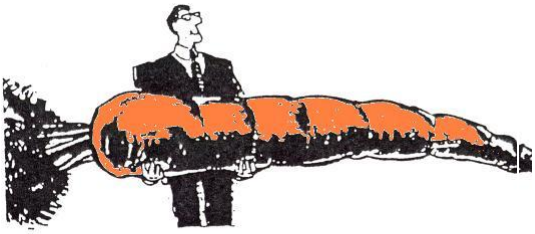

Carotenoid News

September 2014
Vol. 23, No. 2

FROM THE EDITOR

"The important thing is not to stop questioning."
Albert Einstein, theoretical physicist (1879-1955)

As we can see from the variety of topics discussed during CARIG Conference 2014 and 17th International Symposium on Carotenoids, our discipline follows the advice of the famous physicist. We never stop questioning, therefore new vistas are continuously appearing and enticing both young and seasoned researchers. Among currently "hot" questions is the topic of lutein function in the developing human brain and in the maintenance of intellectual and visual acuity in old age. Since our brain distinguishes us from other animals, thanks to which we are the only sentient species and developed civilization, the problem is of utmost importance, especially for nutritional advice in all stages of life. Many nutritionists consider an introduction of dietary recommendations for this important carotenoid. The development of such guidelines (DRI – dietary reference intakes) may help to improve public health and benefit all age groups, including the prevention of macular degeneration and cataracts.

Maria S. Sapuntzakis (Chicago,IL)

CARIG Name Change

The ASN Carotenoid Research Interactive Group RIS membership recently voted to change the name of the **Carotenoid Research Interactive Group RIS** to the **Carotenoid and Retinoid Interactive Group RIS**. The CARIG RIS leadership committee began to solicit feedback at their business meeting at EB 2014 where we discussed the wisdom in making a change to our RIS group name to better, more accurately reflect the nature of our scholarship. There was consensus amongst the group that the current term (**Carotenoid Research Interactive Group**) fails to capture the complete science that underlies the work we do. Feedback indicated that the Carotenoid Research Interactive Group RIS name and purpose did not provide encompassing nomenclature to the field of Carotenoid and Retinoid Research and the sub-specialties that members were engaged in. The CARIG RIS posted an electronic ballot on the question of its name and purpose, which was approved by the membership. This change acknowledges the mission in the areas of carotenoids and retinoids. Please note that this change maintains the recognized 'CARIG' 'brand' and will not change the acronym - only the wording behind it. The new name is **Carotenoid and Retinoid Interactive Group (CARIG) RIS.**

New Purpose Statement: CARIG's mission is to promote research into nutritional roles, functions, and actions of carotenoids, retinoids and their metabolites; actively participate in ASN functions and governance and interact with other RIS's' provide mechanisms for the dissemination of new research; serve as a liaison representing the interests of carotenoid and retinoid research community to government agencies and other organizations; promote and support the training of young researchers; communicate to the wider research community and the public.

CARIG Travel Awards

CARIG will award at least two monetary prizes, based on a poster competition to be held in conjunction with the CARIG/VARIG Social at Experimental Biology 2015. 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 EB'15, printed copies of your slides with a print copy of your abstract and a small banner may be used for the CARIG/VARIG poster competition. No advance registration is required to participate in the poster competition. Contact: Zeina E. Jouni, e-mail: zeina.jouni@kellogg.com or Sherry Tanumihardjo, email: sherry@nutrisci.wisc.edu

News from CARIG Steering and Advisory Committee

CARIG continues to promote research into the nutritional roles, functions, and actions of carotenoids and their metabolites. We would like to remind you all and the CARIG members to mark their calendars for several upcoming CARIG sponsored events to be held next spring at Experimental Biology 2015 in Boston. The CARIG 2015 Conference will be held on March 28th, Friday afternoon before the Saturday opening of the ASN program. EB 2015 also will feature a CARIG/VARIG

trainee poster and award session, and business meeting during the annual social following the CARIG Conference.

CARIG minisymposium topics for EB2015:

1. Carotenoids and Health
2. Carotenoids & Retinoids: Molecular Mechanisms of Action
3. Bioavailability & Metabolism of Carotenoids & Vitamin A
4. Biofortification of Staple Crops with Micronutrients

RIS Officers 2014-2015

Chair – Zeina E. Jouni, Kellogg Company
Chair Elect– Sherry Tanumihardjo, University of Wisconsin-Madison
Treasurer – Jessica Campbell, General Mills
Immediate Past Chair – Loredana Quadro, Rutgers University

I would like to thank all the members who have already volunteered to help us in the coming year. Special thanks to our outgoing Chair Loredana Quadro, who did an outstanding job for her service as CARIG RIS chair 2013-2014, and I look forward to her input and advice during our next journey, I also would like to thank our acting Treasurer Jessica Campbell and our Chair Elect, Sherry Tanumihardjo. If you are interested in contributing as a RIS officer, or if you have ideas for symposia or CARIG Conference topics for EB 2015, please contact the RIS leadership: Loredana Quadro (quadro@AESOP.Rutgers.edu), Zeina E. Jouni (zeina.jouni@kellogg.com), Sherry Tanumihardjo (sherry@nutrisci.wisc.edu) or Jessica Campbell (Jessica.Campbell@genmills.com). Additional information on the upcoming 2015 events will appear through the listserv and in subsequent issues of Nutrition Notes.

Zeina E. Jouni (Chair)

The current membership of the Committee includes, in addition to the above mentioned RIS officers:
Earl Harrison – Ohio State University
Mario Ferruzzi– Purdue University
Lisa Jahns - USDA-ARS, North Dakota
Elizabeth Johnson – Tufts University
Klaus Kraemer – Task Force Sight and Life
Georg Lietz - Newcastle University
Lewis Rubin – University of South Florida
Maria Stacewicz-Sapuntzakis (newsletter editor)
John Landrum - Florida International University (liaison to the International Carotenoid Society, ICS Secretary)
Student representatives:
Jessica Copperstone - Ohio State University
Bryan Gannon - University of Wisconsin
Postdoc representatives:
Shellen Goltz –University of Wisconsin
Matthew Toomey – Washington University

UPCOMING EVENTS

March 28, 2015
CARIG Annual Conference, Boston, MA. Contact**:** Dr. Zeina E. Jouni, CARIG RIS Chair, **e-mail**: zeina.jouni@kellog.com

March 28 - April 1, 2015
Experimental Biology 2015, Boston, MA. Contact: EB2014, FASEB Office of Scientific Meetings & Conferences, 950 Rockville Pike, Bethesda, MD 20814-3998, **website:**www.experimentalbiology.org **e-mail:** eb@faseb.org

July 8 -10, 2015
Macular Carotenoids Conference 2015. Cambridge, UK. Contact: Nutrasight Consultancy Ltd. (Conference Management), Carriganore House, Waterford Institute of Technology West Campus, Carriganore, Waterford, Ireland. Tel: +353 (0)51 302153. **Website**: www.macularcarotenoids.org **e-mail**: info@ivr.ie

FORTHCOMING / RECENT PUBLICATIONS

SIGHT AND LIFE Magazine 28 (1) 2014. PO Box 2116, 4002 Basel, Switzerland, **tel:** 41-61-815-8756, **e-mail**: klaus.kraemer@sightandlife.org **website:** www.sightandlife.org. See especially:
Emerging science on lutein in the brain. Johnson E. James Allen Olson Memorial Lecture, pp 22-26.
The 2014 CARIG Conference, San Diego, California. Solomons N. pp 70-72.

Carotenoid Science, vol 18, June 2014. Special issue. Abstracts of the papers presented at the 17th International Symposium on Carotenoids.

Skin and plasma carotenoid response to a provided intervention diet high in vegetables and fruit: uptake and depletion kinetics. Jahns L, Johnson LK, Mayne ST, et al. Am J Clin Nutr 2014;100:930–7.

Macular pigment carotenoids in the retina and occipital cortex are related in humans. Vishwanathan R, Schalch W, Johnson EJ. Nutr Neurosci (accepted).

Bioavailability of AREDS1 micronutrients from softgel capsules and tablets: a pilot study. Johnson EJ, Vishwanathan R, Rasmussen HM, Lang JC. Mol Vis 2014; 20:1228-42.

Lutein is the predominant carotenoid in infant brain: Preterm infants have decreased concentrations of brain carotenoids. Vishwanathan R, Kuchan MJ, Sen S, Johnson EJ. J Ped Gastr & Nutr 2014 Mar 31. [Epub ahead of print]. PMID: 2461400

Genetic Evidence for Role of Carotenoids in Age-Related Macular Degeneration in the Carotenoids in Age-Related Eye Disease Study (CAREDS). Meyers KJ, Mares JA, Igo RP, et al. Inv Ophthal Vis Sci 2014; 55:587-99.

Caco-2 accumulation of lutein is greater from human milk than from infant formula despite similar bioaccessibility. Lipkie TE, Banavara D, Shah B, Morrow AL, McMahon RJ, Jouni ZE, Ferruzzi MG. Mol Nutr Food Res 2014 Jun 27.[Epub ahead of print]. Mnfr:201400126

Biofortified orange maize is as efficacious as a vitamin A supplement in Zambian children even on the background of high liver reserves of vitamin A: a community-based, randomized placebo-controlled trial. Gannon B, Kaliwile C, Arscott S, et al. Am J Clin Nutr (accepted).

Alphabetical Listing of Recent Publications may be found at **www.carotenoidsociety.org/articles-books-and-databases.** It is prepared by Dr. Harold Furr, Department of Nutritional Sciences, University of Wisconsin, Madison.

MEETING REPORTS

CARIG Conference 2014 in San Diego

The CARIG Conference 2014 was held on Friday, April 25, at the San Diego Convention Center. Dr. Elizabeth Johnson (Tufts University) gave the Olson Memorial Lecture entitled “Emerging Science on Lutein in the Brain”. The topic of this year Symposium was “Biological actions of apocarotenoids”. Four speakers were invited to present their latest findings in the field:

Ken Riedl, from Ohio State University, presented a talk entitled “Picking up the pieces - analysis of apocarotenoids by LCMS”, focusing on the most advanced technologies to detect apocarotenoids in biological samples.

Carlo De La Sena, from Ohio State University, presented a talk entitled “Substrate specificity and reaction mechanism of vertebrate carotenoid cleavage oxygenases”, providing novel data that resolved a long-standing debate in regards to the mechanisms of action of the symmetric carotenoid cleavage enzyme.

Johannes von Lintig, from Case Western Reserve, presented a talk entitled “Two carotenoid oxygenases and provitamin A metabolism”, highlighting his latest finding in regards to the contribution of the two carotenoid cleavage enzymes towards the formation on retinoids *in vivo*.

Matthew Toomey, from Washington University, presented a talk entitled “Selective apocarotenoid metabolism facilitates avian color vision “, providing an update on the role of xanthophylls droplets narrowing the absorption spectrum, and the four cone types that supply increased acuity to bird vision.

All the talks were extremely exciting and presented the most recent findings from leading laboratories in the field of carotenoid research. The Q&A session reflected the high degree of interest of the topic of the Conference.

The CARIG Social & Poster Competition was very well attended. About 20 posters were displayed and discussion around them was again very active. Four volunteer judges selected the three winners of the poster competition (two graduate students and one undergraduate student), who received a $200 awards. The poster competition winners were: Brianna Costabile (Food Science Department, Rutgers University) "Mechanisms of β-carotene transfer from placenta to embryos in mammals"; Bryan Gannon "Biofortified orange maize is as efficacious as a vitamin A supplement in Zambian children even on the background of high liver reserves of vitamin A: a community-based, randomized placebo-controlled trial"; Kara Bresnahan "The acute phase response affected traditional measures of micronutrient status in rural Zambian children during a randomized, controlled feeding trial", both affiliated with Interdepartmental Graduate Program in Nutritional Sciences, University of Wisconsin, Madison. I would like to thank the co-Chair, Dr. Earl Harrison, for his help in organizing the CARIG EB 2014 Symposium.

For further information on the Symposium please also refer to *Sight and Life* 2014, 28 (1).

Loredana Quadro (CARIG Chair, 2013-2014)

Report on the 17th International Carotenoid Symposium 2014

Two hundred twenty carotenoid scientists from 33 countries gathered together at Canyons Mountain Resort in Park City, Utah for the 17th International Carotenoid Symposium (ICS) from June 29 to July 4, 2014. Held every three years, this marked the conference’s first return to the continental United States since 1987. The ICS meeting uniquely brings together hundreds of scientists from academia, industry, and government for five days of comprehensive interactions encompassing all

aspects of carotenoid science ranging from chemical synthesis to human genetics, and from photosynthesis to functional foods for chronic disease prevention. The local organizers, Paul and Ann Bernstein, along with crucial support from members of the International Carotenoid Society Council, put together an intriguing program with eight plenary speakers and 73 invited and selected platform presentations along with 87 poster presentations from young and established investigators. George Britton will prepare a more detailed summary of the science presented at the meeting, which will appear on the International Carotenoid Society's website. Thanks to generous support from 24 sponsors, the attendees were treated to a superb social program that included a cowboy-themed mountain top opening reception, tours of Salt Lake City's Temple Square and the University of Utah's Museum of Natural History, a gala dinner at the Utah Olympic Sports Park featuring the Flying Aces aerial ski team, and an all-resort Independence Day fireworks show. Feedback from the attendees was uniformly positive, and we hope even more carotenoid researchers will attend upcoming meetings including the Macular Carotenoids Conference in Cambridge, England, July 2015, the Gordon Conference on Carotenoids in 2016, and the 18th International Carotenoid Symposium in Lucerne, Switzerland, July 2017.

Paul S. Bernstein (Salt Lake City, UT)

TECHNICAL NOTES

Carotenoids colorants in food industry

Manufacturers of energy drinks and flavored waters can now use clear carotenoid solutions from DSM instead of azo dyes.

FDA recently approved the use of tomato lycopene extract and concentrate as coloring agents in ready-to-eat meat products. Lycopene may restore color to processed meats, giving manufacturers of sausages, deli meats and jerky an alternative to synthetic FD&C Red#40 and carmine. Carmine is made from crushed cochineal beetles and cannot be used in kosher or halal products.

www.foodmanufacture.co.uk 8/21/2014
www.foodnavigator-usa.com 8/19/2014

Astaxanthin production in thin-walled tubes

A closed tube system has been used by Algatechnologies Ltd. to grow *Haematococcus pluvialis*, an astaxanthin-producing algae, in the Negev region of southern Israel. Open pond systems are more susceptible to large scale contamination. The company is testing now thinner glass tubes produced by Schott AG (DURAN glass). They absorb less solar radiation and caused 10% increase in production of astaxanthin, branded as AstaPure.

Nutraingredients-usa.com 9/23/2014

NEWS AND VIEWS

Lutein is the predominant carotenoid in infant brain

Lutein and zeaxanthin are dietary carotenoids that may influence visual and cognitive development. The objective of this study was to provide the first data on distribution of carotenoids in the infant brain and compare concentrations in preterm and term infants. Voluntarily donated brain tissues from 30 infants, who died during the first 1.5 years of life, were obtained from the NICHD Brain and Tissue Bank. Tissues (hippocampus and prefrontal, frontal, auditory and occipital cortices) were extracted using standard lipid extraction procedures and analyzed using reverse phase HPLC. Lutein, zeaxanthin, cryptoxanthin and β-carotene were the major carotenoids found in the infant brain tissues. Lutein was the predominant carotenoid accounting for 59% of total carotenoids. Preterm infants (n=8) had significantly lower concentrations of lutein, zeaxanthin and cryptoxanthin in their brain compared to term infants (n=22). Among formula-fed infants, preterm infants (n=3) had lower concentrations of lutein and zeaxanthin compared to term infants (n=5). Brain lutein concentrations were not different between breast milk-fed (n=3) and formula-fed (n=5) term decedents. In contrast, term decedents with measurable brain cryptoxanthin, a carotenoid that is inherently low in formula, had higher brain lutein suggesting that type of feeding is an important determinant of brain lutein concentrations. These data reveal preferential accumulation and maintenance of lutein in the infant brain despite its low amounts in the typical infant diet. Further investigation on the impact of lutein on neural development in preterm infants is warranted.

Vishwanathan R et al. J Pediatr Gastroenterol Nutr. 3/31 (2014). [Epub ahead of print]

Effects of maternal lutein supplementation in women and their infants

Lutein is a carotenoid that varies in breast milk depending on maternal intake. Data are lacking with regard to the effect of dietary lutein supplementation on breast milk lutein concentration during lactation and subsequent plasma lutein concentration in breast-fed infants. This study was conducted to determine the impact of lutein supplementation in the breast milk and plasma of lactating women and in the plasma of breast-fed infants, 2-3 mo postpartum. Lutein is the dominant carotenoid in the infant brain and the major carotenoid found in the retina of the eye. Eighty-nine lactating women 4-6 wk postpartum were randomly assigned to be administered either

placebo, 6 mg/d of lutein (low-dose), or 12 mg/d of lutein (high-dose). The supplements were consumed for 6 wk while mothers followed their usual diets. Breast milk carotenoids were measured weekly by HPLC, and maternal plasma carotenoid concentrations were measured at the beginning and end of the study. Infant plasma carotenoid concentrations were assessed at the end of the study. No significant differences were found between dietary lutein + zeaxanthin intake and carotenoid concentrations in breast milk and plasma or body mass index at baseline. Total lutein + zeaxanthin concentrations were greater in the low- and high-dose-supplemented groups than in the placebo group in breast milk (140% and 250%, respectively; P<0.0001), maternal plasma (170% and 250%, respectively; P<0.0001), and infant plasma (180% and 330%, respectively; P<0.05). Lutein supplementation did not affect other carotenoids in lactating women or their infants. Lactating women are highly responsive to lutein supplementation, which affects plasma lutein concentrations in the infant.

Sherry CL et al. J Nutr 144:1256-63 (2014)

Skin and plasma carotenoid response

Objective biomarkers are needed to assess adherence to vegetable and fruit intervention trials. Blood carotenoids are considered the best biomarker of vegetable and fruit intake, but collecting blood is invasive and the analyses are relatively expensive for population studies. Resonance Raman spectroscopy (RRS) is an innovative method for assessing carotenoids in skin noninvasively. Our objective was to compare blood carotenoid concentrations with skin carotenoid assessments by RRS during a controlled feeding intervention. Twenty-nine participants consumed low-carotenoid diets (6 wk, phases 1 and 3), a provided diet containing 6-cup equivalents (1046 g/d) of vegetables and fruit (8 wk, phase 2), and usual diet (final 8 wk, phase 4). At baseline, skin and plasma total carotenoid values were correlated (r = 0.61, P< 0.001). Skin and plasma carotenoid values decreased (P<0.001) 36% and 30%, respectively, from baseline to the end of phase 1 and then increased (P<0.001) by >200% at the end of phase 2. Plasma carotenoids returned to baseline concentrations by the middle of phase 3 and skin carotenoid concentrations by the middle of phase 4. Skin carotenoid status predicted plasma values by using a mixed linear model including all time points (r = 0.72, P<0.001), which indicates that changes in skin carotenoid status closely follow changes in plasma across a broad range of intakes. At the individual level, skin carotenoids predicted plasma values (r = 0.70, P<0.001) over all time points. Skin carotenoid status assessed by resonance Raman spectroscopy is a noninvasive, objective biomarker of changes in vegetable and fruit intake.

Jahns L et al. Am J Clin Nutr 100:930-37 (2014)

β-carotene-producing gut bacteria may provide vitamin A

Vitamin A deficiency (VAD) is an overwhelming public health problem that affects hundreds of millions of people worldwide. A definitive solution to VAD has yet to be identified. Because it is an essential nutrient, vitamin A or its carotenoid precursor β-carotene can only be obtained from food or supplements. In this study, we wanted to establish whether β-carotene produced in the mouse intestine by bacteria synthesizing the provitamin A carotenoid could be delivered to various tissues within the body. We used *Escherichia coli* MG1655*, an intestine-adapted spontaneous mutant of *E. coli* MG1655, and the plasmid pAC-BETA, containing the genes coding for the four key enzymes of the β-carotene biosynthetic pathway (geranylgeranyl pyrophosphate synthase, phytoene synthase, phytoene desaturase, and lycopene cyclase) from *Erwinia herbicola*. We engineered the *E. coli* MG1655* to produce β-carotene during transformation with pAC-BETA (MG1655*-βC) and gavaged wild-type and knockout mice (for β-carotene 15,15'-oxygenase) with this recombinant strain. Various regimens of bacteria administration were tested (single vs. multiple and low vs. high doses). β-Carotene concentration was measured by HPLC in mouse serum, liver, intestine, and feces. Enumeration of MG1655*-βC cells in the feces was performed to assess efficiency of intestinal colonization. We demonstrated *in vivo* that probiotic bacteria could be used to deliver vitamin A to the tissues of a mammalian host. These results have the potential to pave the road for future investigations aimed at identifying alternative, novel approaches to treat VAD.

Wassef L et al. J Nutr 144:608-13 (2014)

Avocado consumption enhances β-carotene absorption and conversion

Dietary lipids have been shown to increase bioavailability of provitamin A carotenoids from a single meal, but the effects of dietary lipids on conversion to vitamin A during absorption are essentially unknown. Based on previous animal studies, we hypothesized that the consumption of provitamin A carotenoids with dietary lipid would enhance conversion to vitamin A during absorption compared with the consumption of provitamin A carotenoids alone. Two separate sets of 12 healthy men and women were recruited for 2 randomized, 2-

way crossover studies. One meal was served with fresh avocado (*Persea americana* Mill), cultivated variety Hass (delivering 23 g of lipid), and a second meal was served without avocado. In study 1, the source of provitamin A carotenoids was a tomato sauce made from a novel, high–β-carotene variety of tomatoes (delivering 33.7 mg of β-carotene). In study 2, the source of provitamin A carotenoids was raw carrots (delivering 27.3 mg of β-carotene and 18.7 mg of α-carotene). Postprandial blood samples were taken over 12 h, and provitamin A carotenoids and vitamin A were quantified in triglyceride-rich lipoprotein fractions to determine baseline-corrected area under the concentration-vs.-time curve. Consumption of lipid-rich avocado enhanced the absorption of β-carotene from study 1 by 2.4-fold (P <0.0001). In study 2, the absorption of β-carotene and α-carotene increased by 6.6- and 4.8-fold, respectively (P<0.0001 for both). Most notably, consumption of avocado enhanced the efficiency of conversion to vitamin A (as measured by retinyl esters) by 4.6-fold in study 1 (P<0.0001) and 12.6-fold in study 2 (P = 0.0013). These observations highlight the importance of provitamin A carotenoid consumption with a lipid-rich food such as avocado for maximum absorption and conversion to vitamin A, especially in populations in which vitamin A deficiency is prevalent.

Kopec RE et al. J. Nutr (2014) 144: 1158-1166

"Super" banana

Genetically modified Australian fruit could save the sight and lives of thousands of East African children. Queensland University of Technology (QUT) researchers have engineered bananas to increase the levels of α- and β-carotene, which are converted to vitamin A in the body. About 10 kilograms of the yellow fruit with orange flesh, grown near Innisfail, have been shipped to Iowa State University, where the trials are being conducted. Five Ugandan PhD students are working with Professor James Dale on the nine-year project, backed by nearly 10 million dollars from the Bill and Melinda Gates Foundation. Dr. Dale said that by 2020 the pro-vitamin A-enriched banana varieties would be grown by farmers in Uganda, where about 70% of the population survive on the fruit. "The East African cooking banana, which is chopped and steamed, is a staple food of many East African nations, but it has low levels of micronutrients, particularly pro-vitamin A and iron. We are aiming to increase the level of pro-vitamin A to a minimum level of 20 µg/g dry weight." Previous US trials using Mongolian gerbils had already proved successful. However, for the bananas to be planted in Uganda, the country's legislature has to approve a bill allowing genetically modified crops. The same technology could be transfered to plantains, which are dietary staples in Rwanda, parts of the Democratic Republic of Congo, Kenya and Tanzania.

Washington Post 6/17/2014

Bear's Dilemma

"It is a real struggle to stay on a healthy, Ω-3 and carotenoid rich diet, when junk food is so readily available."
(Adapted from Non Sequitur by Wiley Miler)

Internet Addresses for Carotenoid Researchers

1. USDA Nutrient Database for Standard Reference (SR25) is a major source of food composition data for epidemiologists and nutritionists. The carotenoid database contains the best available estimates of carotenoid content in foods. The Agricultural Research Service (ARS) searchable database allows one to view carotenoid profile for more than 13,000 foods: www.ars.usda.gov/foodsearch, www.ars.usda.gov/Services/docs.htm?docid=2114.
2. International Carotenoid Society (ICS) **Website**: www.carotenoidsociety.org
3. Carotenoid Section of the Lipid Database developed by Research Institute, International Medical Center of Japan webpage: www.lipidbank.jp. Also available on ICS webpage: www.carotenoidsociety.org through **Articles** button.

Published twice a year, in February and August, by

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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