions to prevent age-related declines in cognitive ability, cardiovascular function, bone health, muscle strength, and physical activity, among others.

### **Anticipated Products**

- Accurate assessments of dietary, genetic, and lifestyle influences upon maternal/child outcomes.
- Development of dietary and activity-based methods to improve cognition, cardiovascular risk factors, bone health, and muscle strength in older Americans.
- Increased insight on mechanisms by which diet, nutrition, and physical activity influence cellular function, physiology and metabolism, behavior, and health of individuals at different life stages.
- Development/refinement of tools and models to investigate changes in metabolic status at all stages of the lifespan, including growth, development, and aging, and how these affect nutrient requirements.
- Longitudinal data on normal development and aging in the context of diet, nutrient intake, and health outcomes.

## **Potential Benefits**

- The results of this research will provide the understanding required to adopt evidence-based recommendations for individuals at all ages, so they can better adapt to the metabolic and physiologic changes that occur throughout the lifespan and enjoy improved health.
- Data generated by ARS scientists will be used to inform the Dietary Reference Intakes, *Dietary Guidelines for Americans*, and to form the basis for recommendations from health professionals and policy makers.

## **Problem Statement 5B: Identify Determinants and Consequences of Nutritional Status, Diet and Body Composition on Metabolic Programming**

Mammalian development proceeds via a specific series of irreversible steps from conception to adulthood that affects body structures, functions, and gene expression patterns. The irreversible nature of biological development involves diverse “critical windows,” developmental periods during which specific milestones must be achieved to lay the groundwork for subsequent steps. While it is clear that diet has a fundamental role in these developmental processes, there are relatively few data on the nutritional requirements and/or the mechanisms through which foods and food components function during these critical windows. Research on nutritional programming will lead to dietary recommendations during periods of development in order to optimize short- and long-term health.

## **Research Needs**

Improved knowledge of mammalian development and the specific mechanisms by which nutrients affect these processes is necessary to develop nutritional interventions and strategies to enhance health over life’s stages. We will investigate mechanisms regulating developmental alterations in cell number, intercellular signaling, tissue remodeling, and epigenetic regulation. Researchers also need to identify the critical windows during which nutritional deficiency and adequacy induce long term or permanent changes in mammalian structure, function, and gene expression, as well as the specific nutrients and food components that affect developmental outcomes. There is a need to determine the extent to which nutritional programming influences physiologic processes that modulate chronic disease risk throughout the lifespan. Researchers will elucidate the complex relationship between maternal nutrition and nutrition of the fetus and infant. More data are needed to understand the relationship of nutritional programming as it relates to obesity development in children and adults. Human biomarkers need to be identified that can serve as indicators of nutritional exposures and nutritional programming during critical developmental periods.

## **Anticipated Products**

- More accurate information about the fundamental mechanisms responsible for long-term development and molecular regulation of organ structure, function, and metabolism, and an improved understanding of how specific nutrients and other food components induce permanent changes in these processes.
- Enhanced knowledge of the critical periods of development during which targeted nutritional and physical activity interventions are most likely to have long-term health benefits on development, growth, obesity, and non-communicable diseases.

## **Potential Benefits**

- More complete understanding of specific mechanisms, critical developmental periods, nutrients, and food components important to nutritional programming will enable the development of nutritional interventions and strategies that promote physical and cognitive health and well-being throughout the lifespan.
- New insights into dietary strategies for the prevention of obesity and reduction of diseases such as heart disease, cancer, bone disorders, and type 2 diabetes.