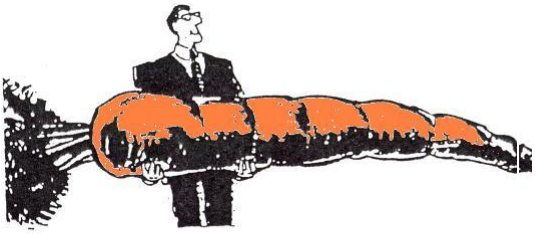

Carotenoid News

Vol. 22, No. 2
August 2012

FROM THE EDITOR

"Why, then, can one desire too much of a good thing?" Shakespeare, As You Like It, Act 4, Scene 1

We all want to live a long life in excellent health and therefore we are always looking for good things to assure our well being – special diets, supplements and exercise. It is natural to think that higher doses of these good things will have even more beneficial effects. Recently, however, many scientists are expressing doubts about high intakes of some nutrients, including β-carotene, even in dietary form. The excessive intake may be particularly unwise for people with preexisting cancer, those who smoke or indulge in alcohol. We do not know enough about the actions of β-carotene, a powerful nutraceutical, certainly not limited to providing safe doses of vitamin A and a nice tint to our skin. Apparently degradation products of β-carotene eccentric cleavage (enzymatic and nonenzymatic) include β-apocarotenals, corresponding carotenoic acids and carotenones, which may be found in human plasma (*Eroglu et al, 2012*, see News and Views). Some of these degradation products compete with retinoic acid for binding to its receptors (RARs), which are nuclear transcription factors. This antagonism with vitamin A may inhibit the expression of retinoid responsive genes that control a plethora of biological processes. Medical literature reports cases of negative health effects in people ingesting excessive amounts of other carotenoids (lycopene, canthaxanthin) due to self-imposed, very restrictive diets or supplements. Apparently it is possible to desire too much of a good thing. As Hippocrates advised – "*everything in excess is opposed to nature"*, even carotenoids!

Maria S. Sapuntzakis (Chicago)

News from CARIG Steering Committee

CARIG continues to promote research into nutritional roles, functions, and actions of carotenoids and their metabolites. Please mark your calendars for several upcoming CARIG sponsored events to be held next spring at *Experimental Biology 2013*. The CARIG 2013 Conference will again be held on the Friday afternoon before the Saturday opening of the ASN program. *EB2013* also will feature a CARIG/VARIG trainee poster and award session and business meeting during the annual social following the CARIG Conference. The steering committee has also set the CARIG minisymposium topics for 2013:
Carotenoids and Health
Carotenoids & Retinoids: Molecular Mechanisms of Action
Bioavailability & Metabolism of Carotenoids & Vitamin A
Carotenoids: Eye and Brain Health
Biofortification of Staple Crops with Micronutrients
Thank you to all who have already volunteered to help us in the coming year. Special thanks to our outgoing officers, Mario Ferruzzi, Chair, and Elizabeth Johnson, Treasurer, and to our new Treasurer, Jessica Campbell, and Chair Elect, Loredana Quadro. If you are interested in contributing as a RIS officer, or if you have ideas for symposia or CARIG Conference topics for *EB 2014*, please contact RIS leadership: Mario Ferruzzi (Past Chair, mferruzz@purdue.edu), Earl Harrison (Chair, harrison.304@osu.edu), or Loredana Quadro (Chair Elect, quadro@aesop.rutgers.edu). Additional information on these events will appear through the CARIG ListServe and in subsequent issues of *Nutrition Notes,* as well as in the next issue of *Carotenoid News.*
The current membership of the Committee includes:
Earl Harrison (Chair) – Ohio State University
Mario Ferruzzi (Past Chair) – Purdue University
Loredana Quadro(Chair Elect) – Rutgers University
Jessica Campbell (Treasurer) – General Mills
Harold Furr - University of Wisconsin - Madison
Elizabeth Johnson – Tufts University
Klaus Kraemer – Task Force Sight and Life
Lewis Rubin – University of South Florida
Maria Stacewicz-Sapuntzakis (newsletter editor)
Sherry Tanumihardjo – University of Wisconsin
Student representatives:
Shellen Goltz – Purdue University
Kara Bresnahan - University of Wisconsin - Madison

We are grateful to Elizabeth Johnson and Lewis Rubin for organizing very successful CARIG EB 2012 Conference. The report from this conference may be found in this newsletter.

Earl Harrison, CARIG Chair

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 2013. 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'13, 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: Earl Harrison, **e-mail**: harrison.304@osu.edu

UPCOMING EVENTS

November 29 - December 1, 2012
12th International Conference: Functional Food Ingredients and Nutraceuticals in Chronic Diseases: Science and Practice. Dallas, TX, Contact: Organizing Committee, 100 N. Central Exppy, Suite 522, Richardson TX, 75080, USA, **tel**: 866-464-6955 (toll free), or 469-441-8272, **website**: www.functionalfoodscenter.net

January 6-11, 2013
Gordon Research Conference (GRC) on Carotenoids, Ventura, CA. The GRC will be preceded by a new **Carotenoids Gordon Research Seminar (GRS)** for early career scientists to be held at the same location on **Jan 5-6, 2013**. Contact: www.grc.org [see information below]

April 20-24, 2013
Experimental Biology 2013, Boston, MA.
Contact: EB2013, FASEB Office of Scientific Meetings & Conferences, 950 Rockville Pike, Bethesda, MD 20814-3998, **website:** www.experimentalbiology.org, **e-mail:** eb@faseb.org

Gordon-Kenan Research Seminar
Emerging Roles of Carotenoids in Living Organisms
January 5-6, 2013
Ventura Beach Marriott, Ventura, CA
Chair: Jaime Amengual Terrasa
Associate Chair: Jesus Beltran

The Carotenoids Gordon-Kenan Research Seminar will be held in conjunction with the Carotenoids Gordon Research Conference. Those interested in attending both meetings must submit an application for the GRC in addition to an application for the GKRS. The Gordon Research Seminar on Carotenoids is a unique forum for graduate students, post-docs, and other scientists with comparable levels of experience and education to present and exchange new data and cutting edge ideas. The focus of this meeting is to explore the broad spectrum of the carotenoid field, from basic to applied research. Topics of interest include, but are not limited to: recent advances in carotenoid research in plants, fungi and animal models, genomics and systems biology of carotenoids, carotenoid biosynthesis and cleavage, carotenoids and their derivatives as signaling molecules in plants and animals, and the relationship of carotenoids with health and disease processes. The meeting will feature approximately 10 talks and 2 poster sessions. All attendees are expected to actively participate in the GRS either by giving an oral presentation or presenting a poster. Therefore, all applications must include an abstract.

Gordon Research Conference on Carotenoids
January 6-11, 2013
Ventura Beach Marriott, Ventura, CA
Chairs: Eleanore T. Wurtzel & Xiang-Dong Wang
Vice Chair: Johannes Von Lintig

Carotenoids are among the most ubiquitous of natural pigments and have been the focus of research efforts in the fields of plant biology, chemistry, biochemistry, physiology, nutrition, and medicine for over a century. The Gordon Research Conference on Carotenoids has been held triennially since 1992. The 2013 8th Gordon Research Conference on Carotenoids will uphold the tradition of bringing together multidisciplinary research investigators at the forefront of carotenoid science. The conference will showcase exciting developments and updates with presentations on breeding for human health; metabolic engineering of provitamin A carotenoids; biosynthesis and regulation; apocarotenoid biogenesis and signaling; carotenoid transport and metabolism; biological actions of carotenoids and their metabolites; carotenoids and chronic disease prevention; carotenoids in photosynthesis and apocarotenoids in vision. Academic, industrial and government participants are welcome and all are strongly encouraged to present their most recent unpublished findings as posters for which ample time has been allotted. Selected posters will be chosen for short oral presentations during the conference.

Preliminary session topics and speakers:

Breeding for Human Health (*Joseph Hirschberg / Gerard Barry / Yaakov Tadmor / Giovanni Giuliano)*

Carotenoid Biosynthesis (*Manuel Rodriguez-Concepcion / Barry Pogson / Li Li / Jerilyn A. Timlin / Asaph Aharoni)*

Carotenoids and Health: Epidemiology and Animal Studies (*Susan Mayne / Nancy Engelmann*

Moran / Lisa Jahns / Chun Liu)

Apocarotenoid Biogenesis (*Earl Harrison / Salim Al-Babili / Loredana Quadro / William S. Blaner / Glenn Lobo)*

Carotenoids and Health: Molecular Mechanisms (*Paola Palozza / John Erdman / Ralph Rühl / Patrick Borel)*

Apocarotenoid Signaling (*Harry Klee / Enrico Martinoia / Peter McCourt / Ouliana Ziouzenkova / Catherine Rameau)*

Carotenoid and Apocarotenoid Functions in Diverse Organisms (Asaph Aharoni / *Kevin J. McGraw / Joseph Bassaganya-Riera / Sean Cutler)*

Photosynthesis and Photochemistry (*Harry Frank / Ana Moore / Michael Tauber / Krishna Niyogi / Michel Havaux)*

Apocarotenoids in Vision (*Paul Bernstein / Kris Palczewski / Graeme Wistow / Rosalie Crouch)*

RECENT / FORTHCOMING PUBLICATIONS

SIGHT AND LIFE Magazine 26 (1) 2012. PO Box 2116, 4002 Basel, Switzerland, **tel:** 41-61-815-8756, **website:** www.sightandlife.org
e-mail: klaus.kraemer@sightandlife.org

Molecular Nutrition & Food Research, 56(2), 2012. Special Issue: Carotenoids in Nutrition and Health – Developments and Future Trends. Ed. W Stahl.

Life on Two Sides of the Planet by Arun Barua. Kindle eBook, April 2012. A memoir of well known scientist involved in vitamin A and carotenoid research.

Lifting the Shadow of Death. World Review of Nutrition and Dietetics Vol 104. 2012. Eds. RD Semba, B. Koletzko, AP Sinopoulos.

Alphabetical Listing of Recent Publications may be found at www.carotenoidsociety.org under **Articles.** It is prepared by Dr. Harold Furr, Department of Nutritional Sciences, University of Wisconsin, Madison.

MEETING REPORT
CARIG CONFERENCE 2012 IN SAN DIEGO

The annual Carotenoid Research Interactive Group (CARIG) Conference was held in San Diego on Friday, April 20, 2012. The keynote speech (the 11th James Allen Olson *Perspectives on Carotenoids* Memorial Lecture) was delivered by Dr. Sherry Tanumihardjo of the University of Wisconsin-Madison, who had worked for over 20 years with Prof. Olson at the Iowa State University. Her topic was "Xanthophylls as Provitamin A Carotenoids," which bridged from the biological considerations currently directed at disease prevention, to the context of nutritional adequacy of vitamin A in developing countries. It included the biopathways for the production of β-cryptoxanthin, as a neglected provitamin A, and its importance in high-carotenoid maize varieties for vitamin A interventions in Africa.

Four additional talks filled out the conference theme of "Xanthophylls: Dietary Sources and Impact through the Life Cycle". This was led off by a discussion by B. Randy Hammond Jr., of the Visual Science Laboratory of the University of Georgia – Athens, with a talk entitled "Xanthophylls and eye development". Within the eye, lutein and zeaxanthin are concentrated in the macula (fovea) of the retina. In human development, these xanthophylls are highest in the vitreal space of the fetal eye at 6 weeks, but redistributed to the lens and the retina by 20 weeks of gestation. During pregnancy, the concentration of these oxy-carotenoids rises with advancing trimesters, and they constitute the highest fraction of the carotenoids family in cord blood at birth. The combined levels of lutein and zeaxanthin double from the first to the second year of postnatal life. Lutein is in highest concentration among the carotenoids in colostrum, falling by half in mature maternal milk. At one month of life, the plasma levels of lutein in infants fed regular infant formula are one-fourth those of breast-fed infants. Lutein in milk tracks that in the circulation of the lactating mother. However, a lutein-supplemented formula can produce comparable levels as with natural lactation, although the efficiency of uptake is superior from maternal milk. Increased antioxidant capacity with lutein supplementation has recently been demonstrated in infants.

Rohini Vishwanathan mobilized an impressive amount of inferential as well as direct evidence to discuss the theme of "Xanthophylls in the infant brain" in a two-stage syllogism: 1) lutein status is related to cerebral function, and 2) xanthophyll carotenoids predominate in the pediatric brain. This inductive journey began at the other extreme of the lifespan, with illustration of retinal luteín and zeaxanthin's relationship with macular degeneration and the differentiation of the pattern of circulating carotenoids (dominated by β-carotene) and of cerebral carotenoids (dominated by lutein). Functional associations were demonstrated for the elderly in macular xanthophyll density and resistance to degenerative ocular disease, as well as for cerebral xanthophyll levels and slower rates of cognitive decline. Finally, evidence from non-human primates was shown that brain xanthophyll

concentrations correlated with macular lutein and zeaxanthin. It was concluded that cerebral lutein may be a correlate of high central nervous functions of vision and cognition. On the other hand, the circulating levels of lutein plus zeaxanthin increase over the first month of life. Approximately one-quarter of the carotenoids in human milk is constituted by lutein. Concentrations of the two xanthophylls increase in milk over time of lactation, whereas carotenes are stable. Postmortem cerebral material from 30 infants dying from SIDS and other acute illnesses was obtained from tissue banks and analyzed for carotenoids content. Lutein was the most abundant carotenoid. Comparing the pattern of average dietary carotenoids intake from 2 to 11 months (using NHANES data), with the concentrations of the respective carotenoids in the brain, there is evidence for selectivity; lutein constitutes 12% of the dietary carotenoids and 60% of the brain carotenoid content. Dr. Vishwanathan tentatively concludes that lutein may be important in early neural development and called for further investigation in that regard.

Maize is a staple crop of many parts of the world. Originally a New World crop, corn was imported into Africa to improve the efficiency of the slave trade, and has become a staple crop in West and Southern Africa. As discussed in the Olson Memorial lecture, plant breeding can produce variety of maize cultivars. To the detriment of vitamin A nutrition, the major preference is for white maize. Across the world, yellow corn is often associated with animal fodder and rejected for human consumption. Since maize has been bred to be white, the acceptability of deeply hued corn is an uncharted territory. This connected directly to the presentation entitled “Breeding for Enhanced Carotenoid Profiles” by Torbert Rocheford of Purdue University, exploring research to understand the genetic bases of the cross-breeding of maize for greater expression of provitamin A carotenoids, which can be sources of active vitamin A.

The diverse array of colors among the varieties of maize is a product of the expression of various enzymes of the carotenoid pathways. The biosynthetic pathways of carotenoids are well understood. What the Purdue group has done is to understand the genetic basis of the natural variation of the traits determining carotenoids, with a specific focus on maximizing β-carotene (and other provitamin A carotenoids). Dr. Rocheford demonstrated a genetic mapping for maize varieties, which can be performed with HPLC analysis, genetic polymorphism assessment and gene sequencing. In this way, the investigation can determine the association of the color and the genetic make-up of the corn plant. Then, with inbreeding and intensification of the trait, the relationship with the genetic constitution can be assessed. The approach proved valid to select genotypes that stream more of the carotenoids pathway into the provitamin A (β-carotene) expression.

Joanne Holden, from the Nutrient Data Laboratory (NDL) of the USDA at the Beltsville Human Nutrition Research Center, wrapped up the day’s session with an update on food-composition data for the carotenoids content in foods and beverages. She defined her objectives as threefold: 1) to present the history of carotenoids databases in NDL; 2) to discuss the status of efforts to expand carotenoid data for foods; and 3) to feature data for lutein and for zeaxanthin. With respect to the first objective, the food-composition work began in 1983, when it was considered imperative to go beyond “total carotenoids” and to specify individual carotenoids. Ten years later, a provisional database with 5 carotenoids in 206 foods was released. Pressure from the ongoing NHANES process pushed the process forward, so that by 2012 the NDL provides carotenoids content of 3000 foods. The process is based on five steps: acquisition of data sources, evaluation of data quality, aggregation of acceptable values, compilation and calculations, and finally dissemination of database. The data sources include the literature, food industry data, label information and various specific public and private sources. These are churned through a central database before going into the Standard Reference and finally to the Food and Nutrition Database for Dietary Surveys (FNDDS). There is a steering element for this process in the National Food and Nutrient Analysis Program (NFNAP), in charge of identifying key foods and critical nutrients of interest, evaluating existing data quality, devising and implementing a nationally-based sampling plan, analyzing sampled foods and the validity of the analytical methods, and making representative estimates. In terms of lutein and zeaxanthin, there have been relatively few recent and ongoing new analyses. In the entire data-base for lutein/zeaxanthin, only 8.6% are analyzed values. Some 48.3% are calculated data, and the remaining 42.8% are assumed to be negligible. Green leafy vegetables, spinach and kale, have the highest values. Broccoli, pistachio nuts, and raw egg yolks are other foods with high lutein levels, whereas three forms of maize (popcorn, boiled sweet corn and tortilla chips) and raw egg yolks are leaders for zeaxanthin. Levels of both xanthophylls are negligible in sweet potato and cauliflower.

There were three winners in the poster competition for graduate students and post-doctoral fellows in the evening’s CARIG/VARIG Reception

Social. Rohini Vishwanathan of Tufts University was awarded for her poster “Relationship between brain lutein (L) and zeaxanthin (Z) and retinal L and Z in humans.” Amy Elsen of the University of Illinois-Champagne/Urbana won for her presentation “Genotypic differences impact serum and hepatic lipids in mice lacking carotenoid cleavage enzymes.” Tristan Lipkie of Purdue University received the competition prize on the basis of his work “Effect of lactation stage on the content and bioaccessibility of carotenoids in human milk.”

In addition to the stimulating presentations and discussions at the CARIG Conference and Social, the Experimental Biology 2012 had four sessions, featuring research on carotenoids in health, bioavailability & metabolism, and eye & brain.

Noel W. Solomons
CeSSIAM, Guatemala City

Elizabeth A. Johnson
The Jean Mayer Human Nutrition Research Center on Aging, Boston, MA, USA

Winners of CARIG 2012 poster competition
From left: Tristan Lipkie, Amy Elsen, Rohini Vishwanathan, *with Dr. Mario Ferruzzi (in glasses)*

TECHNICAL NOTE

Enhanced biohybrid solar cells

An interdisciplinary team of researchers at Vanderbilt University has developed a way to combine the photosynthetic protein (PS1) from spinach, with silicon, the material used in solar cells *(LeBlanc et al. Advanced Materials, 9/4/2012, doi: 10.1002/adma. 201202794).* When a PS1 protein exposed to light, it absorbs the energy in the photons and uses it to free electrons and transport them to one side of the protein. PS1 contains β-carotene molecules in its structure. More than 40 years ago, scientists discovered that PS1 continued to function when it was extracted from plants. Then they determined that PS1 converts sunlight into electrical energy with nearly 100% efficiency, compared to conversion efficiencies of less than 40% achieved by manmade devices. Researchers have developed ways to extract PS1 efficiently from leaves. They have demonstrated that it can be made into cells that produce electrical current when exposed to sunlight. However, the amount of power that these biohybrid cells can produce per square inch has been substantially below that of commercial photovoltaic cells. The Vanderbilt researchers report that their PS1/silicon combination produces 850 microamps of current per cm^2 at 0.3 volts. That is nearly 2.5-fold more current than the best level reported previously from a biohybrid cell. The reason this combo works so well is because the electrical properties of the silicon substrate have been tailored to fit those of the PS1 molecule. This is done by implanting electrically charged atoms in the silicon to alter its electrical properties: a process called "doping." In this case, the protein worked extremely well with silicon doped with positive charges and worked poorly with negatively doped silicon. To make the device, the researchers extracted PS1 from spinach into an aqueous solution and poured the mixture on the surface of a p-doped silicon wafer. Then they put the wafer in a vacuum chamber in order to evaporate the water away leaving a film of protein. They found that the optimum thickness was about one micron, about 100 PS1 molecules thick. The potential advantage of these biohybrid cells is that they can be made from cheap and readily available materials, unlike many microelectronic devices that require rare and expensive materials like platinum or indium.

www.laboratoryequipment.com/news/2012/09

NEWS AND VIEWS

Eccentric cleavage products of β-carotene function as antagonists of retinoic acid receptors

β-Carotene is the major dietary source of provitamin A. Central cleavage of β-carotene catalyzed by β-carotene oxygenase 1 yields two molecules of retinaldehyde. Subsequent oxidation produces all-trans-retinoic acid (ATRA), which functions as a ligand for a family of nuclear transcription factors, the retinoic acid receptors (RARs). Eccentric cleavage of β-carotene at non-central double bonds is catalyzed by other enzymes and can also occur non-enzymatically. The products of these reactions are β-apocarotenals and β-apocarotenones, whose biological functions in mammals are unknown. We used reporter gene assays to show that none of the β-apocarotenoids significantly activated RARs. Importantly, however, β-apo-14′-carotenal, β-apo-14′-carotenoic acid, and β-apo-13-carotenone antagonized ATRA-induced transactivation of RARs. Competitive radioligand binding assays demonstrated that these putative RAR antagonists compete directly with retinoic acid for high affinity binding to purified receptors. Molecular modeling studies confirmed that β-apo-13-carotenone can interact directly with the ligand binding site of the retinoid receptors. β-Apo-13-carotenone and the β-apo-14′-carotenoids inhibited ATRA-induced expression of retinoid responsive genes in Hep G2 cells. Finally, we developed an LC/MS method and found 3–5 nM β-apo-13-carotenone was present in human plasma. These findings suggest that β-apocarotenoids function as naturally occurring retinoid antagonists. The antagonism of retinoid signaling by these metabolites may explain the negative health effects of large doses of β-carotene.

Eroglu A et al. J Biol Chem 2012; 287:15886-95

Dietary fat amount and type modulates postprandial absorption of carotenoids

Dietary lipids are considered to be primary potentiators of carotenoid absorption, yet the amount and source required to optimize bioavailability has not been systematically evaluated. The objective of this study was to examine the impact of both amount and source of triacylglycerols on postprandial absorption of carotenoids from vegetable salads. Healthy subjects (n = 29) were randomized using a Latin square design (3×3) and consumed three identical salads with 3, 8, or 20 g of canola oil, soybean oil, or butter. Blood was collected for 10 h and triacylglycerol-rich fractions (TRLs) were isolated by ultracentrifugation. Carotenoid contents of TRL fractions were analyzed by HPLC with diode array detection. Considering all lipid sources, 20 g of lipid promoted higher absorption compared to 3 and 8 g for all carotenoid species (p<0.05), except for α-carotene (p = 0.07). The source of lipid had less impact on the absorption of carotenoids than amount of lipid. Pooling results from all lipid amounts, monounsaturated fatty acid rich canola oil trended toward enhancing absorption of lutein and α-carotene compared to saturated fatty acid rich butter (p = 0.06 and p = 0.08, respectively). While both amount and source of co-consumed lipid affect carotenoid bioavailability from vegetables, amount appears to exert a stronger effect.

Goltz SR et al. Mol Nutr Food Res 2012;56:866-77

Light-induced electron transfer and ATP synthesis in aphids

A singular adaptive phenotype of a parthenogenetic insect species (*Acyrthosiphon pisum*) was selected in cold conditions and is characterized by a remarkable apparition of a greenish color. The aphid pigments involve carotenoid genes well defined in chloroplasts and cyanobacteria and amazingly present in the aphid genome, likely by lateral transfer during evolution. The abundant carotenoid synthesis in aphids suggests strongly that a major and unknown physiological role is related to these compounds beyond their canonical anti-oxidant properties. We report here that the capture of light energy in living aphids results in the photo induced electron transfer from excited chromophores to acceptor molecules. The redox potentials of molecules involved in this process would be compatible with the reduction of the NAD^+ coenzyme. This appears as an archaic photosynthetic system consisting of photo-emitted electrons that are *in fine* funnelled into the mitochondrial reducing power in order to synthesize ATP molecules.

Valmalette JC et al. Nature, August 16, 2012, doi:10.1038/srep00579

Macular carotenoid supplementation in subjects with atypical spatial profiles of macular pigment

This study was designed to investigate the impact of macular carotenoid supplementation on the spatial profile of macular pigment (MP) in subjects where the profile does not exhibit the typical central peak (i.e. peaked MP at foveal epicentre). Healthy subjects with such atypical MP spatial profiles were assigned to one of three intervention groups: Group 1: (n = 10), 20 mg/day lutein (L), 2 mg/day zeaxanthin (Z); Group 2: (n = 10), 10 mg/day *meso*-zeaxanthin (MZ), 10 mg/day L, 2 mg/day *Z*; Group 3:

(n = 10), 17 mg/day MZ, 3 mg/day L, 2 mg/day Z. Subjects were instructed to take one capsule daily over an 8-week period. MP at 0.25°, 0.5°, 1°, 1.75°and 3° was measured using customized-heterochromatic flicker photometry at baseline, 4 weeks and 8 weeks. Over the study period, we report no statistically significant increase in MP at any eccentricity in Group 1 (p>0.05, for all eccentricities). There was a trend towards an increase in MP at all eccentricities in Group 2, with a significant increase found at 0.25° and 0.50° (p = 0.000 and p = 0.016, respectively). There was a statistically significant increase evident in MP at 0.25° in Group 3 (p = 0.005), but at no other eccentricity (p>0.05, for all other). We report that the typical central peak of MP can be realized in subjects with atypical spatial profiles, following supplementation with a preparation containing all three macular carotenoids, but not with a supplement lacking MZ. It seems that the *meso*-zeaxanthin supplement normalizes the spatial profile of macular pigment and is required to realize central MP in atypical profiles. All three macular carotenoids are needed for rapid augmentation of macular pigment.

Nolan JM et al. Exp Eye Res 101:9-15 August 2012

Internet Addresses for Carotenoid Researchers

1. USDA Nutrient Database for Standard Reference (SR24) is a major source of food composition data for epidemiologists and nutritionists. Carotenoid database contains best available estimates of carotenoid content in foods. Agricultural Research Service (ARS) prepared searchable database 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 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.

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