

Photobiology News (2002)

by Peter A. Ensminger

December 20, 2002

Photosynthesis in Artificial Membranes

In the November 28 issue of *Nature*, **ASP** members Ana Moore, Thomas Moore (**ASP** President, 2003-2004), Devens Gust, and their colleagues demonstrate the light-driven active transport of calcium ions across an artificial photosynthetic membrane [1]. In their artificial membranes, light induces electron transfer via a photoactive carotenoid-porphyrin-naphthoquinolone based molecule and this drives the active transport of calcium ions. The liposomes develop a concentration gradient of calcium ions and a membrane potential. This is accompanied by a significant electrochemical potential, despite a low quantum yield for the photochemical reaction.

1. Bennett IM, Farfano HM, Bogani F, Primak A, Liddell PA, Otero L, Sereno L, Silber JJ, Moore AL, Moore TA, Gust D, 2002, Active transport of Ca(2+) by an artificial photosynthetic membrane. *Nature* 420:398-401.

Photoperiodic Control of Flowering

Kuo-Chen Yeh and **ASP** member J. Clark Lagarias showed previously that the plant pigment phytochrome is a light-regulated serine/threonine protein kinase [2]. Now, in the December issue of *Plant Cell*, **ASP** member Pill-Soon Song and his colleagues show that a self-regulatory phytochrome kinase/phosphatase coupling is important in the photoperiodic control of flowering in *Arabidopsis thaliana* [1]. Their results demonstrate the importance of protein phosphorylation in signaling by phytochrome kinase and elucidate the physiological and developmental importance of the phytochrome kinase.

1. Kim DH, Kang JG, Yang SS, Chung KS, Song PS, Park CM, 2002, A Phytochrome-Associated Protein Phosphatase 2A Modulates Light Signals in Flowering Time Control in *Arabidopsis*. *Plant Cell* 14:3043-56.
2. Yeh KC, Lagarias JC, 1998, Eukaryotic phytochromes: light-regulated serine/threonine protein kinases with histidine kinase ancestry. *Proc Natl Acad Sci USA* 95:13976-81.

Scotopic Color Vision

Humans and most other animals have color vision at high light levels, but not at low light levels. In a recent issue of *Nature*, researchers from Lund University in Sweden used behavioral experiments to demonstrate that the nocturnal hawkmoth (*Deilephila elpenor*) has color vision at 10^{-4} cd m⁻², corresponding to dim starlight. Humans are color-blind at this light level. The nocturnal hawkmoth, which feeds on nectar during the darkest part of night, uses its scotopic color vision to guide it towards nectar-rich flowers.

1. Kelber A, Balkenius A, Warrant EJ, 2002, Scotopic colour vision in nocturnal hawkmoths. *Nature* 419: 922-5.

November 29, 2002

2002 Gerhard Herzberg Canada Gold Medal for Science and Engineering

Juan Cesar (Tito) Scaiano, **ASP** member and editor of *Photochemistry and Photobiology*, was recently awarded the Gerhard Herzberg Canada Gold Medal for Science and Engineering for his research in photochemistry [1]. This prize awards \$250,000 over the next five years to supplement his existing research funding of \$1 million from the Natural Sciences and

Engineering Research Council. Dr. Scaiano is professor of chemistry at the University of Ottawa, founder of Luzchem Research [2], and a prolific author, having written more than 500 articles in refereed research journals. Dr. Scaiano is the most widely cited chemist in Canada and among the 100 most-cited chemists worldwide.

1. NSERC, 2002, The chemist who saw the light.
2. Luzchem.

Light-Switchable Gene Promoter System in Yeast

Phytochrome is a plant sensory protein that exists in two photoisomerizable forms (recently reviewed by **ASP** member Pill-Soon Song and colleagues [1]). Red light (~670 nm) produces the active Pfr form and far-red light (~730 nm) produces the inactive Pr form. Peter Quail (1988 **ASP** Research Awardee) and colleagues from the University of California at Berkeley used phytochrome to develop a photoregulated transgene system in yeast [2]. In yeast cells transformed with chimeric phytochrome proteins, red light induces selectable genes and this induction is far-red light reversible. This system provides rapid, noninvasive, and reversible control of the expression of genes to a selected levels without the problems associated with other induction systems that rely upon exogenous chemicals or heat shock.

1. Kim JI, Kozhukh GV, Song PS, 2002, Phytochrome-mediated signal transduction pathways in plants. *Biochem Biophys Res Commun* 298: 457-63.
2. Shimizu-Sato S, Huq E, Tepperman JM, Quail PH, 2002, A light-switchable gene promoter system. *Nat Biotechnol* 20:1041-4.

November 15, 2002

New Method for Characterization of Photosensitizers

In photodynamic therapy, a photosensitizer is activated by visible light and generates cytotoxic oxygen species that kill malignant cells. **ASP** member Andreas Kubin (Ludwig Boltzmann Institute for Clinical Oncology and Photodynamic Therapy, Vienna, Austria) and colleagues developed a method that can characterize newly developed photosensitizers based on their production of reactive oxygen species [1]. This method uses an HPLC assay that allows simultaneous measurement of the photosensitizer, reactant (luminol), and oxidized product.

1. Wierrani F, Kubin A, Loew HG, Henry M, Spangler B, Bodner K, Grunberger W, Ebermann R, Alth G, 2002, Photodynamic action of some sensitizers by photooxidation of luminol. *Naturwissenschaften* 89: 466-9.

Retina and Circadian Rhythms

Dopamine is a neurotransmitter and hormone that regulates light-adaptive retinal processes and may serve as a retinal circadian signal. Michael Menaker (University of Virginia), **ASP** member and Lifetime Achievement Awardee in 2002, and colleagues tested whether dopamine and its breakdown products are rhythmic in rats with normal and dystrophic retinas [1]. Their results show clear circadian rhythms of dopamine content and turnover in rats with normal and dystrophic retinas. This suggests that a normal retina is not required for generation of a circadian rhythm in dopamine levels.

1. Doyle SE, McIvor WE, Menaker M, 2002, Circadian rhythmicity in dopamine content of mammalian retina: role of the photoreceptors. *J Neurochem* 83: 211-9.

New Enzyme in the Visual Cycle

In the visual cycle, light isomerizes the 11-cis retinal of rhodopsin into all-trans-retinal, which then enters a series of reactions that eventually regenerate 11-cis retinal [1]. Many of these reactions occur in the retinal pigment epithelium (RPE). **ASP** member Rosalie Crouch (Department of Ophthalmology, Medical University of South Carolina) and colleagues identified a novel retinol oxidase (RDH10) that is expressed in the RPE and may play an important role in the visual cycle [2].

1. Photoisomerization of Rhodopsin.
2. Wu BX, Chen Y, Chen Y, Fan J, Rohrer B, Crouch RK, Ma JX, 2002, Cloning and Characterization of a Novel all-trans Retinol Short-Chain Dehydrogenase/Reductase from the RPE. *Invest Ophthalmol Vis Sci* 43: 3365-72.

November 1, 2002

The Global UV Project

The World Health Organization (WHO) has a web site devoted to the health effects of ultraviolet radiation [1]. An important aim of the web site is reduction in the worldwide incidence of skin cancer and cataracts. Their recently released document, Global Solar UV Index [2], describes the ultraviolet index (UVI), a simple measure of ultraviolet radiation at the earth's surface. The UVI is calculated using the International Commission on Illumination (CIE) reference action spectrum for ultraviolet-induced erythema. The WHO web site [1] provides links to the UVI in many countries.

1. WHO, 2002, The Global UV Project.
2. WHO, 2002, Global Solar UV Index.

Light and Alzheimer's Disease

Patients with Alzheimer's disease often wake up many times throughout the night. This typically causes them to fall asleep more often during the day and may result in nighttime wandering, a common reason for institutionalization. In a pilot study, researchers at the Lighting Research Center of Rensselaer Polytechnic Institute (Troy, NY) have shown that patients with Alzheimer's disease sleep better when they are exposed to blue LED lighting for several hours before bed [1]. A report of this pilot study will be published in *Sleep Review* [2]. The researchers plan to repeat their study with a larger population.

1. *LRC News*, October 3, 2002.
2. *Sleep Review*.

Mechanism of Macular Degeneration

Age-related macular degeneration (AMD) is the main cause of blindness in the elderly. AMD causes blindness because the center of the retina breaks down, with drusen (proteinaceous debris) typically accumulating beneath the macula. A recent study in the *Proceedings of the National Academy of Sciences* [1] shows that drusen proteins of AMD patients are more likely to show signs of oxidative damage than drusen proteins of normal patients. This supports the view that protein oxidation contributes to the development of AMD.

1. Crabb JW, Miyagi M, Gu X, Shadrach K, West KA, Sakaguchi H, Kamei M, Hasan A, Yan L, Rayborn ME, Salomon RG, Hollyfield JG, 2002, Drusen proteome analysis: An approach to the etiology of age-related macular degeneration. *Proc Natl Acad Sci USA* Oct 21; [epub ahead of print].

October 18, 2002

Ultraviolet Radiation and Skin Cancer

In the recent issue of *Skin Pharmacology and Applied Skin Physiology*, **ASP** member Frank R. De Gruijl (Leiden University Medical Center, The Netherlands) reviews the roles of UV-B (280-320 nm) and UV-A (320-400 nm) radiation in causing skin cancer [1]. UV-B is much more effective than UV-A in causing basal and squamous cell carcinomas. UV-B damages DNA directly whereas most UV-A damage is mediated by reactive oxygen species. The effects of UV-A and UV-B have been debated at recent **ASP** annual meetings and will certainly be discussed at the forthcoming meeting in Baltimore (July 5-9, 2003) [2].

1. De Gruijl FR, 2002, Photocarcinogenesis: UVA vs. UVB Radiation. *Skin Pharmacol Appl Skin Physiol* 15: 316-20.
2. Upcoming Events in Photobiology, 2002, American Society for Photobiology.

Expression Patterns of Arabidopsis Phytochromes

Arabidopsis thaliana has five known phytochrome genes (A, B, C, D, and E) [1]. **ASP** member Robert A Sharrock (Montana State University) and Ted Clack used monoclonal antibodies specific for each of the five apoproteins to examine their expression patterns under different light conditions [2]. They show that phytochrome A is highly light labile, whereas phytochromes B-E are relatively stable. The light-stable phytochromes are present at nearly constant levels throughout development from the rosette stage to the reproductive stage. All five phytochromes are present in leaves, stems, roots, and flowers.

1. Nagy F, Schäfer E, 2002, Phytochromes control photomorphogenesis by differentially regulated, interacting signaling pathways in higher plants. *Annu Rev Plant Biol* 53: 329-55.
2. Sharrock RA, Clack T, 2002, Patterns of Expression and Normalized Levels of the Five Arabidopsis Phytochromes. *Plant Physiol* 130: 442-456.

Origin of Dinoflagellate Chloroplasts

Dinoflagellates are aquatic photosynthetic organisms that are important primary producers and notorious for producing toxic red tides. The chloroplast genome of dinoflagellates is unique in that certain chloroplast ribosomal RNA genes and protein genes are located alone on separate minicircular chromosomes [3]. Now, a phylogenetic analysis of the PsbO protein (the 33 kDa manganese stabilizing protein [2]) by Ishida and Green shows that the original psbO gene of the dinoflagellate *Karenia brevis* was replaced by a psbO gene from a haptophyte nucleus, a tertiary symbiogenesis [1]. Their phylogenetic analysis also shows that a red alga is the origin of the peridinin-type dinoflagellate plastid.

1. Ishida K, Green BR, 2002, Second- and third-hand chloroplasts in dinoflagellates: Phylogeny of oxygen-evolving enhancer 1 (PsbO) protein reveals replacement of a nuclear-encoded plastid gene by that of a haptophyte tertiary endosymbiont. *Proc Natl Acad Sci USA* 99: 9294-9299.
2. Wolfson Laboratories, Imperial College (London), 2002, Photosystem II.
3. Zhang Z, Green BR, Cavalier-Smith T, 1999, Single Gene Circles in Dinoflagellate Chloroplast Genomes. *Nature* 400: 155-159.

October 4, 2002

New Blue Light Photoreceptor

Cryptochrome and phototropin are well known flavin-based light receptors that control various plant responses to blue light [2]. In the recent issue of *Cell*, Masuda and Bauer describe another flavin-based light receptor in the photosynthetic bacterium, *Rhodobacter sphaeroides* [4]. This receptor, designated AppA, is an antirepressor that regulates expression of photosystem genes in

response to light and oxygen levels [1]. Interestingly, the flavin-binding domain of AppA is similar to the amino terminal region of a photosensitive adenylyl cyclase from *Euglena gracilis*. Earlier this year, **ASP** member Masakatsu Watanabe and his colleagues identified this adenylyl cyclase as the blue light receptor that controls photophobic avoidance in *Euglena* [3].

1. Braatsch S, Gomelsky M, Kuphal S, Klug G, 2002, A single flavoprotein, AppA, integrates both redox and light signals in *Rhodobacter sphaeroides*. *Mol Microbiol* 45: 827-36.
2. Briggs WR, Huala E, 1999, Blue-light photoreceptors in higher plants. *Annu Rev Cell Dev Biol* 15: 33-62.
3. Iseki M, Matsunaga S, Murakami A, Ohno K, Shiga K, Yoshida K, Sugai M, Takahashi T, Hori T, Watanabe M, 2002, A blue-light-activated adenylyl cyclase mediates photoavoidance in *Euglena gracilis*. *Nature* 415: 1047-51.
4. Masuda S, Bauer C, 2002, AppA is a blue light photoreceptor that antirepresses photosynthesis gene expression in *Rhodobacter sphaeroides*. *Cell* 110:613-23.

Photodynamic Therapy for Barrett's Esophagus

In a recent issue of *Diseases of the Esophagus*, **ASP** member Stuart Marcus and his colleagues review the use of photodynamic therapy for treatment of Barrett's esophagus [1]. In this disorder, the lining of the esophagus undergoes cellular changes following the chronic irritation caused by gastroesophageal reflux disease (GERD). An estimated 700,000 adults in the United States suffer from this disorder, placing them at increased risk of esophageal cancer.

1. Kelty CJ, Marcus SL, Ackroyd R, 2002, Photodynamic therapy for Barrett's esophagus: a review. *Dis Esophagus* 15:137-44.

September 20, 2002

Ultraviolet Radiation Monitoring by SRRB

The Surface Radiation Research Branch (SRRB) of the National Oceanic & Atmospheric Administration (NOAA) was founded in 1993 and is located in Boulder, Colorado. SRRB researchers study various aspects of solar radiation at the earth's surface. Their primary goal, in collaboration with NIST and the USDA, is operation of the Central Calibration and Test Facility for ultraviolet radiation monitoring instruments. The SRRB web site (<http://www.srrb.noaa.gov>) is a rich resource for students and professionals alike. Two of the many links on the SRRB web site are:

- "UV Links", which provides access to a wide variety of data sets, including Total Ozone Mapping (TOMS) data.
- A "Sunrise/Sunset Calculator" and "Solar Position Calculator", which will entertain many, as will the explanations (with JavaScript source code) used for the calculations.

Review of Melanoma

In a recent issue of *Cancer Biology & Therapy*, Kapaettu Satyamoorthy and **ASP** member Meenhard Herlyn (The Wistar Institute, Philadelphia) review the cellular and molecular biology of melanoma in humans [2]. Melanoma is increasing at a rate of 2.5 to 4% per year in the United States, but available treatment options are currently limited [1]. Many studies have examined the environmental, genetic/epigenetic, epistatic, and microenvironmental effects on the induction and progression of melanoma. However, the precise molecular changes responsible for melanoma progression have not yet been identified.

1. National Cancer Institute, 2002, What You Need To Know About Melanoma.
2. Satyamoorthy K, Herlyn M, 2002, Cellular and molecular biology of human melanoma. *Cancer Biol Ther* 1: 4-7.

Blind Mole Rats have Functional per Genes

Mole rats are Old World burrowing rodents. Members of the mole rat superspecies *Spalax ehrenbergi* have atrophied eyes and live solitary lives in elaborate tunnel systems. Despite their subterranean life, these rodents have retinas and harderian glands (sebaceous glands adjacent to the eye) that are involved in photoperiod perception. Now, Aaron Avivi and his colleagues show that *Spalax ehrenbergi* has three functional per genes [2]. These genes have well-recognized importance in regulation of circadian rhythms in diverse organisms [1]. Analysis of per expression patterns in the harderian gland suggests that this organ plays an important role in interacting with the suprachiasmatic nuclei.

1. Allada R, Emery P, Takahashi JS, Rosbash M, 2001, Stopping time: the genetics of fly and mouse circadian clocks. *Annu Rev Neurosci* 24:1091-119.
2. Avivi A, Oster H, Joel A, Beiles A, Albrecht U, Nevo E, 2002, Circadian genes in a blind subterranean mammal II: conservation and uniqueness of the three Period homologs in the blind subterranean mole rat, *Spalax ehrenbergi* superspecies. *Proc Natl Acad Sci USA* 99:11718-23.

September 6, 2002

Locking Retinal and Blocking Vision

Rhodopsin is a visual pigment that has an 11-cis retinal chromophore in most higher animals. Light absorption by rhodopsin induces a C-11/C-12 isomerization of retinal and this triggers changes in protein conformation, formation of an active intermediate, and activation of transducin, a G protein. **ASP** member Friedrich Siebert and his colleagues at the University of Freiburg (Germany) and the Weizmann Institute of Science (Israel) recently published two papers on the photochemistry of a rhodopsin analogue with an 11-cis-locked chromophore [1,2]. In these rhodopsin analogues, photoisomerization around the C-11/C-12 bond is blocked by a 6-carbon ring. Their results show that light can still activate these "locked" pigments by inducing isomerization around other double bonds in retinal. Furthermore, these novel rhodopsin analogues are non-bleachable and, like bacteriorhodopsin, can repeatedly undergo photoactivation-relaxation cycles.

1. Fan G, Siebert F, Sheves M, Vogel R, 2002, Rhodopsin with 11-cis-locked chromophore is capable of forming an active state photoproduct. *J Biol Chem* Aug 12; [epub ahead of print].
2. Vogel R, Fan G, Ludeke S, Siebert F, Sheves M, 2002, A non-bleachable rhodopsin analogue with a slow photocycle. *J Biol Chem* Aug 12 [epub ahead of print].

History of Phytochrome

Biologists previously believed that phytochrome originally evolved in land plants several hundred million years ago so that these plants could better sense and respond to their light environments. **ASP** members J. Clark Lagarias (University of California, Davis) and Beronda Montgomery (Indiana University) review recent evidence suggesting that phytochrome evolved several billion years ago [2]. Recent studies have identified phytochrome-related proteins in cyanobacteria, purple bacteria, nonphotosynthetic eubacteria, and fungi. While many of these proteins likely function as photoreceptors, their occurrence in nonphotosynthetic species suggest alternative regulatory functions. Indeed, a phytochrome-related protein in a photosynthetic *Bradyrhizobium* endosymbiont of plants appears to function as a light-modulated, linear tetrapyrrole sensor to regulate the expression of its photosynthetic apparatus [1].

1. Giraud E, Fardoux J, Fourier N, Hannibal L, Genty B, Bouyer P, Dreyfus B, Vermeglio A. 2002, Bacteriophytochrome controls photosystem synthesis in anoxygenic bacteria. *Nature* 417: 202-205.

2. Montgomery, BL, Lagarias, JC, 2002, Phytochrome ancestry: sensors of bilins and light. *Trends in Plant Science* 7: 357-366.

August 23, 2002

Lighting up Prostate Cancer

In American men, prostate cancer is the second leading cause of cancer deaths. Elevated serum levels of prostate-specific antigen (PSA) is one sign of disease [2]. The August issue of *Nature Medicine* features the work of UCLA researchers who developed a targeted adenovirus vector that expresses firefly luciferase [1]. This vector glows in the presence of prostate cancer cells that express PSA, allowing the researchers to monitor tumor size in mice by measurement of luminescence. This study demonstrates a non-invasive imaging technique that may be applicable to the diagnosis and therapy of prostate cancer in humans.

1. Adams JY, Johnson M, Sato M, Berger F, Gambhir SS, Carey M, Iruela-Arispe ML, Wu L, 2002, Visualization of advanced human prostate cancer lesions in living mice by a targeted gene transfer vector and optical imaging. *Nat Med* 8: 891-897.
2. National Library of Medicine, 2002, MedLine Plus Health Information: Prostate Cancer.

Coping with Too Much Light (part 2)

The August 9 issue of "Current News" featured an article on the xanthophyll cycle, a mechanism that many plants use to dissipate the energy from excess absorbed light. In the August issue of *Plant Cell*, Elrad et al. characterize a npq5 mutant of *Chlamydomonas reinhardtii* which displays little thermal dissipation [1]. Their results suggest that most of the thermal dissipation within the light-harvesting complex of photosystem II (LHCII) depends upon a light-harvesting polypeptide present in the trimers of photosystem II antennae. A related article by **ASP** member (and former president) Govindjee [2] discusses this paper and briefly reviews the scientific controversy surrounding the thermal dissipation of excess absorbed light.

1. Elrad D, Niyogi KK, Grossman AR, 2002, A major light-harvesting polypeptide of Photosystem II functions in thermal dissipation. *Plant Cell* 14: 1801-1816.
2. Govindjee, 2002, A Role for a Light-Harvesting Antenna Complex of Photosystem II in Photoprotection. *Plant Cell* 14: 1663-1668.

Sonoluminescence and Sonofusion (part 2)

The May 16 issue of "Current News" had an article on sonoluminescence which described the work of Taleyarkhan et al. published in the March 8 issue of *Science* [2]. These researchers claimed that nuclear fusion accompanies a specific type of "table-top" sonoluminescence reaction. New research by Didenko and Suslick, published in the July 25 issue of *Nature*, casts doubt upon that conclusion [1]. In particular, Didenko and Suslick monitored the energy budget of chemical reactions within single bubble sonoluminescence and measured the yield of nitrite ions, hydroxyl radicals, and luminescence. They conclude that there is insufficient energy available to drive nuclear fusion.

1. Didenko YT, Suslick KS, 2002, The energy efficiency of formation of photons, radicals and ions during single-bubble cavitation. *Nature* 418: 394-7.
2. Taleyarkhan RP, West CD, Cho JS, Lahey RT Jr, Nigmatulin RI, Block RC, 2002, Evidence for nuclear emissions during acoustic cavitation. *Science* 295: 1868-73.

August 9, 2002

Blue Light Receptor in Neurospora

Blue light controls carotenoid synthesis and entrains the circadian clock of *Neurospora crassa*, an ascomycete fungus. In the August 2 issue of *Science*, two research groups present compelling evidence that the white collar-1 (WC-1) protein is an FAD-based blue light receptor in *Neurospora*. He et al. [1] based their conclusions on studies in which the light, oxygen, and voltage (LOV) domain of the *wc-1* gene was selectively removed. Froehlich et al. [2] used electrophoretic mobility shift assays with the promoter region of the *frq* gene, along with additional techniques, and come to the same conclusion. It remains to be shown whether *Phycomyces*, a well known zygomycete fungus with a panoply of blue light responses, has a blue light receptor that is similar to WC-1, one of the blue light receptors of higher plants (phototropin or cryptochrome), or an entirely different photoreceptor.

1. He Q, Cheng P, Yang Y, Wang L, Gardner KH, Liu Y, 2002, White Collar-1, a DNA binding transcription factor and a light sensor. *Science* 297: 840-3.
2. Froehlich AC, Liu Y, Loros JJ, Dunlap JC, 2002, White Collar-1, a circadian blue light photoreceptor, binding to the frequency promoter. *Science* 297: 815-8.

Coping with Too Much Light

Plants exposed to excess light can suffer from photo-oxidative stress, and they have evolved a variety of mechanisms for coping with this problem. One of the most important mechanisms is the xanthophyll cycle, in which carotenoids remove excess excitation energy from chlorophyll before it is used to generate reactive oxygen species [2]. In the July 11 issue of *Nature*, researchers from Robert Hill Institute in Sheffield, England show that over-expression of the *chyB* gene in *Arabidopsis*, which codes for an enzyme involved in xanthophyll synthesis, increases the size of the xanthophyll cycle pool and protects plants that are exposed to excess light [1]. These findings suggest that it may be possible to genetically engineer crop plants that are more tolerant of high light levels.

1. Davison PA, Hunter CN, Horton, P, 2002, Overexpression of β -carotene hydroxylase enhances stress tolerance in *Arabidopsis*. *Nature* 418: 203-6.
2. The xanthophyll cycle.

Bacteriorhodopsin Photoisomerization

Bacteriorhodopsin is a model protein for study of the photoisomerization of retinal-based proteins and of the chemical dynamics of proteins in general [2]. In this reaction, light (wavelength maximum, 568 nm) transforms all-trans retinal into 13-cis retinal. There has been controversy about the rate of photoisomerization. Some researchers have proposed a slow relaxation process but others have proposed a rapid reaction, on the order of ~500 femtoseconds. In the August 2 issue of *Science*, Herbst et al. use mid-infrared absorption spectroscopy with a time resolution of 200 femtoseconds to probe bacteriorhodopsin photoisomerization [1]. Based on analysis of the C-C, C=C, and C=NH bonds, they show that isomerization of the retinal occurs within about 500 femtoseconds.

1. Herbst J, Heyne K, Diller R, 2002, Femtosecond infrared spectroscopy of bacteriorhodopsin chromophore isomerization. *Science* 297: 822-5.
2. Luecke H, 2002, Bacteriorhodopsin.

July 26, 2002

Eyedrops and Glaucoma

Primary open-angle glaucoma, the most common form of glaucoma, affects about 2.2 million Americans over age 40. High eye pressure is a significant risk factor for glaucoma. Now, a study published in the *Archives of Ophthalmology*, shows that pressure-lowering eyedrops significantly

reduces the risk of glaucoma [1]. About 9.5 percent of the study participants who did not receive drops developed glaucoma, whereas about 4.4 percent of the medicated participants developed glaucoma.

1. Kass MA, Heuer DK, Higginbotham EJ, Johnson CA, Keltner JL, Miller JP, Parrish RK 2nd, Wilson MR, Gordon MO, 2002, The Ocular Hypertension Treatment Study: a randomized trial determines that topical ocular hypotensive medication delays or prevents the onset of primary open-angle glaucoma. *Arch Ophthalmol* 2002 Jun;120(6):701-13.

Kyoto Encyclopedia of Genes and Genomes

KEGG, the Kyoto Encyclopedia of Genes and Genomes, is a online database developed by Minoru Kanehisa and colleagues [1]. Its objective is to provide an updated knowledge base of metabolic and regulatory pathways and molecular assemblies. More specifically, KEGG has five types of data:

- Pathway maps: graphics that represent interacting molecules and genes
- Ortholog group tables: tables with an alternative representation of "Pathway Maps"
- Molecular catalogs: tables of enzymes, chemical compounds, and elements
- Genome maps: graphics that show the locations of genes
- Gene catalogs: text-based classifications of all known genes for many organisms

Students and professional photobiologists will be particularly interested in seeing the graphical pathway maps of photosynthesis [2], carbon fixation [3], and other photobiology reactions.

1. Kyoto Encyclopedia of Genes and Genomes, 2002.
2. Photosynthesis - Reference pathway, 2002, Kyoto Encyclopedia of Genes and Genomes.
3. Reductive carboxylate cycle (CO₂ fixation), 2002, Kyoto Encyclopedia of Genes and Genomes.

Vitamin E and Macular Degeneration

Age related macular degeneration (AMD) is the leading cause of blindness among older Americans. Research suggests that accumulated oxidative damage increases the risk of AMD. If so, then dietary antioxidants may be expected to reduce the risk. Now, Australian researchers have published a prospective, randomised, placebo-controlled clinical trial in which participants were given a daily 500 IU supplement of vitamin E or a placebo for four years [2]. The results showed that vitamin E had no effect. This study argues against a protective effect of vitamin E, but there are at least three alternative interpretations [1]: First, four years may not have been long enough to detect an effect; Second, the baseline antioxidant level of participants may have been too high for supplementation to be effective; and Third, the small sample size (1193 participants) was not large enough to detect a modest protective effect.

1. Hall NF, Gale CR, 2002, Prevention of age related macular degeneration *Brit Med J* 325:1-2.
2. Taylor HR, Tikellis G, Robman LD, McCarty CA, McNeil JJ, 2002, Vitamin E supplementation and macular degeneration: randomised controlled trial. *Brit Med J* 325:11-14.

July 12, 2002

American Society for Photobiology Meets in Quebec City

On July 13-17, the American Society for Photobiology holds its 30th Annual Meeting at the Fairmont Le Chateau Frontenac in Quebec City, Canada [1]. Michael Menaker, **ASP** Lifetime Achievement awardee, will deliver the keynote lecture on Saturday evening, "Non-visual responses of vertebrates to visible light; the evolution of a neglected sensory modality". Dr. Menaker, Professor of Biology at the University of Virginia, studies the neurobiology and endocrinology of circadian rhythms in numerous vertebrates, including the golden hamster and

the green iguana [2]. Additional symposia will cover ultraviolet radiation effects, photodynamic therapy, photosensory biology, and circadian rhythms.

1. 30th Annual Meeting of the American Society for Photobiology, 2002, American Society for Photobiology.
2. Michael Menaker, 2002, University of Virginia.

Identification of Gene Responsible for Melanoma

Scientists from the Cancer Genome Project of the Sanger Institute report in the June 27 issue of *Nature* that somatic missense mutations in the BRAF gene occur in about two thirds of all cases of malignant melanoma [1]. BRAF (v-raf murine sarcoma viral oncogene B1) is an oncogene that lies on chromosome 7q34 and codes for a cytoplasmic serine/threonine kinase that is regulated by binding RAS, another oncogene [3]. The researchers noted that all BRAF mutations were within its kinase domain, leading to enhanced kinase activity and ultimately to unchecked cell proliferation. The researchers expect that this discovery, already widely reported in medical journals [2,4], will lead to the rapid development of melanoma therapies that target the specific genetic defect.

1. Davies H, et al. 2002, Mutations of the BRAF gene in human cancer. *Nature* 417: 949-54.
2. Gould, M, 2002, Gene responsible for most malignant melanomas is discovered. *Brit Med J* 324:1412.
3. Hamosh, A, McKusick, V, 1999, 164757 V-RAF murine sarcoma viral oncogene homolog B1; BRAF. *Online Mendelian Inheritance in Man*.
4. Stephenson, J, 2002, Melanoma susceptibility gene. *JAMA* 288: 155.

June 28, 2002

Animal Models for Study of Melanoma

About 7,400 Americans are expected to die from malignant melanoma this year. **ASP** member Ronald D. Ley reviews the use of different animal models for the study of UV radiation-induced cutaneous melanoma [1]. A new hepatocyte growth factor/scatter factor (HGF/SF) transgenic mouse may be particularly useful for such studies. **ASP** member Richard B. Setlow and colleagues have pioneered the use of hybrid *Xiphophorus* fish to study UV radiation-induced melanoma [2,3,4]. Studies of these fish and the opossum (*Monodelphis domestica*) suggest that UV-A radiation (320-400 nm) may be an important contributor to cutaneous melanoma in humans.

1. Ley RD, 2002, Animal models of ultraviolet radiation (uvr)-induced cutaneous melanoma. *Front Biosci* 7: d1531-4.
2. Setlow RB, Woodhead AD, Grist E, 1989, Animal model for ultraviolet radiation-induced melanoma: platyfish-swordtail hybrid. *Proc Natl Acad Sci USA* 86, 8922-6.
3. Setlow RB, 2002, Shedding light on proteins, nucleic acids, cells, humans and fish. *Mutat Res* 511, 1-14.
4. Wang SQ, Setlow R, Berwick M, Polsky D, Marghoob AA, Kopf AW, Bart RS, 2001, Ultraviolet A and melanoma: a review. *J Am Acad Dermatol* 44, 837-46.

Macular Degeneration

Age-related macular degeneration (AMD) is a progressive disease that alters retinal tissues of the eye and is the major cause of blindness in people over age 50. A fascinating web site by the Association for Macular Diseases shows pictures of diseased retinas and of what patients actually see when they have AMD [1]. Dietary antioxidants, such as zeaxanthin and zinc, reportedly have a protective role, but a recent Cochrane Review concludes that additional large trials in other

populations are needed to conclusively establish their benefit [3]. Photodynamic therapy with Visudyne is one of the novel treatments for the 'wet' form of AMD. **ASP** member Thomas J. Dougherty reviews this and other recent applications of photodynamic therapy [2].

1. Association for Macular Diseases.
2. Dougherty TJ, 2002, An update on photodynamic therapy applications. *J Clin Laser Med Surg* 20, 3-7.
3. Evans JR, 2002, Antioxidant vitamin and mineral supplements for age-related macular degeneration (Cochrane Review). *Cochrane Database Syst Rev* 2002;(2):CD000254.

Rhodopsins in Green Algae

In 1984, rhodopsins were predicted from retinal analog experiments to function as phototaxis receptors in *Chlamydomonas reinhardtii*, a flagellated green alga [1]. Now, John Spudich (current **ASP** President) and his colleagues have demonstrated two rhodopsin proteins as photosensory receptors in *Chlamydomonas*, one for low-intensity phototaxis and one for high-intensity phototaxis [2]. Each receptor has a 300-residue transmembrane portion that is homologous to archaeal rhodopsins and a 400-residue signal transduction domain. The high-intensity receptor absorbs maximally at 510 nm and the low-intensity receptor absorbs maximally at 470 nm. An integrated light signal controls phototaxis at intermediate light intensities.

1. Foster KW, et al, 1984, A rhodopsin is the functional photoreceptor for phototaxis in the unicellular eukaryote *Chlamydomonas*. *Nature* 311, 756-59.
2. Sineshchekov, OA, Jung, K-H, Spudich JL, 2002, Two rhodopsins mediate phototaxis to low- and high-intensity light in *Chlamydomonas reinhardtii*. *Proc Natl Acad Sci USA* [epub ahead of print].

June 14, 2002

Blue Light Responses

The phototropins are recently discovered proteins that regulate diverse plant responses to blue light, including phototropism, chloroplast migration, and stomatal opening. **ASP** member Winslow Briggs and John Christie reviewed the biochemistry of phototropins in the recent issue of *Trends in Plant Science* [1]. They note that phototropins function as receptor kinases, but the transduction chain(s) they use to regulate the diverse plant responses is presently unknown. Although phototropins have been considered unique to higher plants, recent research by other **ASP** members has identified a phototropin-like protein in the bacterium, *Bacillus subtilis* [2].

1. Briggs WR, Christie JM, 2002, Phototropins 1 and 2: versatile plant blue-light receptors. *Trends Plant Sci* 7, 204-10.
2. Losi A, Polverini E, Quest B, Gaertner W, 2002, First evidence for phototropin-related blue-light receptors in prokaryotes. *Biophys J* 82, 2627-34.

Two Roles for Melanins

Melanins are ubiquitous pigments that screen out harmful ultraviolet radiation in skin and other organs [2]. However, ultraviolet irradiation of melanins can also generate reactive oxygen species. **ASP** members from Duke University attribute these apparently contradictory effects to different aggregation states of melanin [1]. Unaggregated oligomers generate reactive oxygen species with a significantly higher quantum yield than bulk pigment. They suggest that physiological processes that disrupt melanin aggregates *in vivo* may have deleterious consequences [2].

1. Nofsinger JB, Liu Y, Simon JD, 2002, Aggregation of eumelanin mitigates photogeneration of reactive oxygen species. *Free Radic Biol Med* 32, 720-30.
2. Simon, JD, Liu, Y, Nofsinger, JB, 2002, Assembly and aerobic photoreactivity of melanin. *The Spectrum* 15(1), 1-6.

New Photosynthetic Electron Carrier in Higher Plants

In photosynthetic organisms, plastocyanin and cytochrome c6 function as electron donors to photosystem I (PSI). The traditional view is that only plastocyanin is a PSI donor in higher plants, but that both proteins are PSI donors in eukaryotic algae and cyanobacteria [1]. Now, Gupta et al. [2] report a functional cytochrome c6 in the higher plant, *Arabidopsis thaliana*. Their genetic analysis shows that neither electron carrier is essential, but that plants lacking both do not survive. Database searches identified proteins with cytochrome c-6-like sequences in soybean, maize, and rice.

1. De la Rosa MA, et al, 2002, An evolutionary analysis of the reaction mechanisms of photosystem I reduction by cytochrome c(6) and plastocyanin. *Bioelectrochemistry* 55, 41-5. .
2. Gupta, R, et al, 2002, Functional relationship of cytochrome c6 and plastocyanin in *Arabidopsis*. *Nature* 417, 567-71.

May 31, 2002

The Eyes Have It

The *Annals of the New York Academy of Sciences* recently published "Neurobiology of Eye Movements: From Molecules to Behavior", with full text articles available for free download [1]. The papers in this volume are from a conference held at Case Western Reserve University in October of 2001 to honor Robert B. Daroff. This was the first conference to deal with the subject of eye movements from the level of individual molecules to complex behavioral responses. The papers include reviews and new research in this active area.

1. Henry J. Kaminski, R. John Leigh (eds.), 2002, Neurobiology of Eye Movements: From Molecules to Behavior. *Annals of the New York Academy of Sciences*. Vol 956 (April).

Ultraviolet Radiation and the Origin of Terrestrial Amino Acids

Amino acids may have formed on prebiotic earth or may have been deposited onto earth by interstellar bodies. The second explanation is now supported by the results of two independent teams of scientists, one based in California and one in Europe [1,2]. These groups reported the formation of amino acids under laboratory conditions similar to those of deep space. Each group started with a mixture of molecules commonly found in interstellar clouds and then exposed them to ultraviolet radiation under the conditions of deep space. The California group measured the formation of glycine, alanine, and serine. The European group, using slightly different conditions, measured the formation of 16 amino acids. Together, these results indicate that meteoric amino acids may result from deep space photochemistry and suggest that amino acids could have been deposited onto prebiotic Earth by meteorites or other interstellar bodies.

1. Bernstein MP et al, 2002, Racemic amino acids from the ultraviolet photolysis of interstellar ice analogues. *Nature* 416: 401-3.
2. Munoz Caro GM et al, 2002, Amino acids from ultraviolet irradiation of interstellar ice analogues. *Nature* 2002 416: 403-6.

Increasing Incidence of Melanoma

A discussion at the recent annual meeting of the American Academy of Dermatology examined the increasing incidence of malignant melanoma [1,2]. The risk was about 1 of 1500 in 1930 but

is about 1 of 68 today. Is this a true increase or merely an artifact of better screening and surveillance? Darrel Rigel, professor of dermatology at the NYU Medical Center and former AAD president, argued that the increase is genuine. He contrasted the statistics of melanoma with those of prostate cancer, whose rising incidence can be attributed to better surveillance. In prostate cancer, the dramatic increase was transient and directly attributed to the introduction of the PSA test, which detects preclinical disease [4]. In malignant melanoma, there has been a steady increase over many years and no tests can yet detect malignant melanoma in a preclinical state [3].

1. Anonymous, 2002, Bad to Worse: Melanoma Increases Again, The Skin Cancer Foundation.
2. Lamberg, L, 2002, "Epidemic" of Malignant Melanoma: True Increase or Better Detection? *JAMA* 287, 2201 (May 1).
3. National Cancer Institute, 2002, *SEER*. Incidence: Melanoma of the Skin.
4. Stanford JL, Stephenson RA, Coyle LM, Cerhan J, Correa R, Eley JW, Gilliland F, Hankey B, Kolonel LN, Kosary C, Ross R, Severson R, West D. Prostate Cancer Trends 1973-1995, SEER Program, National Cancer Institute. *NIH Pub. No. 99-4543*. Bethesda, MD, 1999.

May 17, 2002

Fire burn and cauldron bubble ...

Sonoluminescence occurs when vapor bubbles in a liquid, created by bombarding the liquid with sound waves, rapidly implode and generate flashes of radiation [1]. Six months ago, European researchers showed that claws of the snapper shrimp (*Alpheus heterochaelis*) emit sonoluminescence when they clasp shut [2]. More recently, Russian and American scientists claimed that nuclear fusion accompanies a specific type of "table-top" sonoluminescence reaction [4]. In addition to the expected light flashes, they claim to have measured neutron emission and tritium decay, signs of nuclear fusion. Other researchers, attempting to replicate the results, reported no evidence of fusion [3].

1. Gibbs, W, 2002, Sonic Fusion. *Scientific American Online*. (includes QuickTime video of the Taleyarkhan et al. Sonoluminescence experiment).
2. Lohse D, et al., 2001, Snapping shrimp make flashing bubbles. *Nature* 413: 477-8.
3. Shapira, D, Saltmarsh, MJ, 2002, Comments on reported nuclear emissions during acoustic cavitation. ORNL.
4. Taleyarkhan, RP, et al, 2002, Evidence for nuclear emissions during acoustic cavitation. *Science* 295: 1868-73.

Norwegian Royalty Suffers From Sunburn

Norwegian Crown Prince Haakon and Princess Mette-Marit suffered severe facial sunburns following a 65 minute interview with a German television company [1,2]. The interview was conducted on May 8th at the couple's Skaugum estate, near Oslo. The exact cause of the skin damage is not clear at the moment. The sun itself could not have caused the damage, so reflectors or defective projector lamps are suspected. The Crown Prince is now performing his duties on a visit to Germany. The Princess, who suffered from more severe damage, including photokeratitis and skin sores that her doctors feared could become infected, did not accompany the Prince.

1. Associated Press, 2002, Sunburn keeps Mette-Marit at home.
2. BBCi, 2002, UK Norwegian princess suffers sunburn.

April 27, 2002

Optics and Western Artists

In *Secret Knowledge: Rediscovering the Lost Techniques of the Old Masters*, artist David Hockney systematically examines thousands of paintings by western artists, from the 15th century to the present. He concludes that western artists commonly used optical devices, such as lenses, mirrors, and the camera lucida (invented in 1806), to create projected images from which they created their paintings. This bold hypothesis has received supportive [1,3,4] and critical reception [2].

1. Ouellette, J, 2001, Teaching Old Masters New Tricks, *Discover*, December, p 82-3.
2. Sharratt, B, 2001, David Hockney's 'Secret Knowledge': Optical Illusions, *The New York Times*, December 23.
3. Teuber, A., 2002, Camera Obscurities, *American Scientist*, March-April.
4. Weschler, L, 2000, The Looking Glass, *The New Yorker*, January 31.

Aquaporins and the Rain Tree

The plant *Samanea saman* (Rain Tree) is well known for regulating circadian changes in leaf movement via water flux from motor cells. Researchers from the Hebrew University of Jerusalem and the Julius von Sachs Institute of Germany [1] have cloned two genes from the motor cells of this plant that were characterized as aquaporins, members of a family of membrane proteins that facilitate water transport. The aquaporin mRNA levels were regulated diurnally in phase with leaflet movements and their transcription was under circadian control.

1. Mosheliona, M et al, 2002, Plasma membrane aquaporins in the motor cells of *Samanea saman*. Diurnal and circadian regulation. *Plant Cell* 14: 727-739.

Fluorescence Anisotropy in Green Fluorescent Protein

Researchers from the Marine Biological Laboratory at Woods Hole and colleagues from New York and Japan [1] have shown that crystals of green fluorescent protein (GFP) exhibit six-fold brighter emission when the excitation beam is polarized parallel to the long axis of the crystal. They propose that the elongated crystal is made of GFP molecules tilted 60° so that the fluorophores are parallel to the crystal's long axis. This may correspond to the arrangement of GFP molecules in vivo, in which resonant energy is transferred from Ca²⁺-activated aequorin in jellyfish photophores.

1. Inoue, S et al., 2002, Fluorescence polarization of green fluorescence protein. *Proc Natl Acad Sci USA* 99: 4272-4277.