Variability in Responses to Diet and Food

A top priority for future nutrition research is the need to better understand variability in metabolic responses to diet and food. All individuals have varying responses to diet and food components and their impact on overall health. Findings in variability will lead to advances in personalized nutrition and will better inform public health and food policy, such as Dietary Reference Intakes for nutrients and recommendations for bioactives. Research in the following areas is necessary to determine the origins and components of variability, and to explain similar responses to diet and food components by subpopulations, such as ethnic and racial minorities:

### Omics

Omics research, such as nutrigenomics (e.g. nutrigenetics, epigenetics, transcriptomics), proteomics and metabolomics, will help to determine how specific nutrients interact with genes, proteins and metabolites to predict an individual’s health. Omics provides information on individualized nutrient requirements, including how nutrients are digested, absorbed, and metabolized- and their functions in the body. Omics will help to determine and reflect an individual’s nutritional status and will aid in the creation of new nutritional and disease biomarkers.

### Microbiome

Diverse microbes, such as bacteria and viruses, live in and on each person’s body and make up their microbiome, which is estimated to have 10 times as many cells as the body itself. Microbes vary from person to person, making each individual’s microbiome unique—although certain subpopulations may have similar microbiome characteristics. Research is needed to determine the microbiome’s role in varying metabolic responses to diet and food components and in disease prevention and progression. Conversely, research is also needed to show how the microbiome is influenced by diet and the environment.

### Imprinting

Imprinting research examines how exposures to dietary components during critical periods of development “program” and contribute to an individual’s long-term health and well-being. Research is needed to determine how early nutritional events contribute to disease later in life and alter an individuals’ normal developmental progression.

### Biological Networks

Research is needed to provide a better understanding of biological networks, such as an individuals’ genome (DNA and RNA make-up), and how these networks impact metabolic responses to diet and food. Environmental interactions, including nutrients and other dietary components, bacteria, viruses and chemical contaminants, all may impact how an individual’s biological networks respond to diet and food.

### Tissue Specificity and Temporality

Research is needed to describe how dietary factors impact variability in human development and functioning, including when in the life cycle and in which tissues dietary factors have the most impact.
The Impact of Nutrition on Healthy Growth, Development, and Reproduction

**Epigenetics/Imprinting**

Epigenetics and imprinting research examine how exposures to dietary components during critical periods of development “program” an individual’s long-term health and wellbeing. For example, animal studies show that adequate consumption of choline, an essential B vitamin, during pregnancy may positively impact a baby’s brain development and memory capacity and provide resistance to cardiovascular disease and certain cancers in later life. Research is needed to determine how other early nutritional events contribute to disease later in life and alter an individual’s normal developmental progression.

**Childhood Nutrition**

Research is necessary to better understand the role of diet and individual food components on normal growth and development. This includes the role of both parent’s pre-conception diets, the mother’s diet during pregnancy, and the child’s early nutritional events. Studies indicate that the timing of an infant’s introduction to solid foods may increase the likelihood of that child becoming obese later in life. The number of overweight children in the U.S. has increased dramatically in recent years, and excess calorie intake, increased portion size, and steady decline in physical activity are all, in part, responsible. Research is now needed to determine how best to influence these factors in early life. The important role of nutrition throughout childhood on normal growth and development, as well as health and well-being, must be continually assessed.

**Nutrition and Reproductive Health**

The impact of nutrition on reproductive health, including pre- and post-conception, requires further research. Nutrition has a direct impact on both male and female fertility and the ability to conceive, and also plays a key role in preventing diseases related to reproductive organs, such as prostate and ovarian cancers. For example, some evidence suggests that cancers of the prostate, breast, and cervix may be prevented by lycopene intake throughout adulthood. Lycopene is a carotenoid, which provides red pigment in various fruits and vegetables, and acts as an antioxidant to fight free radicals in the body.
The Role of Nutrition in Health Maintenance

Health maintenance includes non-communicable disease prevention and treatment, as well as weight management. The role that food components, particularly novel ingredients, play in health maintenance requires further research. Researchers and the public rely on Dietary Reference Intakes (DRIs) to guide dietary decisions and public health policy. Research is needed to better define the DRIs that best support health maintenance in all population subgroups, from infants to the elderly. Nutrition across the life cycle is a fundamental issue that requires investigation so that nutrient recommendations will “match” with true physiological needs.

**Optimal Bodily Function**

Research is needed to determine the roles that nutrition and fitness, both singularly and together, play in maintaining bodily functions, including cognitive, immune, skeletal, muscular, and other functions. Evolving research areas include prevention of disease-related processes, such as inflammation. An emerging and extremely important area is the relationship of diet and the microbiota that inhabit the intestine and are necessary for optimal health. The human microbiota needs to be better defined, and changes due to diet, age, physiological state, and disease, determined. Animal models are also important in defining mechanisms, and in understanding the requirements for optimal health of production animals.

**Achieving Energy Balance**

Research is also needed to examine the use of a systems approach to achieve energy balance including and integrating environmental, biological, psycho-social, and food system factors. A systems approach is preferable since the standard experimental approach of varying one factor at a time has done little to address the population-wide problem of energy imbalance. A solution-oriented approach that is comprehensive in nature and takes into account the complexities of achieving energy balance must be created. “Shape Up Somerville, MA,” effectively reduced weight gain in high-risk children through a multifaceted community-based environmental change campaign. Shape Up Somerville increased the entire community’s physical activity and healthful eating through physical infrastructure improvements and city-wide policy and programming changes.
The Role of Nutrition in Medical Management

The rapid translation of nutrition research advances into evidence-based practice and policy is a priority for ensuring optimal patient care and effective disease management. Nutrition researchers play a key role in bridging the gap between disease prevention and disease treatment by fostering clinical research, providing innovative education for caregivers and patients, and delineating best practices for medical nutrition in primary care settings.

Disease Progression and Prevention

To improve the medical management of disease, research is needed to determine how nutritional factors influence both disease initiation and progression, as well as how nutrition affects a patient’s response to therapy. Genetic variations among individuals can result in both positive and negative responses to diets, to specific foods and to novel food components. Two exciting new scientific fields, “nutrigenetics” and “nutrigenomics,” are advancing a basic understanding of an individual person’s unique response to nutritional factors, and these will lead to “personalized nutrition” for disease prevention and treatment. Nutrigenetics studies the effect of genetic variations on complex nutrient-gene-environment interactions, while nutrigenomics includes studies on the effect of nutritional factors on gene expression (transcriptomics) and thus, on a person’s present and future health status.

Research will allow us to better understand and minimize unfavorable impacts of both reduced and elevated nutrient intakes on disease progression and overall health. Disease/mortality response curves are U-shaped for many nutrients (that is, there is an increased risk of adverse outcomes if the nutrient is ingested in either too low or too high amounts). The importance of achieving a proper nutrient balance is seen in the example of chronic inflammation. Chronic inflammation contributes to many chronic illnesses and can result from high intakes of pro-inflammatory omega-6 fatty acids in the face of low intakes of anti-inflammatory omega-3 fatty acids. Research will help to determine the desired intake for essential and non-essential nutrients alone and when combined with other nutrients in the diet.

Nutrition Support for Special Subgroups

Nutrition research is needed to establish the required nutritional needs that best support survival, growth, and development in subpopulations, such as in chronically diseased patients, in children and in older adults. With the success of medical advances, as have been seen with in vitro fertilization and neonatal care, caring for pre-term infants presents a new challenge in early nutritional management. Pre-term infants have special nutrition needs that will greatly impact their future growth and development, as well as their eventual health status as adults.
**Nutrition-Related Behaviors**

### Drivers of Food Choice

Understanding the link between behavior and food choices can help tackle obesity and other nutrition-related issues which are of extreme public health importance. Individual food choices can be influenced by a number of different drivers including government policy; environmental cues; cultural differences; and communication tools, such as social networking and food marketing. Research is needed to identify the impact of these various drivers and understand how they work alone or together to influence nutrition-related behavior. Research will show how these drivers should be altered to have the highest positive influence on individual behavior and therefore public health. For example, the state of Mississippi recorded a 13% decline in obesity among elementary school students from 2005 to 2011. Multiple changes in the environment occurred, such as the setting of standards for foods sold in school vending machines, setting a requirement for more school exercise time, mandating healthier environments in childcare settings, and establishing programs for encouraging fruit/vegetable consumption. The challenge now is to determine what effect these combined actions will have on obesity-related behaviors in the long run.

### Nutrition and Brain Functioning

Further explorations of the biochemical and behavioral bases for food choices and intake over time are essential. Brain function as it relates to food desire and choice needs to be clarified through research, and the multiple hormones that impact eating require further study as well. Factors such as meal frequency and size, speed of meal consumption, and how these factors are influenced by social cues require objective data which can only be provided by research. Understanding how the marketing of healthy behaviors could help consumers achieve dietary guidance goals should be a priority. As part of this approach, innovative and practical methods for accurately measuring and evaluating food purchases and eating occasions must be developed.

### Imprinting

Additional research is needed to determine if eating and satiety behaviors are imprinted during critical periods of development, and show how food components affect neural biochemistry and brain functioning - and therefore shape behavior. This research will provide us with a better understanding of how and why an individual makes particular food choices. While scientists recently validated the concept that food availability during pregnancy has permanent effects on gene expression in children, human studies are needed to confirm or refute the hypothesis that fetal programming, resulting from maternal obesity, leads to excess weight in children and into adulthood.
Food Environment and Food Choice

Simply knowing or understanding what constitutes a healthy diet is not enough to change an individual’s diet or lifestyle. Understanding how the food environment affects dietary and lifestyle choices is necessary before effective policies can be instituted that will change a population’s diet in a meaningful way. Examples of key questions that should be addressed include: Is current dietary guidance an effective way of communicating dietary change? Do food assistance programs promote positive dietary patterns or have negative dietary and health consequences? What role does food advertising play in food decision-making? How do farm-to-fork food systems, with an increased emphasis on local agricultural production and consumption, influence dietary patterns and behaviors? Can they be ultimately be used to promote healthy behaviors and improve public health? How can we most effectively measure, monitor, and evaluate dietary change?

Novel Foods and Food Ingredients

Having an affordable, available, sustainable, safe and nutritious food supply is also an important underpinning for making significant changes to a population’s diet and lifestyle. Examples of key research areas to address include: Enhancing our knowledge of the nutrient and phytonutrient content and bioavailability of foods produced, processed, and consumed; and studying how to better align and foster collaboration between nutrition and agricultural production. Can shifting agricultural focus from principally agronomic to include quality factors (such as taste, flavor, and nutritional value) have positive effects on fruit and vegetable consumption? Can we leverage technologies, such as biotechnology and nanotechnology, to develop novel foods and food ingredients that will improve health, both domestically and abroad, and provide credible, tangible functional health benefits?

Public/ Private Partnerships

To tackle these enormous challenges requires the coordinated efforts of public and private partners. The development of public/private partnerships between industry, government, academia, and non-governmental organizations (NGOs) has the potential to advance nutrition research, enabling meaningful changes to be made to American and global diets (e.g., increase fruit and vegetable consumption to match government recommendations). We need to examine successful examples of public/private partnerships which have resulted in improved nutritional status and food security in specific populations.
Tools to Advance Nutrition Research

The following 5 tools are essential for advancing nutrition research to the next level in the 21st century. The development of new, impactful tools will enable researchers to more effectively quantify dietary intake and food waste, and to determine the usefulness of setting nutrition standards, such as Dietary Reference Intakes (DRIs) and the Dietary Guidelines. Without development of these tools, cutting-edge, translatable research in nutrition science will not occur.

Omics

Omics (especially genomics, proteomics and metabolomics) will enable us to determine how specific nutrients interact with genes, proteins and metabolites to predict the future health of an individual. Sometimes referred to as personalized nutrition, omics hold the keys to major nutrition breakthroughs in chronic disease and obesity prevention. Omics provide information on how well nutrients are digested, absorbed, metabolized and utilized by an individual. Moreover, omics will lead to new biomarkers that reveal both a person’s nutritional status and health status.

Bioinformatics

Bioinformatics is an interdisciplinary field that utilizes computer science and information technology to develop and enhance techniques to make it easier to acquire, store, organize, retrieve, and use biological data. Bioinformatics will enable nutrition researchers to more efficiently manage, analyze and understand nutrition data, and make connections between diet and health that were not previously possible. Databases are necessary to gain the full benefits of bioinformatics, as they make nutrition data easily accessible in a machine-readable format.

Databases

Food and nutrient databases are essential to track and observe trends related to the nutrition and health of individuals. Databases link food and supplement composition and intake data to health outcomes. Nutrient databases should be expanded to cover more foods and their bioactive components, including non-essential nutrients. Nutrition data must also be incorporated into databases related to novel research areas, such as nutrigenomics and the microbiome, to adequately link these areas with nutrition. Data collection must be improved with enhancements such as photographic food intake documentation; direct upload of food composition and sensory characteristics (if not proprietary) from food manufacturers; and biological sample collection.

Biomarkers

Intake, effect and exposure biomarkers allow us to determine and monitor the health and nutritional status of individuals and subpopulations, such as ethnic and racial minorities. Biological markers that are responsive to diet and nutrition will help assess disease progression and variability in response to treatment, while improving early diagnosis and prevention. Biomarkers must continue to be developed and verified to accurately track food and nutrient intake given our rapidly changing food supply.

Cost effectiveness analysis

Cost effectiveness analysis is a tool used to calculate and compare the relative costs and benefits of nutrition research interventions. Cost effectiveness analysis helps to determine the most cost effective option that will have the greatest benefit to public health.