FY 2018 Annual Report for National Program 107 Human Nutrition

The Human Nutrition National Program (NP 107) addresses high-priority problems of national importance as outlined in Strategic Goal Area 1 of the ARS Strategic Plan for FY 2012-2017: Improve the Nation's Nutrition and Health. Specifically, this program contributes to Objective 1.1: Enable Americans to make health-promoting, science-based dietary choices. The mission of NP 107 is to define the role of food and its components in maintaining health throughout the life cycle. The vision of the program is that well-nourished Americans make health-promoting diet choices based on scientific evidence. To accomplish these goals, the Human Nutrition Program of ARS conducts basic and applied research resulting in discoveries at the molecular, cellular, individual, and population levels on nutrient requirements, metabolism and health, and intake of foods and nutrients in the U.S.

There are five research components in the Human Nutrition Action Plan for 2014-2019:

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

Selected accomplishments completed during fiscal year 2018 and expected to have high impact in the field are listed below. Links to publicly available documentation are provided after each result.

Following the Dietary Guidelines for Americans has limited health benefit. The Dietary Guidelines for Americans (DGA) are the basis for Federal nutrition policy and are jointly published by USDA and HHS but they had never been tested in a controlled study. DGA recommend more fruits, vegetables, whole grains, and dairy than are usually eaten. A controlled feeding study by ARS scientists in Davis, California, in which all foods were provided over 8 weeks to 52 overweight or obese women who followed the DGA showed significant improvement in systolic blood pressure but no improvements in levels of insulin, glucose, or lipids in the blood compared with women who ate a typical American diet. This was the first controlled feeding trial of the DGA. The diets were designed to maintain body weight, so a follow-up study will be conducted to determine whether weight loss from following the DGA is needed to achieve further improvements in health.

Publication: Krishnan S, Adams SH, Allen LH, Laugero KD, Newman JW, Stephensen CB, Burnett DJ, Witbracht M, Welch LC, Que ES, Keim NL. A randomized controlled-feeding trial based on the Dietary Guidelines for Americans on cardiometabolic health indexes. Am J Clin Nutr. 2018;108:266-278.

A gene may be the reason for propensity to gain weight. The APOA2 gene, one of the most common proteins that moves fats through the body and plays an important role in the cardiovascular system, may also be associated with increased body mass index. ARS and ARS-funded researchers in Boston, Massachusetts, used a variety of techniques to examine genes at the molecular level and the genetic background of people involved in both the Boston Puerto Rican Health Study and the Framingham Heart Study. By closely examining the characteristics of people who reported eating high levels of red meat, poultry, cheese, and butter, the researchers found that only people with the APOA2 variant gene were likely to gain weight, whereas people without the variant maintained lower body mass index. These results may be important in understanding the variation of response to specific dietary patterns implicated in obesity.

Publication: Lai, C.Q., Smith, C.E., Parnell, L.D., Lee, Y.C., Corella, D., Hopkins, P., Hidalgo, B.A., Aslibekyan, S., Province, M.A., Absher, D. and Arnett, D.K. Epigenomics and metabolomics reveal the mechanism of the APOA2-saturated fat intake interaction affecting obesity. Am J Clin Nutr, 2018;108:188-200.

A new hormone discovered that controls desire to eat. Several hormones are involved in control of appetite including insulin, glucagon, leptin, and ghrelin, but altering levels of these hormones has not resulted in reduced eating or weight loss. Asprosin is a recently discovered hormone produced by fat cells and induced by fasting. Asprosin circulates in the blood and targets the liver to produce glucose. Scientists in Houston, Texas, found that asprosin enters the brain and activates nerves there through a series of steps that stimulate appetite and add weight and body fat. Obese humans and mice have elevated levels of asprosin in the bloodstream; blocking it in mice reduced appetite and weight. This is a new potential target for the prevention and treatment of obesity and type 2 diabetes.

Publication: Duerrschmid C, He Y, Wang C, Li C, Bournat JC, Romere C, Saha PK, Lee ME, Phillips KJ, Jain M, Jia P, Zhao Z, Farias M, Wu Q, Milewicz DM, Sutton VR, Moore DD, Butte NF, Krashes MJ, Xu Y, Chopra AR. Asprosin is a centrally acting orexigenic hormone. Nat Med. 2017 Dec;23(12):1444-1453

Moderate exercise improves mobility of older adults. As people age and become less active they lose mobility, leading to falls, hip fractures, and often loss of independence. ARS-funded researchers in Boston, Massachusetts, took part in the Lifestyle Interventions and Independence for Elders (LIFE) study, a large multicenter randomized controlled trial designed to compare the effects of moderate-intensity physical activity with an established health education program. The study showed that previously inactive people in their 70s and 80s can improve their ability to move and function by walking at a moderate speed for at least 48 minutes a week. The researchers found participants in the exercise group increased their walking speed and distance and experienced less decline in mobility than study participants enrolled in a health education program that did not include walking. Influencing older adults to walk at least 1 hour a week may reduce healthcare costs and improve the quality of life for millions.

Publication: Fielding, R.A., Guralnik, J.M., King, A.C., Pahor, M., McDermott, M.M., Tudor-Locke, C., Manini, T.M., Glynn, N.W., Marsh, A.P., Axtell, R.S. and Hsu, F.C. Dose of physical activity, physical functioning and disability risk in mobility-limited older adults: Results from the LIFE study randomized trial. PloS One, 2017;12: p.e0182155.

Technology to improve measurement of food intake. Most observational food studies depend on asking people what they ate. This is fraught with potential errors such as poor memory, cheating, bias, and lack of ability to estimate portion size. These in turn contribute to error rates of 25 percent or more in estimating what people eat. ARS scientists in Houston, Texas, are testing a multisensor the size of an Oreo cookie that takes photos every 4 seconds throughout the day. The multisensor/camera is worn near the chest area, and a new wire mesh software procedure has brought the estimation of portion size to an accuracy of 77 percent. Continued refinement of these methods will enable greater accuracy for diet surveys that contribute to the foundation for Federal nutrition policies.

Publications: Beltran A, Dadabhoy H, Ryan C, Dholakia R, Baranowski J, Li Y, Yan G, Jia W, Sun M, Baranowski T. Reliability and validity of food portion size estimation from images using manual flexible digital virtual meshes. Public Health Nutr. 2018 Feb 12:1-7

Beltran A, Dadabhoy H, Ryan C, Dholakia R, Jia W, Baranowski J, Sun M, Baranowski T. Dietary Assessment with a Wearable Camera among Children: Feasibility and Intercoder Reliability. J Acad Nutr Diet. 2018;118:2144-2153

Exercise may aid in weight loss, provided you do enough. Some people lose weight with exercise, whereas others do not, and when people do not lose the amount of weight they expect, they lose motivation. ARS researchers in Grand Forks, North Dakota, demonstrated that losing weight from exercise depends on the amount of exercise a person performs. The researchers demonstrated that people who expended 600 kcal/day, 5 days per week for 12 weeks through exercise ate the same number of additional calories as people who expended 300 kcal/day through exercise. In short, people who expended 600 kcal/day lost weight and fat, whereas those who expended only 300 kcal/day did not lose weight or fat. This study shows that people can lose weight and fat with exercise, but that they must expend more than 1,500 calories/week, and likely closer to 3,000 calories/week exercising, to have meaningful changes in weight.

Publication: Flack, K. D., Ufholz, K. E., Johnson, L. K., Fitzgerald, J. S. and Roemmich, J. N. Energy Compensation in Response to Aerobic Exercise Training in Overweight Adults. Am J Physiol Regul Integr Comp Physiol, 2018;315:R619-R626.

Nut consumption changes intestinal bacteria numbers. ARS scientists in Beltsville, Maryland, previously reported that eating whole nuts offered fewer calories to the body than what is listed on the nutrition facts label. Ongoing analyses now show that eating almonds or walnuts results in changes of several bacterial species in the intestine. In addition, secondary bile acids, which are bacterial metabolites of the primary bile acids made in the liver and associated with increased risk of colon cancer, are significantly reduced in people who eat 1.5 ounces of walnut halves daily. Consumption of finely ground almonds to make almond butter caused no changes in intestinal bacteria. Whole nuts are one way to modify intestinal bacteria and related risks for both colon cancer and heart disease.

Publications: Holscher HD, Taylor AM, Swanson KS, Novotny JA, Baer DJ. Almond Consumption and Processing Affects the Composition of the Gastrointestinal Microbiota of Healthy Adult Men and Women: A Randomized Controlled Trial. Nutrients. 2018;10. pii: E126.

Holscher HD, Guetterman HM, Swanson KS, An R, Matthan NR, Lichtenstein AH, Novotny JA, Baer DJ. Walnut Consumption Alters the Gastrointestinal Microbiota, Microbially Derived Secondary Bile Acids, and Health Markers in Healthy Adults: A Randomized Controlled Trial. J Nutr. 2018;148:861-867.

New test for children's intestinal health. Some children in rural Africa exhibit stunted growth because of intestinal inflammation. ARS investigators from Houston, Texas, studied 300 children in Malawi to compare their gut health using two different tests. Traditionally, gut health is measured by a sugar absorption test and this was compared to a panel of seven messenger RNA probes in fecal samples that serve as an indicator of intestinal cellular function. The comparison found that either test can be used to identify poor intestinal health. The new test is faster and less expensive than the sugar absorption test and will give healthcare workers the ability to diagnose intestinal inflammation with a simpler method.

Publication: Ordiz MI, Wold K, Kaimila Y, Divala O, Gilstrap M, Lu HZ, Manary MJ. Detection and interpretation of fecal host mRNA in rural Malawian infants aged 6-12 months at risk for environmental enteric dysfunction. Exp Biol Med. 2018;243:985-989.

National dietary survey data and new database released. ARS scientists in Beltsville, Maryland, released two large batches of information from What We Eat in America, an update of the dietary intake interview component of the National Health and Nutrition Examination Survey (NHANES) and the Food Patterns Equivalents Database (FPED) for 2015–2016. The former is a collaboration with the Centers for Disease Control and Prevention (CDC) and is the only nationally representative evaluation of what Americans eat that provides information on foods and nutrients in the U.S. food supply as well as what is eaten. This forms the basis for many nutrition policies throughout the country including at the USDA Food and Nutrition Service and the Department of Defense for military meals. FPED allows academic researchers to compare individual diets to the Dietary Guidelines for Americans and shows what nutrients are under- or overconsumed.

Databases: What We Eat in America (NHANES) 2015-2016
Food Patterns Equivalents Database (FPED) 2015-2016

Pigs are a good model for studying human dietary patterns. Good animal models for elucidating the role of diet on human health remain a challenge. ARS scientists in Beltsville, Maryland, in collaboration with ARS-funded scientists at Tufts University, used Ossabaw pigs to study the interaction of two human dietary patterns (the Western Diet, high in saturated fat, cholesterol, and refined grains; and the Heart Healthy Diet, high in unsaturated fat, whole grains, and fruits/vegetables) with atorvastatin (statin) therapy. Pigs fed the Western Diet developed early atherosclerotic lesions in the heart, along with greater lipid deposition. Modest improvements in cardiometabolic risk factors and a lower degree of lesion formation were observed in pigs fed the Western Diet + statin. Pigs manifested an altered lipid profile that was accompanied by early stage atherosclerosis when they were fed a Western Diet, but not a Heart Healthy Diet. This pig model presents a new approach to examining the pathways involved in diet-drug interactions and resulting effects on the development of atherosclerosis.

Publication: Matthan NR, Solano-Aguilar G, Meng H, Lamon-Fava S, Goldbaum A, Walker ME, Jang S, Lakshman S, Molokin A, Xie Y, Beshah E, Stanley J, Urban JF Jr, Lichtenstein AH. The Ossabaw Pig Is a Suitable Translational Model to Evaluate Dietary Patterns and Coronary Artery Disease Risk. J Nutr. 2018;148:542-551.

Intestinal bacteria predict progression of type 2 diabetes. (T2D). Bacterial species in the intestine are altered in obesity and T2D but it is not known if these changes are controlled by dietary factors or declines in metabolic health. Using a rat model genetically predisposed to T2D, scientists in Little Rock, Arkansas, showed that 45 bacterial species distinguished between early and late stages of T2D. Additionally, 61 bacterial genes were identified for their metabolism of nutrients and stress response changes during progression of diabetes even though diet was held constant. These results indicate that changes in the intestinal bacteria track progression of diabetes independent of diet and age, suggesting a potential way to reduce the occurrence or severity of T2D.

Publication: Piccolo BD, Graham JL, Stanhope KL, Nookaew I, Mercer KE, Chintapalli SV, Wankhade UD, Shankar K, Havel PJ, Adams SH. Diabetes-Associated Alterations in the Cecal Microbiome and Metabolome are Independent of Diet or Environment in the UC Davis Type 2-Diabetes Mellitus Rat Model. Am J Physiol Endocrinol Metab. 2018 Jul 17

A high-fat diet induces precancerous changes and increases bad bacteria in the colon. Mice fed a high-fat diet and given a chemical to induce colon cancer exhibited intestinal inflammation and a greater number of precancerous cells. Although these observations confirm previous research, ARS scientists in Grand Forks, North Dakota, also found fewer intestinal bacteria that produce health-promoting short-chain fatty acids in mice fed a high-fat diet, and a pathogenic bacterium, Anaeroplasma, was more prevalent than in mice fed a low-fat diet. This information contributes to our understanding of the role of the microbiome in health, and especially to the causative role of intestinal bacteria in the risk for developing colon cancer, which differs from person to person.

Publication: Zeng H, Ishaq SL, Liu Z, Bukowski MR. Colonic aberrant crypt formation accompanies an increase of opportunistic pathogenic bacteria in C57BL/6 mice fed a high-fat diet. J Nutr Biochem. 2018;54:18-27.

The concentration of iron in milk is genetically controlled. Iron deficiency in infants is a major problem worldwide. ARS researchers in Houston, Texas, conducted a genome-wide association study using mice to understand how genetics regulates milk mineral concentrations and found that normal variants in a region on chromosome 1 resulted in a 35 percent increase in the concentration of iron in milk. The team also demonstrated that iron transporter genes are expressed at high levels in the mammary tissue of mice that carry genetic modifications of this region. The identification of these transporter genes could lead to strategies aimed at increasing the concentrations of iron in breast milk.

Publication: Hadsell DL, Hadsell LA, Rijnkels M, Carcamo-Bahena Y, Wei J, Williamson P, Grusak MA. 2018. In silico mapping of quantitative trait loci (QTL) regulating the milk ionome in mice identifies a milk iron locus on chromosome 1. Mammalian Genome, 29(9-10):632-655.

Food Chemical Codex guidelines for detection of adulteration in foods and botanical supplements. Detection of economically motivated adulteration in foods and botanical supplements is a serious problem in the world market. In collaboration with the U.S. Pharmacopeia, ARS scientists in Beltsville, Maryland, assisted in developing a Food Chemicals Codex for nontargeted methods to detect adulteration. Nontargeted methods, as the name implies, employ spectral and chromatographic profiling techniques to survey the chemical composition of a sample for components that should not be present and result in a fingerprint of the ingredients in products. The guidelines established general approaches for selecting methods and processing tools to detect adulteration. The guidelines provide direction for researchers and laboratories needing to establish quality assurance procedures to ensure the quality of their products.

Publication: United States Pharmacopeia (USP). Appendix XVIII: Guidance on Developing and Validating Non-targeted Methods for Adulteration Detection.

Development of software to analyze gene expression by the gut microbiome. There is much interest in understanding how one's diet can affect the gut microbiome. One way to assess this is to study the metatranscriptome; that is, all the genes expressed by microbes in a sample. However, a barrier to the use of this technique has been the availability of software to analyze the results. ARS scientists in Davis, California, and collaborators at the University of California, Davis, published such a software package, Simple Analysis of Metatranscriptomes through Sequence Annotation version 2 (SAMSA2; https://github.com/transcript/samsa2). SAMSA2 is designed for stand-alone use on a supercomputing cluster or large workstation, or to work with additional reference databases. This represents a significant advancement over the original SAMSA software (developed by this same team) because this version is not dependent on third-party resources for the computationally expensive mapping step. This version can, therefore, be used by a broader group of biologists than the original software, which increases the breadth and potential influence of metatranscriptome analysis in the biological sciences.

Publication: Westreich ST, Treiber ML, Mills DA, Korf I, Lemay, DG. 2018. SAMSA2: a standalone metatranscriptome analysis pipeline. BMC Bioinformatics, 19(1):175.