



Carotenoid & Retinoid News

October 2018
Vol. 27, No. 2

Nutrition 2019 Abstract Submission

Abstract submission for Nutrition 2019 will open October 24th, or soon after, and will close January 18, 2019. Please submit your abstracts to CARIG categories, which this year are:

1. Carotenoids and Human Health
2. Retinoids and Human Health
3. Carotenoids and Retinoids: Molecular Mechanisms of Action
4. Carotenoids and Neuroscience

Abstract acceptance letters will be sent in March 2019. The number of abstracts received determines the number and format of CARIG mini-symposia (ePoster vs. podium) in the final program. Pass the word along to your students, postdoctoral fellows and colleagues!

CARIG Travel Awards!

CARIG will award at least two monetary prizes, based on a poster competition to be held in conjunction with the CARIG reception at Nutrition 2019 on Friday, June 7, 2019. Graduate students and postdoctoral trainees are eligible. Posters must address carotenoid and/or vitamin A research. For those assigned an oral presentation rather than a poster at Nutrition 2019, printed copies of your slides with a print copy of your abstract and a small banner may be used for the CARIG poster competition. No advance registration is required to participate in the poster competition.

Contact: Nancy Moran (Nancy.Moran@bcm.edu).

Registration for CARIG RIS

Many International Carotenoid Society members are also participants in the Carotenoid and Retinoid Interactive Research Group (CARIG) RIS associated with the American Society of Nutrition. If you attend ASN's Nutrition meeting, the CARIG meeting, and are also a member of ASN, it is important that you log onto your ASN NutriLink profile and join the CARIG RIS. We receive benefits from ASN including the opportunity to schedule space during the Nutrition meeting for the CARIG Symposium, so it is extremely important for members to identify their participation in the CARIG RIS. Membership in the RIS has declined because members did not update profiles during their renewal process. Although we

currently have 351 members we would like to increase that number! You can join the CARIG RIS on ASN's NutriLink website at:
<https://nutrilink.nutrition.org/home>

News from CARIG Steering and Advisory Committee

We wish to welcome our new Chair-Elect, **Helen Everts** from Texas Woman's University! Several upcoming CARIG sponsored events will be held next summer at Nutrition 2019 in Baltimore, MD. The CARIG 2019 symposium will take place at 1:00 pm on June 7, 2019, Friday afternoon, before the Saturday opening of the Nutrition 2019 program. The title is "**Carotenoids and Vitamin A for Pregnancy, Lactation, and Early Life Nutrition: New Findings and Considerations for Dietary Guidelines**" (proposed by Nancy Moran and Elizabeth Johnson), and the Olson Lecturer is A. Catharine Ross, who will speak on "**Carotenoid and Vitamin A DRIs for Pregnancy and Early Life - What Comes Next and Special Considerations.**" We will also have a business meeting (5:30 pm) and a CARIG trainee poster and award session (6:30-8:30 pm) during the annual social following the CARIG Conference.

RIS Officers 2018-2019

Chair – Nancy Moran, USDA/ARS Children Nutrition Research Center at Baylor College of Medicine

Chair-Elect – Helen Everts, Texas Woman's University

Past Chair – Elizabeth Johnson, Tufts University

Secretary – Jessica Cooperstone, The Ohio State University

Treasurer - Bryan Gannon, Cornell University

Newsletter Editor – Lisa Jahns, USDA Grand Forks

Student Representatives:

Caitlyn Edwards – University of Illinois

Ambria Crusan – University of Minnesota

CARIG Steering Committee 2018-2019

- Jessica Campbell- General Mills
- Wendy White- Iowa State, staying on.
- Neal Craft – Craft Technologies Inc.
- Zeina E. Jouni - Kellogg Company
- Sherry Tanumihardjo- Univ Wisconsin
- Georg Lietz - Newcastle University
- Loredana Quadro – Rutgers University

- John Landrum - Florida International University (liaison to the International Carotenoid Society, ICS Secretary)
- Xiao-Ming Gong- Texas Tech

STUDENT SPOTLIGHT

Caitlyn Edwards, PhD Student

University of Illinois at Urbana-Champaign.



Caitlyn is a fourth year PhD student at the University of Illinois at Urbana-Champaign in the Body Composition and Nutritional Neuroscience Lab under Dr. Naiman Khan. Her work focuses on Nutritional Neuroscience, specifically on dietary interventions

that increase retinal lutein concentrations and subsequent measures of cognitive control. As a former chef she has experience designing dietary interventions for randomized-control trials. Her current project is an egg-based intervention in 7-12 year olds. She is a co-Student Representative for the year 2018-2019 and excited for a great year of CARIG activities!

UPCOMING EVENTS

October 23-25, 2018

Workshop on Carotenoids in Foods, Nutrition and Health and EUROCAROTEN 5th Management Committee and 4th Working Groups Meeting

Website:

<https://congresos.adeituv.es/eurocaroten/ficha.en.html>

June 7, 2019

CARIG Annual Symposium, Nutrition 2019, Baltimore, MD. Contact: Nancy Moran, CARIG RIS Chair, Email: Nancy.Moran@bcm.edu

June 8-11, 2019

Nutrition 2019, Baltimore, MD.

Website: <http://meeting.nutrition.org/>

November 26-29, 2019

International Conference on Carotenoid Research and Applications in Agro-Food and Health (EUROCAROTEN COST FINAL MEETING), Lemesos, Cyprus.

Website:

<http://web.cut.ac.cy/fruitsciencesgroup/eurocaroten2019/>

July 5-7, 2021

Brain and Ocular Nutrition 2021, Cambridge, UK.

Website: www.bonconference.org

FORTHCOMING / RECENT PUBLICATIONS

SIGHT AND LIFE Magazine: Production

Innovation. 32(1) 2018. PO Box 2116, 4002 Basel, Switzerland, tel: 41-61-815-8756, Website: www.sightandlife.org

Carotenoids in Nature: Biosynthesis, Regulation and Function (Subcellular Biochemistry) Aug 24, 2018 by Claudia Stange.

The Biochemistry of Retinoid Signaling II: The Physiology of Vitamin A - Uptake, Transport, Metabolism and Signaling (Subcellular Biochemistry) Dec 1, 2018 by Mary Ann Asson-Batres and Cecile Rochette-Egly.

Nutrients: The journal *Nutrients* is hosting two specials issues, one on **Carotenoids and Human Health** (deadline for submission 28 February 2019), and another on **Vitamin A and Human Health**. (deadline for submission 15 May 2019. Consider submitting a manuscript at: https://www.mdpi.com/journal/nutrients/special_issues/vitamin_A_health or https://www.mdpi.com/journal/nutrients/special_issues/Carotenoids_Human_Health

MEETING REPORTS

CARIG Annual Symposium at Nutrition 2018

This year's CARIG symposium focused on "Carotenoids and Retinoids throughout the Lifespan". The symposium opened with the James A. Olson Memorial Lecture given by Dr. Keith West from Johns Hopkins Bloomberg School of Public Health. The lecture was titled "Vitamin A, Carotenoids, Health and Survival by Person, Place and Time". The following presentations covered Vitamin A status in infants, possible toxicity of biofortification in children, and the influence of carotenoids on hearing, vision, and cognitive decline.

We would like to thank **Abbott Nutrition, Mars Symbioscience, Amway, and ZeaVision** for their generous support of the 2018 CARIG symposium.

The **CARIG Poster Competition** for graduate students and post doctorate fellows had three winners:

1st Place: **Jirayu Tanprasertsuk**, Tufts University, *"Brain fat-soluble nutrient pattern is related to pre-mortem cognition among non-demented centenarians"*. Co-authors: Tammy Scott; Xiang-Dong; Aron Barbey; Kathryn Barger; Mary Ann Johnson; Leonard; Elizabeth Johnson

2nd place: **Jelena Mustra Rakic**, Tufts University, *"Dietary lycopene feeding inhibits cigarette smoke induced COPD and lung preneoplastic lesions in ferret model"* Co-authors: Chun Liu; Sudipta Veeramachaneni; Lynne Ausman; Xiang-Dong Wang

3rd place: **Zhi Chai**, Pennsylvania State University, *"Differential Expression and Co-expression Analyses on Transcriptional Profiles of Lower Small Intestine Suggest Key Pathways Regulated by Vitamin A"*. Co-authors: Zhi Chai, Yafei Lyu, Qiuyan Chen, Cheng-Hsin Wei, Lindsay Snyder, Veronika Weaver, Margherita T. Cantorna, Qunhua Li, A. Catharine Ross.



Judges: CARIG Chair: Elizabeth Johnson (Tufts), CARIG Chair-elect: Nancy Moran (Baylor College of Medicine), CARIG Committee Member: Sherry Tanumihardjo (University of Wisconsin)

The **Emerging Leaders in Nutrition Competition** is intended to highlight the very best research submitted by students and young investigators to ASN's Scientific Sessions. This year, Minkyung Bae, University of Connecticut, and Jelena Mustra Rakic, Tufts University, tied for first place for the CARIG section. Judged by: CARIG Chair: Elizabeth Johnson, CARIG Chair-elect: Nancy Moran.

Minkyung Bae, University of Connecticut, presented *"Hepatic Stellate Cells Exposed to Astaxanthin During Activation Exhibit a Distinct Metabotype from Quiescent and Activated Hepatic Stellate Cells"*, Co-

authors: Tho Pham; Yoojin Lee; Siqi Hu; Dong-Guk Shin; Pujan Joshi; Seung-Hyun Hong; Nathan Alder; Sung Koo; Ji-Young Lee

Jelena Mustra Rakic, Tufts University, presented *"Dietary lycopene feeding inhibits cigarette smoke induced COPD and lung preneoplastic lesions in ferret model"* Co-authors: Chun Liu; Sudipta Veeramachaneni; Lynne Ausman; Xiang-Dong Wang

Congratulations to all of our CARIG junior investigators!

The 10th Gordon Research Conference

The 10th Gordon Research Conference (GRC) on Carotenoids (June 17-22) was held in Newry, Maine with the theme of **"Carotenoids, Apocarotenoids and Retinoids: From Nature to Bedside."** With over 125 attendees from 5 continents, the GRC addressed the full spectrum of carotenoid and apocarotenoid research, fostering interdisciplinarity and transfer of research methods between different experimental systems. The majority of the sessions included speakers from different fields (microbial/plant biology and biomedical research) to enhance cross-fertilization and exchange of ideas. The GRC was held in conjunction with the **Gordon Research Seminar on Carotenoids**, a unique forum for graduate students, postdocs and other early career researchers in carotenoids.

The 4th BON Conference 2018



150 researchers from across the world recently participated at the 2018 Brain and Ocular Nutrition (BON; www.bonconference.org) conference held at Downing College in Cambridge, UK. This was the 4th BON conference since inception in 2011. The theme of this conference was on the study of the role of nutrition and lifestyle for the eye and the brain. This international conference showcased research from 16 different countries and respected

organizations from around the world. In total, there are now 184 official BON members, with 28 scientists forming an Early Investigator Society (EIS) within this specialized group. Abstracts from the BON conference have been published in the *Journal of Alzheimer's Disease* and can be viewed at www.ncbi.nlm.nih.gov/pubmed/29991139. Early

2019, the journal of *Molecular Nutrition and Food Research* will publish a special issue of original papers and review papers presenting the key topics and research from the 2018 BON conference (www.onlinelibrary.wiley.com/journal/16134133).

Professor John Nolan, Chair of the BON Conference, highlighted that, "We now live in a time where our science can have a measurable and meaningful impact on policy, industry and human health and function. I am sure that our collective work is a stakeholder for a better future". He continued, "...it is essential that we remain focused on our core research values. The success of this group is most certainly because we stay focused and specialized". To become a member please visit the BON website www.bonconference.org.

TECHNICAL NOTES

Simple and sensitive dilute-and-shoot analysis of carotenoids in human plasma

Carotenoids in human plasma are used as biomarkers of vegetable and fruit intake. Large sample volumes and intensive sample processing make measurement of these species cumbersome. We developed a dilute-and-shoot method for the quantitation of α -carotene, β -carotene, β -cryptoxanthin, lycopene and lutein/zeaxanthin using 10 μ L of plasma. Plasma was injected into methanol containing internal standard and deproteinized by centrifugation. The carotenoids in the supernatant were separated using a YMC C-30 column and quantified by tandem mass spectrometry. The linearity for carotenoids ranged from sub-fmol to approximately 300 fmol on-column. Spike recovery experiments were used to correct for matrix effects. The method was validated using the human plasma standard NIST SRM 968e. Over 400 sample analyses were performed using the same guard and analytical columns. This method represents an improvement over current techniques because of the small sample size needed, ease of sample preparation, and improvement in the determination of carotenoid content.

Bukowski et al.

J Chromatogr B Analyt Technol Biomed Life Sci.,
1095:32-38 (2018)

HIGHLIGHTED NEW RESEARCH ABSTRACTS

An in vivo test of the biologically relevant roles of carotenoids as antioxidants in animals

Carotenoids are well known for their contribution to the vibrant coloration of many animals and have been hypothesized to be important antioxidants. Surprisingly few examples of carotenoids acting as biologically relevant antioxidants in vivo exist, in part because experimental designs often employ dosing animals with carotenoids at levels that are rarely observed in nature. Here we use an approach that reduces carotenoid content from wild-type levels to test for the effect of carotenoids as protectants against an oxidative challenge. We used the marine copepod, *Tigriopus californicus* reared on a carotenoid-free or a carotenoid-restored diet of nutritional yeast and then exposed them to a prooxidant. We found that carotenoid-deficient copepods not only accumulated more damage, but also were more likely to die during an oxidative challenge than carotenoid-restored copepods. We suggest that carotenoid reduction, and not supplementation, better tests the proposed roles of carotenoids in other physiological functions in animals.

Weaver RJ, et al.

Journal of Experimental Biology, (2018)

Pharmacological inhibition of ALDH1A enzymes suppresses weight gain in a mouse model of diet-induced obesity

Retinoic acid (RA) is known to play a role in weight regulation. Because mice without ALDH1A1, a major RA synthesizing enzyme, are resistant to diet induced obesity, pharmacological inhibition of RA synthesis was tested to suppress weight gain in a murine model of diet-induced obesity. Mice treated with WIN 18,446 gained significantly less weight and had decreased adipose tissue weight, adipocyte size, and macrophage infiltration in adipose tissue. In addition, we observed higher UCP1 expression in adipose tissues and decreased expression of RA responsive genes and genes involved in fatty acid synthesis in the livers and lungs of mice treated with WIN 18,446. Therefore, pharmacological suppression of RA synthesis via inhibition of ALDH1A1 may be a potential target for treatment of obesity.

Haenisch, M et al.

Obesity Research & Clinical Practice, 12: 93-101
(2018)

Ablation of carotenoid cleavage enzymes (BCO1 and BCO2) induced hepatic steatosis by altering the farnesoid X receptor/miR-34a/sirtuin 1 pathway

β -Carotene-15, 15'-oxygenase (BCO1) and β -carotene-9', 10'-oxygenase (BCO2) are essential enzymes in carotenoid metabolism. While BCO1/BCO2 polymorphisms have been associated with alterations to human and animal carotenoid levels, experimental studies have suggested that BCO1 and BCO2 may have specific physiological functions beyond the cleavage of carotenoids. In the present study, we investigated the effect of ablation of both BCO1/BCO2 in the development of non-alcoholic fatty liver disease (NAFLD) and its underlying molecular mechanism(s). BCO1/BCO2 double knock out (DKO) mice developed hepatic steatosis (8/8) and had significantly higher levels of hepatic and plasma triglyceride and total cholesterol compared to WT (0/8). Hepatic changes in the BCO1/BCO2 DKO mice were associated with significant: 1) increases in lipogenesis markers, and decreases in fatty acid β -oxidation markers; 2) upregulation of cholesterol metabolism markers; 3) alterations to microRNAs related to TG accumulation and cholesterol metabolism; 4) increases in an hepatic oxidative stress marker (HO-1) but decreases in anti-oxidant enzymes; and 5) decreases in farnesoid X receptor (FXR), small heterodimer partner (SHP), and sirtuin 1 (SIRT1). The present study provided novel experimental evidence that BCO1 and BCO2 could play a significant role in maintaining normal hepatic lipid and cholesterol homeostasis, potentially through the regulation of the FXR/miR-34a/SIRT1 pathway.

Lim JY, et al.

Arch Biochem Biophys., 654:1-9 (2018)

Duration of Retinol Isotope Dilution Studies with Compartmental Modeling Affects Model Complexity, Kinetic Parameters, and Calculated Vitamin A Stores in US Women

Retinol isotope dilution (RID) indirectly estimates vitamin A (VA) status. Multicompartment modeling of RID data is used to refine study designs and equations to calculate VA stores. Previous studies suggest that VA in slowly turning over pools is not traced if follow-up is not long enough; however, shorter RID studies are being investigated. The effect of time on mathematical models of VA kinetics, model parameters, and outcomes was determined in this longitudinal study. Women (mean \pm SD age: 22 \pm 3 y; n = 7) were given 2.0 μ mol [14,15]-13C2-

retinyl acetate. Blood samples were staggered from 4 h to 152 d. Four model-time categories were created: full models that used all data. Outcomes included number of compartments to adequately model serum data, kinetic parameters, total traced VA mass, and time-to-dose equilibration. To gain insight into longer follow-up, an additional participant was given 17.5 μ mol 13C4-VA, and data were modeled as long as enrichment was above baseline (5 y). Longer follow-up times affected kinetic parameters and outcomes. Compared with the 14-d models, long-term full models required an additional compartment for adequate fit (14.3% compared with 100%; P = 0.0056) and had longer [median (quartile 1, quartile 3)] whole-body half-life [15.0 d (10.5, 72.6 d) compared with 135 d (115, 199 d); P = 0.0006], time-to-dose equilibration [3.40 d (3.14, 6.75 d) compared with 18.9 d (11.2, 25.7 d); P < 0.0001], and total traced mass [166 μ mol VA (162, 252 μ mol VA) compared with 476 μ mol VA (290, 752 μ mol VA); P = 0.0031]. Extended RID sampling alters numerous mathematically modeled, time-dependent outcomes in women.

Gannon, BM et al.

The Journal of Nutrition, 148 (8): 1387–1396(2018)

Limited appearance of apocarotenoids is observed in plasma after consumption of tomato juices: a randomized human clinical trial.

Nonvitamin A apocarotenoids occur in foods. Some function as retinoic acid receptor antagonists in vitro, though it is unclear if apocarotenoids are absorbed or accumulate to levels needed to elicit biological function. The aim of this study was to quantify carotenoids and apocarotenoids (β -apo-8'-, -10'-, -12'-, and -14'-carotenal, apo-6'-, -8'-, -10'-, -12'-, and -14'-lycopenal, retinal, acycloretnal, β -apo-13-carotenone, and apo-13-lycopenone) in human plasma after controlled consumption of carotenoid-rich tomato juices. Healthy subjects (n = 35) consumed a low-carotenoid diet for 2 wk, then consumed 360 mL of high- β -carotene tomato juice, high-lycopene tomato juice, or a carotenoid-free control per day for 4 wk. Plasma was sampled at baseline, 2 wk, and 4 wk, and analyzed for carotenoids and apocarotenoids. Apocarotenoids are present in tomato juices at 0.1-0.5% of the parent carotenoids. Plasma lycopene and β -carotene increased (P < 0.001) after consuming high-lycopene and β -carotene tomato juices, respectively, while retinol remained unchanged. β -Apo-13-carotenone was found in the blood of all subjects at every visit, although elevated (P < 0.001) after consuming β -carotene tomato juice for 4 wk (1.01 \pm 0.27 nmol/L) compared with both baseline (0.37 \pm 0.17 nmol/L) and control (0.46 \pm 0.11 nmol/L). Apo-6'-lycopenal

was detected or quantifiable in 29 subjects, while β -apo-10'- and 12'-carotenal were detected in 6 and 2 subjects, respectively. No other apolycopenoids or apocarotenoids were detected. β -Apo-13-carotenone was the only apocarotenoid that was quantifiable in all subjects, and was elevated in those consuming high- β -carotene tomato juice. Levels were similar to previous reports of all-trans-retinoic acid. Other apocarotenoids are either poorly absorbed or rapidly metabolized or cleared, and so are absent or limited in blood. β -Apo-13-carotenone may form from vitamin A and its presence warrants further investigation.

*Cooperstone J et al.
Am J Clin Nutr., (2018)*



Cinco de Mayo Guacamole, photo provided by the HASS avocado board

RECENT REVIEWS

Intrinsic and Extrinsic Factors Impacting Absorption, Metabolism, and Health Effects of Dietary Carotenoids.

Carotenoids are orange, yellow, and red lipophilic pigments present in many fruit and vegetables, as well as other food groups. Some carotenoids contribute to vitamin A requirements. The consumption and blood concentrations of specific carotenoids have been associated with reduced risks of a number of chronic conditions. However, the interpretation of large, population-based observational and prospective clinical trials is often complicated by the many extrinsic and intrinsic factors that affect the physiologic response to carotenoids. Extrinsic factors affecting carotenoid bioavailability include food-based factors, such as co-consumed lipid, food processing, and molecular structure, as well as environmental factors, such as interactions with prescription drugs, smoking, or alcohol consumption. Intrinsic, physiologic factors associated with blood and tissue carotenoid concentrations include age, body composition,

hormonal fluctuations, and variation in genes associated with carotenoid absorption and metabolism. To most effectively investigate carotenoid bioactivity and to utilize blood or tissue carotenoid concentrations as biomarkers of intake, investigators should either experimentally or statistically control for confounding variables affecting the bioavailability, tissue distribution, and metabolism of carotene and xanthophyll species. Although much remains to be investigated, recent advances have highlighted that lipid co-consumption, baseline vitamin A status, smoking, body mass and body fat distribution, and genetics are relevant covariates for interpreting blood serum or plasma carotenoid responses. These and other intrinsic and extrinsic factors are discussed, highlighting remaining gaps in knowledge and opportunities for future research. To provide context, we review the state of knowledge with regard to the prominent health effects of carotenoids.

*Moran NE, et al.
Adv Nutr., 9(4):465-492 (2018)*

Optical assessment of skin carotenoid status as a biomarker of vegetable and fruit intake.

Resonance Raman spectroscopy (RRS) and reflection spectroscopy (RS) are optical methods applicable to the non-invasive detection of carotenoids in human skin. RRS is the older, more thoroughly validated method, whereas RS is newer and has several advantages. Since collective skin carotenoid levels serve as a biomarker for vegetable and fruit intake, both methods hold promise as convenient screening tools for assessment of dietary interventions and correlations between skin carotenoids and health and disease outcomes. In this manuscript, we describe the most recent optimized device configurations and compare their use in various clinical and field settings. Both RRS and RS devices yield a wide range of skin carotenoid levels between subjects, which is a critical feature for a biomarker. Repeatability of the methods is 3-15% depending on the subject's skin carotenoid level and the uniformity of its local distribution. For 54 subjects recruited from an ophthalmology clinic, we first checked the validity of the relatively novel RS methodology via biochemical serum carotenoid measurements, the latter carried out with high performance liquid chromatography (HPLC). A high correlation between RS skin and serum HPLC carotenoid levels was established ($R = 0.81$; $p < 0.001$). Also, a high correlation was found between RS and RRS skin levels ($R = 0.94$ $p < 0.001$). Subsequent comparisons of skin carotenoid

measurements in diverse age groups and ethnicities included 569 Japanese adults, 947 children with ages 2-5 screened in 24 day care centers in San Francisco, and 49 predominantly Hispanic adults screened at an outdoor health fair event. Depending on the particular subject group, correlation coefficients between the RRS and RS methods ranged between $R \sim 0.80$ and $R \sim 0.96$. Analysis of the Japanese screening showed that, on average, skin carotenoid levels are higher in women compared to men, skin levels do not depend on age, and tobacco smokers have reduced levels versus non-smokers. For the two most ethnically diverse groups with widely varying melanin levels, we investigated the effect of dermal melanin on RS and RRS skin carotenoid levels. The analysis revealed that large variations in skin carotenoid levels remain detectable independent of the particular melanin index. This behavior is consistent with the absence of melanin effects on the skin carotenoid levels generated with the instrument configurations. The RS method has an advantage over RRS in its relative simplicity. Due to its detection of skin reflection over a wide spectral range from the near UV to the near IR, it has the unique ability to quantify each of the major tissue chromophores and take them into account in the derivation of skin carotenoid levels.

*Ermakov IV, et al.
Arch Biochem Biophys., 646:46-54 (2018)*

Use of Stable Isotopes to Evaluate Bioefficacy of Provitamin A Carotenoids, Vitamin A Status, and Bioavailability of Iron and Zinc

The ability of nutrition scientists to measure the status, bioavailability, and bioefficacy of micronutrients is affected by lack of access to the parts of the body through which a nutrient may travel before appearing in accessible body compartments (typically blood or urine). Stable isotope-labeled tracers function as safe, nonradioactive tools to follow micronutrients in a quantitative manner because the absorption, distribution, metabolism, and excretion of the tracer are assumed to be similar to the unlabeled vitamin or mineral. The International Atomic Energy Agency (IAEA) supports research on the safe use of stable isotopes in global health and nutrition. This review focuses on IAEA's contributions to vitamin A, iron, and zinc research. These micronutrients are specifically targeted by the WHO because of their importance in health and worldwide prevalence of deficiency. These 3 micronutrients are included in food fortification and biofortification efforts in low- and middle-income regions of the world. Vitamin A isotopic techniques can be used to

evaluate the efficacy and effectiveness of interventions. For example, total body retinol stores were estimated by using $^{13}\text{C}_2$ -retinol isotope dilution before and after feeding Zambian children maize biofortified with β -carotene to determine if vitamin A reserves were improved by the intervention. Stable isotopes of iron and zinc have been used to determine mineral bioavailability. In Thailand, ferrous sulfate was better absorbed from fish sauce than was ferrous lactate or ferric ammonium citrate, determined with the use of different iron isotopes in each compound. Comparisons of one zinc isotope injected intravenously with another isotope taken orally from a micronutrient powder proved that the powder increased total absorbed zinc from a meal in Pakistani infants. Capacity building by the IAEA with appropriate collaborations in low- and middle-income countries to use stable isotopes has resulted in many advancements in human nutrition.

*Sheftel, et. al.
Adv Nutr., 9(5):625-636 (2018)*

FORTHCOMING ISSUE: May 2019

In the next issue of Carotenoid & Retinoid News, we will be highlighting a section on human feeding trials and welcome your contributions about current or recently published interventions, as well as pictures!

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CAROTENOID AND RETINOID INTERACTIVE GROUP (CARIG), a Research Interest Section of the American Society for Nutrition and an Affiliate of the International Carotenoid Society

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