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CYANONEWS

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CYANONEWS - a newsletter intended to provide cyanobacteriologists with a forum for rapid informal communication, unavailable through journals. Everything you read in this newsletter is contributed by readers like yourself. Published occasionally, about three times per year.

SUBSCRIPTIONS - $10 or equivalent/year. (See address label for expiration date). No charge for electronic version.

CONTRIBUTIONS - Expected every couple of years: a new result, an upcoming meeting or a summary of a past meeting, a post-doctoral opening, a new publication, a request for strains, a change of life... something. See last page for addresses you can send news to.

HOW TO FIND OUT MORE ABOUT SOMETHING YOU READ HERE - Each news item contains, prominently displayed, the name of a contact person. A Directory of Cyanobacteriologists is distributed every two years or on request.

INSTRUCTIONS TO AUTHORS - Send news.

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Matters Arising

Dalibor Stys seeks to complement his physico-chemical expertise and resources with genetically- or theoretically-minded COLLABORATORS to study the influence of individual proteins from thylakoid proteins on ion and temperature induced CHANGES IN PHOTOSYSTEM SEGREGATION AND STACKING. He wants to use thylakoid membranes for studies on specific and unspecific lipid-protein and protein-protein interactions as well as formation of membrane domains and ion-induced interactions between membrane lamellae.

He has access to and experience with many spectroscopical techniques and is looking for collaboration with any group that will supply him with mutants with defined modifications of thylakoid membranes.

CONTACT: Dalibor Stys, Plant Cell Biology, Box 7007, 220 07 Lund, Sweden. TEL: 46-46-222-3318, FAX: 46-46-222-4009, E-MAIL: Placebio-Dali@Macpost.Lu.Se or Dalibor.Stys@Placebio.Lu.Se

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L.V. Venkataraman offers to provide *SPIRULINA* TECHNOLOGY, on all aspects regarding setting up plants of various capacities, including information on product formulations.

CONTACT: L.V. Venkataraman, "Sudarshana", #236, 8th Cross, Gokulam 3rd Stage, Mysore 570 002 INDIA. TEL: 821-510006, FAX: 821-512539, TELEX: 0846-320 POLY IN

CRC Press has just published a new monograph entitled *TOXIC MICROCYSTIS*, edited by M.F. Watanabe, K.I. Harada, W.W. Carmichael, and H. Fujiki. It includes chapters on the ecology of *Microcystis*, and the chemistry and biologically effects of its toxins. The book is 400 pages long and costs US$189.95 (within U.S.A.) and US$228 (outside U.S.A.)

CONTACT: CRC Press, 2000 Corporate Blvd., N.W., Boca Raton, FL 33431-9868 U.S.A. TEL: 800-272-7737 (within U.S.A.) 407-994-0555 (outside U.S.A.) FAX: 800-374-3401 (within U.S.A.)

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Beverley Green is writing a REVIEW ON PIGMENT-PROTEINS for Annual Review of Plant Physiology, to be published in 1996 and would be grateful reprints of articles she may not have caught. She would also appreciate comments or questions on controversial points or any other aspect. The review covers cyanobacterial as well as plant proteins, structure determination, macromolecular organization, and molecular evolution.

CONTACT: Beverley R. Green, Botany Dept., University of B.C., Vancouver, B.C. V6T 1Z4 CANADA. TEL: 604-822-2349, FAX: 604-822-6089, E-MAIL: Beverley.Green@Mtsg.Ubc.Ca

Meetings

The 15TH NORTH AMERICAN SYMBIOTIC NITROGEN FIXATION CONFERENCE will be held 13-18 August 1995 at North Carolina State University, Raleigh.

CONTACT: Gerald Elkan, Department of Microbiology, North Carolina State University, Box 7615, Raleigh, NC 27695-7615 U.S.A., TEL: 919-515-3945

A forum on the BIOTECHNOLOGY OF ALGAE will be held in Lake San Marcos Resort, San Diego, California (U.S.A.) 20 Sept 1995 in conjunction with the International Symposium on Plant DNA Preservation (17-20 Sept 1995).

CONTACT: E-MAIL: jonthn@aol.com

The FIRST INTERNATIONAL CONGRESS ON TOXIC CYANOBACTERIA is the new descendent of the formerly biannual Nordic Symposia on Toxin-producing Algae. The Congress will be held on the Danish island of Bornholm in the Baltic on 20-24 August 1995. It is planned that the proceedings will be published.

CONTACT: Peter Henriksen, Dept. of Phycology, Botanical Institute, Ö. Farimagsgade 2 D, DK-1353 Copenhagen K, DENMARK. TEL: 45-35-32-22-90 or 45-35-32-22-99, FAX: 45-35-32-23-21, E-MAIL: PHenriks@Bot.Ku.Dk

The INTERNATIONAL ASSOCIATION OF APPLIED ALGOLOGY will hold its Congress in South Africa from 16-19 April 1996. Topics include algal production systems, photosynthesis and physiology, waste water treatment, and commercial ventures. Registration by the deadline of 30 Nov 1995 is US$200.

CONTACT: Johan Grobbelaar, Bloemfontein, Department of Botany and Genetics, University of the OFS, Bloemfontein 9300, SOUTH AFRICA. TEL: 27-51-4012514, FAX: 27-51-488772, E-MAIL: pjg@Rs.Uovs.Ac.Za

The 13TH INTERNATIONAL SYMPOSIUM ON CYANOPHYTE RESEARCH will take place in Rome 27 Aug to 3 Sep 1995. The Symposium will focus on taxonomy, extreme environments, biodiversity, cyanobacterial associations with other organisms, and ecophysiology. Registration is 200,000 lira. Meals and hotel accommodations start at 900,000 lira for the nine day symposium.

CONTACT: Patrizia Albertano, Department of Biology, University of Rome 'Tor Vergata', via della Ricerca scientifica, 00133 Rome Italy. TEL: 39-6-72594345, FAX: 39-6-2023500, E-MAIL: Albertano@Tovvx1.Ccd.Utovrm.It

The EUROPEAN SOCIETY FOR PHOTOBIOLOGY will hold its 6th Congress in Cambridge (Churchill College) from 2nd to 9th September 1995. The congress will have special session on "Carotenoids in Photosynthesis and Medicine" and "Application of protein engineering for the study of light reactions of oxygenic photosynthesis"

CONTACT: Paul Heelis, Faculty of Science, Health and Medical Studies, The North East Wales Institute, Plas Coch, Mold Road, Wrexham, Clwyd, LLI 2AW,UK. FAX: 44 (0) 1978 290008, E-MAIL: Heelisp@Newi.Ac.Uk

Positions Offered

POSITION OFFERED: Post-Doc
CONTACT: C.A. Rebeiz, Laboratory of Plant Pigment Biochemistry and Photobiology, 240 A, PABL, 1201 West Gregory Avenue, University of Illinois, Urbana IL 61801 U.S.A. TEL: 217-333-1968, E-MAIL: Tino@Vmd.Cso.Uiuc.Edu
RESEARCH: Either: (1) Study of apoprotein-chlorophyll interaction during the biosynthesis and assembly of functional light harvesting Chl a/b protein (LHC II) in higher plants, or (2) Cloning the [4-vinyl]chlorophyllide a reductase (4VCR) gene [Biochemistry 31:8460-8464 (1992)], an enzyme responsible for the heterogeneity of chlorophyll biosynthesis in plants [Ciba Foundation symposium 180, p177-193 (1994)].
REQUIREMENTS: Some expertise in one or more of the following: porphyrin biochemistry, protein isolation, purification and characterization, or plant molecular biological techniques. For the first position, experience in subcellular organelle isolation, purification and characterization would be helpful
AVAILABLE: Oct 1995
SEND: CV and three letters of recommendation

POSITION OFFERED: Post-Doc
CONTACT: Terry Bricker, Dept. of Microbiology, Louisiana State University, Baton Rouge LA 70803, U.S.A. E-MAIL: Btbric@Lsuvm.Sncc.Lsu.Edu
RESEARCH: Structure and function relationships in photosynthesis
SEND: CV and three letters of recommendation

POSITION OFFERED: Post-Doc
CONTACT: P. Sebban, Photosynthese Bacterienne, Bat. 24, Centre de Genetique Moleculaire, CNRS, 91198, Gif FRANCE. TEL: 33-1-69-82-38-26 FAX: 33-1-69-82-35-62 E-MAIL: Sebban@Citi2.Fr
RESEARCH: Electrostatic effects and proton conduction in bacterial reaction center membrane proteins.
REQUIREMENTS: Well-organized and flexible candidate able to pursue a multidisciplinary approach. Desirable but not definitely needed is experience in biochemistry and spectroscopy and knowledge of molecular biology and genetics.
AVAILABLE: From 1 Oct 1995 for three years
SEND: CV and statement of research interests

POSITION OFFERED: Post-Doc
CONTACT: David Kramer, Institute of Biological Chemistry, Washington State University, Pullman WA U.S.A. TEL: 217-244-8913 or 217-333-7407, E-MAIL: Kramer@Nemo.Life.Uiuc.Edu
RESEARCH: Characterization of photosynthetic electron transfer reactions in intact higher plants and in evolutionarily interesting algal and bacterial species.
REQUIREMENTS: U.S. citizenship or residence status. Experience desirable in one or more of following: isolation of membrane protein complexes, optical or electronics instrumentation, EPR spectroscopy, knowledge of photosynthetic or respiratory electron transfer reactions.
AVAILABLE: 1 Sept 1995

POSITION OFFERED: Post-Doc
CONTACT: H.Y. Yamamoto, University of Hawaii, 3050 Maile Way, Gilmore 202 B, Honolulu, HI 96822 U.S.A. E-MAIL: Yamamoto@Uhunix.Uhcc.Hawaii.Edu
RESEARCH: Molecular biology and physiological function of violaxanthin de-epoxidase, a key enzyme in the xanthophyll-dependent non-radiative energy dissipation of excess energy to down-regulate PSII photochemical efficiency.
REQUIREMENTS: self-motivated individual with a strong background in molecular biology and publication record sought. Knowledge and interest in photosynthesis highly desirable. Ph.D. in plant physiology, biochemistry, molecular biology, or related discipline required.
SEND: CV and names of three references

Positions Sought

POSITION SOUGHT: Visiting professor/scientist (for 2-3 weeks only).
CONTACT: L.V. Venkataraman, "Sudarshana", #236, 8th Cross, Gokulam 3rd Stage, Mysore 570 002 INDIA. TEL: 821-510006, FAX: 821-512539, TELEX: 0846-320 POLY IN
RESEARCH EXPERIENCE: 25 years, basic applied aspects of *Spirulina* effluent treatment, integrated systems, biotransformations, bioenergy production. Over 200 publications.

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L.V. VENKATARAMAN has taken an early retirement from the Central Food Technological Research Institute in Mysore, India. He is keeping his academic research alive, continuing to guide research students and consulting on Spirulina biotechnology in India and abroad (see ANNOUNCEMENTS).

David Laudenbach

We announce with great sadness that David Laudenbach died during surgery on Thursday June 15, 1995 at the age of 35. It is always sad to lose a colleague, and especially sad to lose a colleague who is so young and such an integral part of the cyanobacterial community.

David received his MSc and PhD at the University of Toronto. His research there focussed on the molecular genetic responses of *Synechococcus* PCC 7942 to iron deficiency. He isolated the gene for flavodoxin and showed that it was the second open reading frame of a dicistronic message whose transcription was tightly regulated by iron. He demonstrated that the first open reading frame encoded a protein with high homology to CP43, which he correctly guessed to be the iron-stress-induced, PS II, chlorophyll-binding protein that had been previously discovered in Lou Sherman's laboratory. He also cloned the gene for ferredoxin and showed that its expression was not affected by the concentration of iron in the growth medium. Before graduating David isolated and created mutants for the genes encoding iron superoxide dismutase and cytochrome c_{553}. The productivity of his graduate years set a pattern that would continue throughout the remainder of his career.

David left Toronto to do postdoctoral research at the Carnegie Institution for Plant Science, Stanford University. His project concerned the acclimation of *Synechococcus* to sulfur deficiency. David was able to functionally define systems involved in sulfate transport and sequence the genes encoding the components of these systems. He also defined a novel sulfur limitation induced gene, designated *rhd*, that may be involved in the utilization of certain thiol compounds during sulfur-limited growth. Finally, Dave discovered the regulatory gene *cysR* and postulated its involvement in controlling the utilization of thiocyanate during sulfur limitation. This work was extended to some of the highly productive projects that Dave developed independently as an Assistant Professor at the University of Western Ontario.

David was not the type of scientist that could be satisfied with one project and his curiosity always got the better of him. For example, while at Carnegie he started up collaborations with Dave Fork and Steve Herbert on the acclimation of *Synechococcus* to oxidative stress and its affect on the photosynthetic apparatus. His constant probing and 'playing' in the laboratory provoked both new ideas and the development of new projects. David was a talented and unique scientist.

David is survived by his wife Lori and two children Adam (5) and Theresa (3). A fund has been established for Adam and Theresa. If you wish to contribute please make cheques payable to "Lori Laudenbach in trust" and mail them to CIBC, 228 Oxford Street East, London, Ontario N6A 1T7, Canada. Enclose a letter stating who is making the contribution, including the names and addresses of all for group contributions, and that the contribution is to be directed to the trust fund for Adam and Theresa Laudenbach.

Arthur Grossman & Neil Straus

Allen Acclaimed by National Society

Mary Mennes Allen was honored at the 1995 meeting of the American Society for Microbiology with the Carski Foundation Distinguished Teaching Award, in recognition of her career in inspiring undergraduates towards a career in science. Needless to say, a useful tool in her inspirational efforts has been her ongoing research into the function of cyanophycin in cyanobacteria.

Controlled Expression of Foreign Genes in Chromosomes of *Synechococcus*

A few years ago workers at the University of Utrecht described a novel method to facilitate the stable insertion of foreign genes into an innocuous locus of the chromosome. The constructed chromosomal location, called PIM (for platform for integration in *metF*), consists of a promoterless *bla* gene and *oriV*, both from pBR322, a plasmid commonly used in molecular biology. Insertion of genes of interest into that site could be achieved, with selection for ampicillin (encoded by *bla*), upon recombination between the platform and their pBR322-derived vector. Dirk Geerts now tells us that he and others in Utrecht have extended the technique to permit inducible, high-level expression of genes placed in the platform. The original method has further been modified to greatly reduce the aberrant recombinational events that had plagued the technique in the past.

Their new vector, pTrcIS, provides a strong *trc* promoter whose expression is well controlled by the lactose repressor, encoded by the $lacI^q$ gene also on the plasmid. Downstream from this promoter is the *lac* operon ribosome binding site and a polylinker to facilitate transcriptional or translational fusions of inserted genes. Of particular utility is an NcoI site for the insertion of the 5'end of a gene directly to the ATG start codon. Flanking this region are a complete version of *bla* and *oriV*, required for integration into the platform. The Utrecht group also place *aadA*, determining resistance to streptomycin and spectinomycin.

They found, using *petE* (encoding the precursor to plastocyanin) from *Anabaena* PCC 7937 (*Anabaena variabilis*), and *uidA* (encoding ß-glucuronidase, GUS) from *E. coli*, that double recombination events placing the foreign gene into the platform occurred with a very low incidence of false positives when streptomycin was used as the selective agent. When ampicillin alone was used, the number of colonies recovered was much higher but the majority of recombinants were not true double recombinants, and the frequency with which the foreign gene was expressed in the recombinant varied from 0 to 100%, depending on the insert. Selection for streptomycin evidently ensures that virtually all of the colonies resulting from transformation of *Synechococcus* have the desired phenotype.

Expression of the foreign gene could be controlled within a wide dynamic range by the addition of graded amounts of the *lac* inducer IPTG, with full repression in the absence of the inducer. The highest level of induction was 36-fold, as judged by expression of GUS, or 100-fold, as judged by expression of *petE*. The level of expression by the P_{trc}-*uidA* fusion is almost 4-fold higher than that achieved by the strongest the cyanobacterial promoter (P_{petF}) tested.

The work has recently been fully described [Geerts et al (1995) Microbiol-UK 141:831-841].

Excretion of Ammonia from Immobilized *Anabaena* Explained

Symbiotic cyanobacteria commonly release fixed nitrogen resulting from N_2 fixation to their hosts. It has long been a hope of some that cyanobacteria could be induced to excrete ammonia on a large-scale industrial setting. In 1987, Shi Ding-Ji and others [Planta 172:298-308] reported that ammonia excretion occurred simply by N_2-fixing cyanobacteria immobilized within polyurethane foams. Why this should be the case has been a mystery, but Shi describes to us how Duan Xue-Yan and others at Capital Normal University and Academia Sinica in Beijing have brought us one step closer to its solution.

The Beijing group found that *Anabaena* sp. strain 2B (isolated as an epiphyte of *Azolla caroliniana*) immobilized within polyurethane showed higher (1- to 2-fold) glutamine synthetase (GS) activity than a free-living culture over the several days following initiation of the experiment. Over the longer term, however, GS activity in immobilized *Anabaena* drops 10-20% below that of the free-living culture. This period of low GS activity roughly corresponds to the period of high production of ammonia by immobilized *Anabaena* reported earlier.

Hybridization of mRNA isolated from free and long immobilized cultures to a probe specific for GS mRNA indicate that the drop in GS activity is due to a corresponding decrease in GS message. In order to achieve this result, the group had to improve upon existing methods to extract RNA from immobilized cyanobacteria. Their modification permits efficient isolation, as judged by comparison of stable rRNA from immobilized and free cultures.

Details of the work have been published [Duan et al (1994) Chinese J Bot 6:102-106 (English)].

X INTERNATIONAL CONGRESS ON NITROGEN FIXATION - Meeting Report

The 10th International Congress on Nitrogen Fixation took place 28 May to 3 June of this year in St. Petersburg, Russia. While the majority of presentations concerned themselves with the doings of heterotrophic bacteria, there were a few cyanobacterial nuggets, some of which are reported below.

Bernd Masepohl (Bonn) reported the identification of a NOVEL REPEATED DNA ELEMENT in *Anabaena* PCC 7120 with so far unknown function. This long tandemly repeated repetitive (LTRR) sequence is 37 bp long and contains an inverted repeat sequence. An LTRR-specific probe hybridized to numerous DNA regions in *Anabaena* PCC 7120 and many other cyanobacteria.

In addition he described the construction of a mutant derivative of *Anabaena* PCC 7120 defective in the FERREDOXIN-encoding gene, *fdxH*. The mutant exhibited much reduced nitrogenase activity, confirming that this [2Fe-2S] heterocyst ferredoxin (see B. Schrautemeier, below) is the principal electron donor to nitrogenase, but may also partly be replaced by (an) alternate donor(s).

The mechanism of cyanobacterial NITROGENASE REGULATION OR MODIFICATION into the inactive form of the Fe-protein is still an enigma, according to John Gallon (Swansea). ADP-ribosylation is evidently not involved, in contrast to the importance of such a modification in the case of glutamine synthase, as recently reported by Noel Carr and Nick Mann.

The mechanism of OXYGEN SENSING is now better understood in *Azotobacter vinelandii* (if we may slip in a noncyanobacterium). Ray Dixon (Sussex) described the characterization of the oxygen-sensor protein NifL. It contains FAD with FMN as minor component and controls the catalytic activity of NifA in the active ADP-bound form.

The regulatory protein OxyR plays a role under OXIDATIVE STRESS in *E. coli* and *Salmonella typhimurium*. Karin Jäger (Hannover) found an OxyR-like protein in *Anabaena variabilis* and *Anabaena* PCC 7120 by using a specific antibody against the *E. coli* protein. Southern blot analyses with the E.coli gene probe reveled no signal with cyanobacterial genomic DNAs.

Bernhard Schrautemeier (Bonn) reported on DUAL MO-NIF SYSTEMS expressed from separate nif gene clusters (nif1, nif2) of *Anabaena variabilis* ATCC 29413 that also were independently discovered by Teresa Thiel and coworkers in St. Louis. Teresa, using a *lacZ* reporter system and a fluorescent substrate, conclusively demonstrated localized expression of *nif1* (only in heterocysts) versus *nif2* (in all vegetative cells). Bernhard's approach emphasizes the time component/differential kinetics of oxygen-controlled *nif2*- versus developmentally-controlled *nif1*-expression after nitrogen deprivation: Nif2 is expressed only under strictly anaerobic conditions as early as 1-2 hours after nitrogen stepdown -- long before the appearance of proheterocysts. In contrast, Nif1 is expressed only after (pro)heterocysts have appeared, i. e. not earlier than about 10 hours after nitrogen depletion, irrespective of anaerobic or aerobic growth conditions. By using a standardized comparative induction assay monitoring nitrogenase activity during the 20 hours following nitrogen deprivation, he additionally demonstrated that *Anabaena* PCC 7120 has no characteristics of a functional Nif2 system.

Examining the region upstream from each *nifHDK* cluster, Bernhard hit upon different genes encoding ferredoxins: *fdxH1* and *fdxH2* for the *nif1* and *nif2* clusters, respectively. It is interesting that FdxH1 is oxygen-tolerant in vitro, while FdxH2 is rapidly inactivated by oxygen. Both are equally effective in donating electrons to nitrogenase isolated from heterocysts. The *fdxH2* gene, but not *fdxH1*, is followed by a gene, *fdxB*, encoding a second ferredoxin of unknown function, as also present downstream of *fdxH* from the nonheterocystous filamentous Plectonema PCC 73110. Hence the Nif2 system is homologous to the single, environmentally regulated Mo-Nif system expressed in all cells of nonheterocystous filamentous species [Smoker et al (1990) Meth Molec Cell Biol 2:59-65].

Many additional questions now arise from the work of Bernhard, Teresa, and coworkers. In particular: (a) How do *nif1* and *nif2* differ in their regulatory mechanisms yet intersect in their dependence on nitrogen deprivation? (b) What is the distribution of the two systems amongst nitrogen-fixing cyanobacteria? (c) What is the benefit of two coexisting *nif* systems?

-- Karin Jäger

III EUROPEAN WORKSHOP ON THE MOLECULAR BIOLOGY OF CYANOBACTERIA - Meeting Report

Bioenergetics and Physiology

Several presentations related to the structure and function of FERREDOXIN-DEPENDENT ENZYMES. Data from Herbert Böhme's group in Bonn suggests a common but not identical ferredoxin binding domain on the ferredoxin-dependent enzymes nitrate reductase, nitrite reductase and ferredoxin NADP-reductase (FNR). It is noteworthy that the same mutations in specific amino acids of ferredoxin that stimulated the reversed flow from NADPH-reduced FNR to oxidized ferredoxin also severely inhibited electron transport from reduced ferredoxin to FNR. Carlos Gómez-Moreno (Zaragoza) presented rapid kinetic characterizations of ferredoxin, flavodoxin and FNR mutants in which amino acids involved in the interaction between these proteins had been modified. Two others from Zaragoza, Maria Fillat and Marisa Peleato, described, respectively: (1) the overexpression in a protease-deficient *E. coli* of the 49-kDa form of FNR (the complete product of *petH*) from *Anabaena* and (2) the characterization of different FNR-phycobiliprotein complexes of Anabaena, isolated from vegetative cells and heterocysts.

CAROTENOID BIOSYNTHESIS was the focus of presentations by Gerhard Sandmann (Frankfurt) and Blanca Fernández (Sevilla). Sandmann reported the cloning of the zeta-carotene desaturase gene from *Anabaena* PCC 7120 by heterologous complementation. Fernández, using the *cat* gene as a reporter, showed stimulation of the expression of the phytoene desaturase (*crtP*) promoter at high light

intensities, a result in agreement with the photoprotective role ascribed to carotenes.

The molecular bases of the ADAPTIVE RESPONSES of cyanobacteria to changes in light conditions were addressed by a few presentations. Jean Houmard (Paris) reported that whereas changes in the photosynthetic photon flux density exerts a major influence on the differential expression of genes within the *psbA* and psbD multigene families, changes in light wavelength also result in profound modifications of the light harvesting apparatus, in those strains that exhibit chromatic adaptation. In *Calothrix* PCC 7601, different phosphorylated DNA-binding proteins, namely RcaA and B (which specifically bind to the promoter region of the phycoerythrin operon) and RcaD (which binds to the phycocyanin-2 operon), are expressed under green-light and red-light, respectively. However, no difference was found in the subunit composition of the RNA polymerase isolated from cells grown under the two conditions.

Insights into the LIGHT REGULATION of the *PSBA* GENE FAMILY (encoding D1 protein) in *Synechocystis* PCC 6803 were provided by Christer Jansson (Stockholm) and David Campbell (Umeå). Jansson found that *psbA2* and *psbA3*, two gene copies differing in their promoter elements, were light-regulated and transcribed at vastly different levels (30-fold higher for *psbA2*). Inactivation of *psbA2* by in vitro mutagenesis led to an 8-fold up regulation of *psbA3* gene transcription. Site-specific mutagenesis permitted the identification of putative Mn-binding amino acids within D1 and sequences involved in the light-triggered proteolytic degradation of this protein. Campbell reported that *Synechococcus* responds to excitation stress by replacing the constitutive form of the D1 protein (D1:1) by another form, D1:2, that confers increased resistance to photoinhibitory damage and a higher photochemical efficiency of PS II. This D1 exchange is a response to excess excitation of photosynthetic electron transport, and not a specific response to light intensity per se.

Aaron Kaplan (Jerusalem) described novel HIGH-CO_2-REQUIRING MUTANTS of *Synechococcus* PCC 7942. These mutants were obtained upon integration of plasmids containing DNA internal to the CO_2-related operons, selected from a library composed by short genomic fragments. The mutant-forming plasmids were retrieved and their genomic regions used as probes of wild-type transcripts and genomic DNA. By this means, Kaplan's group showed that the different regions are transcribed and do not lie in close proximity to each other in the chromosome. The study by fusion experiments of the promoter regions of genes modulated by changing CO_2 concentration indicated the presence of enhancing and repressing elements. Conserved sequences were found in the promoter region of several CO_2-responding genes. Francoise Joset's group (Marseille) described the characterization of a gene from *Synechocystis* PCC 6803, *hatR*, involved in a high affinity system of HCO_3^- uptake and the identification of proteins showing different levels of synthesis in response to changes in the levels of inorganic carbon.

Aurelio Serrano (Sevilla) cloned the NAD(P)-dependent GLYCERALDEHYDE 3-PHOSPHATE DEHYDROGENASE (G3P DHase) from *Synechocystis* PCC 6803, by complementation of an *E. coli gap*$^-$ mutant with a genomic library. The enzyme restored the glycolytic pathway in E.coli, and thus may be presumed able to function in that capacity in *Synechocystis* as well. Since G3P DHase is already known to be essential in the reductive pentose phosphate pathway, the enzyme may therefore play both anabolic and catabolic roles in *Synechocystis*. The sequence of the complementing gene predicted a protein very similar (70-80% identity) to G3P DHase from chloroplasts of higher plants. Southern blots using as probes the cloned G3P DHase genes of *Synechocystis* and *E. coli* indicated that two genes, one corresponding to each type, are present in the *Synechocystis* genome. However, since immunological and biochemical data are consistent with the presence in *Synechocystis*, of only an NAD(P)-dependent enzyme, Serrano suggested that the *E. coli*-like gene may be a pseudogene or a gene not expressed under normal culture conditions.

Two presentations had important implications regarding cyanobacterial RESPIRATION. Georg Schmetterer (of Vienna) obtained *cox*$^-$ mutants of *Synechocystis* PCC 6803 in which the three genes coding for the terminal oxidase of aa3 type were inactivated. Surprisingly, although no cytochrome *c* oxidation by membranes of the mutants was observed, the intact cells respire almost normally. Schmetterer explained these results by postulating the existence of An "alternative terminal oxidase", sensitive to KCN, that reduces O_2 in the dark with NAD(P)H. Gunther Peschek (Vienna) presented results indicating that the cyanobacterial cytochrome *c* oxidase might be subject to adenylate regulation. A putative mitochondria-like subunit IV gene (*ctaIV*) was identified in *Synechocystis* exhibiting consensus sequences of adenylate-binding enzymes.

Norio Murata (Okazaki) described very interesting results on the GENETIC MANIPULATION OF MEMBRANE LIPIDS in cyanobacteria. His group was able both to decrease the degree of unsaturation of fatty acids in *Synechocystis* PCC 6803 (by inactivating the corresponding desaturase genes) and to increase the degree of unsaturation of fatty acids in membranes of *Synechococcus* PCC 7942 (by transformation with foreign cyanobacterial desaturase genes). These changes did not affect rates of photosynthesis and photosynthetic electron transport and only scarcely affected heat stability of oxygen evolution. However, a lower degree of unsaturation enhanced photoinhibition at low temperatures and a higher degree of unsaturation accelerated recovery from photoinhibition. These results may help to elucidate the mechanisms of photoprotection of photosynthetic organisms at low temperatures.

-- Aurelio Serrano

Nitrogen Regulation/Metabolism and N_2 Fixation

Antonia Herrero and Ignacio Luque (both of Sevilla) reported results concerning the mechanism of GENE REPRESSION BY AMMONIA in *Synechococcus* PCC 7942. They found that mutant strains that express NtcA to a high and constitutive level still require the absence of ammonium to express NtcA-regulated genes (e.g. *nir* operon, *glnA*). They suggested that a coactivator may be required for the expression of nitrogen-regulated genes or that NtcA protein

is posttranscriptionally interconverted between an active and an inactive form in response to the nitrogen status. Antonia also proposed that the level of NtcA might contribute to the differential regulation of some genes through weak binding of the protein to sites deviating from the known NtcA consensus binding site.

José Frias (Sevilla) discussed the GENES OF NITRATE assimilation: their regulation and function. The *nir-nrtABCD-narB* gene cluster (the *nir* operon) of *Anabaena* PCC 7120 was cloned and analyzed. Northern analysis showed that the *nir* operon is transcribed in the absence of ammonium with or without nitrate or nitrite in the medium, this despite the fact that high levels of nitrate and nitrite reductase activities occur only in the former case. A 460 bp leader sequence between the Ntc-regulated promoter and the first codon of *nir* seems to lack any function: when removed no change in phenotype was observed. Insertional inactivation of *nrtA* resulted in mutants that were unable to transport nitrate at low external concentration (0.1 mM), but at high concentration (18 mM) nitrate was taken up at a slow rate and reduced to ammonium. High activities of the nitrate assimilation enzymes were observed at either level of nitrate concentrations but neither could repress heterocyst formation.

Paco Navarro (Sevilla) found two different genes, *gltS* and *gltB*, in *Synechocystis* PCC 6803, that encode ferredoxin-dependent GLUTAMATE SYNTHASES (GOGAT). Inactivation of either one did not significantly impair growth (concomitant inactivation of both has not yet been tried). While *gltS* was present in many other cyanobacteria tested, *gltB* was additionally found only in *Pseudoanabaena* PCC 6903. Both enzymes expressed in *E. coli* accept electrons from PetF-type ferredoxins, but flavodoxin was inactive. Interestingly, GltB was equally active with heterocyst ferredoxin (FdxH). Figueroa (Sevilla) cloned *gltS* from *Anabaena* PCC 7120. GltS activity was highest in crude extracts of cells using N_2 as the nitrogen source, as opposed to nitrate or ammonium, hinting at a role for this GOGAT in heterocyst metabolism.

Reyes and Florencio (Sevilla) reported that the REDOX STATE controls the transcription of *glnA*, encoding GLUTAMINE SYNTHETASE (GS). Transcript abundance was high when *Synechocystis* PCC 6803 was grown in the light or in the dark with glucose and low in the dark without glucose or when DCMU (a PSII-inhibitor) or DBMIB (a cytochrome b_6/f complex-inhibitor) was added. N-starvation provoked a delay in decrease of *glnA* transcripts suggesting a connection between nitrogen and redox controls of transcript levels. Crespo (Sevilla) found that redox control seems also to govern inactivation of glutamine synthetase (GSI) in vivo. In this case, however, the addition of DBMIB, leading to a reduced plastoquinone (PQ) pool, was not inhibitory. This result suggests that the redox state of PQ or a component of the b_6/f-complex is a signal for modification.

The same group also characterized a SECOND TYPE OF GLUTAMINE SYNTHETASE from *Synechocystis* PCC 6803, encoded by *glnN*, similar to the GSIII-type enzymes found in the *Bacteriodaceae*. GlnN has a larger subunit size (75kD) than the 50kD product of *glnA* and, unlike the dodecameric GlnA, probably exists in its native state as a hexamer. According to Western blot analysis, GSIII is more abundant in PCC 6803 and other non nitrogen-fixing cyanobacteria when they are starved for nitrogen. GSIII is lacking, however, in N_2-fixing *Anabaena* PCC 7120.

Nicole Tandeau de Marsac and coworkers (Paris) described P_{II} PROTEIN as the central node for the coordination of nitrogen and carbon assimilation in cyanobacteria. P_{II} is a protein whose homologue in enteric bacteria is involved in regulation of GS activity and Ntr-regulated gene expression. She reported that a P_{II}-deficient mutant of *Synechococcus* PCC 7942 can take up nitrate even in the normally inhibitory presence of ammonium. The mutant has also lost the ability to adapt rapidly to changes in light, nitrogen, and carbon supplies. P_{II} thus functions to integrate nutritional stimuli and to reestablish a proper C/N-ratio for balanced cell growth. In *Calothrix* PCC 7504, P_{II} is found to be unmodified during the hormogonial stage of growth, whereas P_{II} modification is most pronounced under conditions of heterocyst differentiation. Thus, in filamentous strains P_{II} may be additionally involved in cell differentiation processes.

Karl Forchhammer (Munich) devised an in vitro test for PHOSPHORYLATION OF P_{II} that clearly demonstrated that 2-ketoglutarate is sufficient to activate P_{II} kinase from *Synechococcus* PCC 7942. No other compound tested (e.g., glutamine or other amino acids) could substitute or counteract the stimulation by 2-ketoglutarate. The latter may serve as an intracellular signal to monitor the balance of assimilated carbon and nitrogen that is sensed by P_{II} kinase and transmitted to P_{II} by protein serine phosphorylation.

Lucas Stal (Amsterdam) made an interesting observation related to the CAPABILITY OF NONHETEROCYSTOUS CYANOBACTERIA TO FIX NITROGEN predominantly in the light. He noted that a Cyanothece strain is impaired in nitrogen fixation when grown in batch cultures, where they produce sulfated extracellular polysaccharides and thus rapidly deplete the medium of sulfate. In continuous cultures with a continuous supply of sulfate nitrogenase activity was high and confined predominantly to the light. The same was true when sulfate was added to a sulfate-depleted batch culture. This intriguing observation leaves us once more perplexed (as with the case of *Trichodesmium*): how do they do it without heterocysts?

-- Bernhard Schrautemeier

Ecology

One perennial problem for ecologists is that of IDENTIFYING the ORGANISMS present in natural populations. Strain identification is also a problem for those of us working on newly isolated strains. A variety of molecular techniques are available for strain identification and discrimination; the results presented on three posters (Anneliese Ernst, Konstanz; Gary Barker, Bristol; Suzzanne McColl, Liverpool) lend yet more evidence to what has been long suspected, namely that natural populations of cyanobacteria consist of many distinct clones.

The biology of GAS VACUOLATE CYANOBACTERIA was covered in two presentations. The advantages accruing from gas vesicle production by *Aphanizomenon* in the Baltic Sea is being quantified by Walsby and co-workers (Bristol); such colonial forms can gain a 3-fold photosynthetic advantage over their non-buoyant competitors by rapidly moving back towards surface, and light, after mixing-events. The genes involved in producing gas vesicles and the interactions between the gene products were described by Hayes et al. Once thought to be a simple structure formed by self assembly of a single type of protein, it is now clear that it takes the concerted action of at least six different gene products to assemble these structures.

Elke Dittmann et al. (Berlin) described progress toward the complete characterization of the genes encoding PEPTIDE SYNTHETASES of cyanobacteria. These incredibly complex enzymes are responsible for the synthesis of the cyclic peptide toxins. The group in Berlin have partially characterized a gene from *Microcystis aeruginosa* using conserved domains from peptide synthetases to provide probes. This approach is similar to that described by Leo Rouhiainen et al. (Helsinki) in Urbino for the genes from *Nodularia.* With the genes available from a number of organisms it should now be possible to study the biological role of these toxic compounds.

Molecular mechanisms of SALT TOLERANCE were described in two presentations (Martin Hagemann and Ellen Zuther, Rostok). A total of 18 salt sensitive mutants of *Synechocystis* PCC 6803 were produced by random cartridge mutagenesis; 9 of these were unable to synthesize glucosylglycerol. One of the genes identified, *stpA*, had been previously characterized (Francoise Joset, Marseille). Three other ORFs have been characterized in Rostock; the role of theses genes has yet to be confirmed but glucosylglycerol transport and positive regulation of glucosylglycerol synthesis seem likely candidates.

Nigel Robinson (Newcastle) gave a lucid summary of work carried out in his laboratory on the regulation of expression of the METALLOTHIONINE-ENCODING GENE *smtA* from *Synechococcus* PCC 7942. SmtB is a repressor of *smtA* expression that dissociates from the *smtA* promoter in the presence of Zn^{2+}. Upstream of *smtB* is *smtZ*, a gene that encodes a protein the C-terminal end of which has the features of a zinc-finger: SmtZ may up-regulate *smtA* expression in the presence of Zn^{2+}. Upstream again is *dnaG*, encoding primase which could be a zinc metalloprotein. An octameric palindrome HIP1 (5'-GCGATCGC-3') is involved in the deletion of *smtB* in cells selected for zinc tolerance. This sequence occurs at much higher than expected frequencies in many cyanobacteria (but not in any of the marine isolates investigated); is it involved in genome plasticity? We will have to wait for the answer to that question.

All of the presentations at the meeting were excellent and I wish I had the time to write about them all (in particular Nick Mann, Warwick, gave a first class talk of extreme ecological relevance, but mine came straight afterwards so I missed most of what he saying) but at least you now have the gist of some of the topics covered.

- Paul Hayes

REFERENCES*REFERENCES*REFERENCES*REFERENCES*REFERENCES*REFERENCES*REFERENCES*REF

EVOLUTION and ECOLOGY

Neilan BA (1995). Identification and phylogenetic analysis of toxigenic cyanobacteria by multiplex randomly amplified polymorphic DNA PCR. Appl Environ Microbiol 61:2286-2291

Nimura K, Yoshikawa H, Takahashi H (1994). Sequence analysis of the third *dnaK* homolog gene in *Synechococcus* sp PCC 7942. Biochem Biophys Res Commun 205:2016-2017 (Correction to Vol 201, pg 848, 1994)

Sanangelantoni AM, Tiboni O (1993). The chromosomal location of genes for elongation factor Tu and ribosomal protein S10 in the cyanobacterium *Spirulina platensis* provides clues to the ancestral organization of the *str* and S10 operons in prokaryotes. J Gen Microbiol 139:2579-2584

Shimada A, Kanai S, Maruyama T (1995). Partial sequence of ribulose-1,5-bisphosphate carboxylase/oxygenase and the phylogeny of *Prochloron* and *Prochlorococcus* (*Prochlorales*). J Mol Evol 40:671-677

Budel B, Luttge U, Stelzer R, Huber O, Medina E (1994). Cyanobacteria of rocks and soils of the Orinoco lowlands and the Guayana uplands, Venezuela. Bot Acta 107:422-431

Caumette P, Matheron R, Raymond N, Relexans J-C (1994). Microbial mats in the hypersaline ponds of Mediterranean salterns (Salins-de-Giraud, France). FEMS Microbiol Ecol 13:273-286

Howarth RW, Butler T, Lunde K, Swaney D, Chu CR (1993). Turbulence and planktonic nitrogen fixation: A mesocosm experiment. Limnol Oceanogr 38:1696-1711

Kevbrin VV, Kostrikina NA, Lysenko AM (1994). Isolation and identification of *Pseudomonas nautica*, a heterotrophic satellite of *Microcoleus chthonoplastes* cyanobacteria. Microbiol-Engl Tr 63:607-612

Kraus MP, Gorsuch JW, Lower WR (1991) Cyanophage/host assay for toxicity assessment in water, wastewater, sludges, and composts. In: Lewis MA, Wang W (eds) *Plants for Toxicity Assessment*, vol 2. American Society for Testing and Materials, Philadelphia, PA (U.S.A.). pp.383-391

Lassen C, Jorgensen BB (1994). A fiber-optic irradiance microsensor (cosine collector): Application for in situ measurements of absorption coefficients in sediments and microbial mats. FEMS Microbiol Ecol 15:321-336

Luttge U, Budel B, Ball E, Strube F, Weber P (1995). Photosynthesis of terrestrial cyanobacteria under light and desiccation stress as expressed by chlorophyll fluorescence and gas exchange. J Exp Bot 46:309-319

Mishra SR, Saksena DN (1993). Planktonic flora of textile mill waste water from Birla Nagar industrial complex at Gwalior, Madhya Pradesh. Comp Physiol Ecol 18:124-126

Moller A, Norrby AM, Gustafsson K, Jansson J (1995). Luminometry and PCR-based monitoring of gene-tagged cyanobacteria in Baltic Sea microcosms. FEMS Microbiol Lett 129:43-49

Neale PJ, Priscu JC (1995). The photosynthetic apparatus of phytoplankton from a perennially ice-covered Antarctic lake: Acclimation to an extreme shade environment. Plant Cell Physiol 36:253-263

Sellner KG, Brownlee DC, Bundy MH, Brownlee SG, Braun KR (1993). Zooplankton grazing in a Potomac River cyanobacteria bloom. Estuaries 16:859-872

Singh NK (1993). Studies on density, productivity and species composition of phytoplankton in relation to abiotic spectrum of the Ganges at Sahibganj. J Freshwat Biol 5:1-8

Soto Y, Bianchi M, Martinez J, Rego JV (1993). Seasonal evolution of microplanktonic communities in the estuarine front ecosystem of the Rhone River plume (North-western Mediterranean Sea). Estuar Coast Shelf Sci 37:1-13

Srivastava AK, Renu (1988). Physico-chemical and biological characteristics of a sugar factory effluent. Indian J Ecol 15:192-193

Vaulot D, Marie D, Olson RJ, Chisholm SW (1995). Growth of *Prochlorococcus*, a photosynthetic prokaryote, in the equatorial Pacific Ocean. Science 268:1480-1482

Wood MD, Oliver RL (1995). Fluorescence transients in response to nutrient enrichment of nitrogen- and phosphorus-limited *Microcystis aeruginosa* cultures and natural phytoplankton populations: A measure of nutrient limitation. Aust J Plant Physiol 22:331-340

SYMBIOSIS

Baulina OI, Yagodina IB, Korzhenevskaya TG, Gusev MV (1994). Morphology and ultrastructure of cyanobacterium *Synechococcus elongatus* grown in association with plant cells. Microbiol-Engl Tr 63:365-372

Caudales R, Wells JM, Antoine AD, Butterfield JE (1995). Fatty acid composition of symbiotic cyanobacteria from different host plant (*Azolla*) species: Evidence for coevolution of host and symbiont. Int J Syst Bact 45:364-370

Cohen MF, Wallis JG, Campbell EL, Meeks JC (1994). Transposon mutagenesis of *Nostoc* sp strain ATCC 29133, a filamentous cyanobacterium with multiple cellular differentiation alternatives. Microbiol UK 140:3233-3240

Gantar M, Kerby NW, Rowell P, Obreht Z, Scrimgeour C (1995). Colonization of wheat (*Triticum vulgare* L.) by N_2-fixing cyanobacteria: IV. Dark nitrogenase activity and effects of cyanobacteria on natural ^{15}N abundance in plants. New Phytol 129:337-343

Rasmussen U, Johansson C, Bergman B (1994). Early communication in the *Gunnera-Nostoc* symbiosis: Plant-induced cell differentiation and protein synthesis in the cyanobacterium. Mol Plant Microbe Interaction 7:696-702

Schussler A, Schnepf E, Mollenhauer D, Kluge M (1995). The fungal bladders of the endocyanosis *Geosiphon pyriforme*, a Glomus-related fungus: Cell wall permeability indicates a limiting pore radius of only 0.5 nm. Protoplasma 185:131-139

Uheda E, Kitoh S, Dohmaru T, Shiomi N (1995). Isolation and analysis of gas bubbles in the cavities of *Azolla* leaves. Physiol Plant 93:1-4

TOXINS and NATURAL SUBSTANCES

Cardellina JH II, Munro MHG, Fuller RW, Manfredi KP, McKee TC, Tischler M, Bokesch HR, Gustafson KR, Beutler JA, Boyd MR (1993). A chemical screening strategy for the dereplication and prioritization of HIV-inhibitory aqueous natural products extracts. J Nat Prod (Lloydia) 56:1123-1129

Echavarren AM, Castano AM (1995). Synthesis of 3-methylaspartic acids by ring-contraction of a nickelacycle derived from glutamic anhydride. Tetrahedron 51:2369-2378

Harada K, Fujii K, Shimada T, Suzuki M, Sano H, Adachi K, Carmichael WW (1995). Two cyclic peptides, anabaenopeptins, a third group of bioactive compounds from the cyanobacterium *Anabaena flos-aquae* NRC 525-17. Tetrahedron Lett 36:1511-1514

Horner RA, Postel JR (1993). Toxic diatoms in western Washington waters (U.S. West Coast). Hydrobiol 269-270:197-205

Ikawa M, Sasner JJ, Haney JF, Foxall TL (1995). Pterins of the cyanobacterium *Aphanizomenon flos-aquae*. Phytochemistry 38:1229-1232

Ishida K, Murakami M, Matsuda H, Yamaguchi K (1995). Micropeptin 90, a plasmin and trypsin inhibitor from the blue-green alga *Microcystis aeruginosa* (NIES-90). Tetrahedron Lett 36:3535-3538

Jefford CW, McNulty J (1994). A practical synthesis of (2S,3R)-3-amino-2-methylpentanoic acid from L-aspartic acid. Helv Chim Acta 77:2142-2146

Jones GJ, Orr PT (1994). Release and degradation of microcystin following algicide treatment of a *Microcystis aeruginosa* bloom in a recreational lake, as determined by HPLC and protein phosphatase inhibition assay. Water Res 28:871-876

Kos P, Gorzo G, Suranyi G, Borbely G (1995). Simple and efficient method for isolation and measurement of cyanobacterial hepatotoxins by plant tests (*Sinapis alba* L). Anal Biochem 225:49-53

Lee ESJ, Gleason FK (1994). A second algicidal natural product from the cyanobacterium, *Scytonema hofmanni*. Plant Sci 103:155-160

Menges M, Bruckner R (1995). Enantioselective synthesis of bis(gamma-butyrolactones). Their oxidative degradation to tetraols as a key step in stereoselective syntheses of 1,3,5,7,9-pentaol synthons for polyhydroxylated natural products. Liebigs Annalen:365-384

Murata H, Shoji H, Oshikata M, Harada KI, Suzuki M, Kondo F, Goto H (1995). High-performance liquid chromatography with chemiluminescence detection of derivatized microcystins. J Chromatogr A 693:263-270

Nagle DG, Geralds RS, Yoo HD, Gerwick WH, Kim TS, Nambu M, White JD (1995). Absolute configuration of curacin A, a novel antimitotic agent from the tropical marine cyanobacterium *Lyngbya majuscula.* Tetrahedron Lett 36:1189-1192

Nagle DG, Gerwick WH (1995). Nakienones A-C and nakitriol, new cytotoxic cyclic C-11 metabolites from an Okinawan cyanobacterial (*Synechocystis* sp) overgrowth of coral. Tetrahedron Lett 36:849-852

Nicholson BC, Rositano J, Burch MD (1994). Destruction of cyanobacterial peptide hepatotoxins by chlorine and chloramine. Water Res 28:1297-1303

Park H-D, Watanabe MF, Harada KI, Nagai H, Suzuki M, Watanabe M, Hayashi H (1993). Hepatotoxin (microcystin) and neurotoxin (anatoxin-a) contained in natural blooms and strains of cyanobacteria from Japanese freshwaters. nat toxins 1:353-360

Rapala J, Lahti K, Sivonen K, Niemela SI (1994). Biodegradability and adsorption on lake sediments of cyanobacterial hepatotoxins and anatoxin-a. Lett Appl Microbiol 19:423-428

Rinehart KL, Namikoshi M, Choi BW (1994). Structure and biosynthesis of toxins from blue-green algae (cyanobacteria). J Appl Phycol 6:159-176

Shi L, Carmichael WW, Miller I (1995). Immuno-gold localization of hepatotoxins in cyanobacterial cells. Arch Microbiol 163:7-15

Stratmann K, Burgoyne DL, Moore RE, Patterson GML, Smith CD (1994). Hapalosin, a cyanobacterial cyclic depsipeptide with multidrug-resistance reversing activity. J Org Chem 59:7219-7226

Stratmann T, Burgoyne DL, Moore RE, Patterson GML, Smith CD (1995). Hapalosin, a cyanobacterial cyclic depsipeptide with multidrug-resistance reversing activity (vol 59, pg 7222, 1994). J Org Chem 60:2950

Utkilen H, Gjolme N (1995). Iron-stimulated toxin production in *Microcystis aeruginosa*. Appl Environ Microbiol 61:797-800

White JD, Kim TS, Nambu M (1995). Synthesis of curacin A: A powerful antimitotic from the cyanobacterium *Lyngbya majuscula.* J Am Chem Soc 117:5612-5613

TOXINS and NATURAL SUBSTANCES (Physiological Effects)

An JS, Carmichael WW (1994). Use of a colorimetric protein phosphatase inhibition assay and enzyme linked immunosorbent assay for the study of microcystins and nodularins. Toxicon 32:1495-1507

Claeyssens S, Francois A, Chedeville A, Lavoinne A (1995). Microcystin-LR induced an inhibition of protein synthesis in isolated rat hepatocytes. Biochem J 306:693-696

Elsaadi O, Esterman AJ, Cameron S, Roder DM (1995). Murray River water, raised cyanobacterial cell counts, and gastrointestinal and dermatological symptoms. Med J Aust 162:122-125

English WR, Schwedler TE, Dyck LA (1993). *Aphanizomenon flos-aquae*, a toxic blue-green alga in commercial channel catfish, *Ictalurus punctatus*, ponds: A case history. J Appl Aquacult 3:195-209

Golowasch J, Paupardintritsch D, Gerschenfeld HM (1995). Enhancement by muscarinic agonists of a high voltage-activated Ca^{2+} current via phosphorylation in a snail neuron. J Physiol-London 485:21-28

Hamel E, Blokhin AV, Nagle DG, Yoo HD, Gerwick WH (1995). Limitations in the use of tubulin polymerization assays as a screen for the identification of new antimitotic agents: The potent marine natural product curacin A as an example. Drug Develop Res 34:110-120

Hayakawa K, Kohama K (1995). Reversible effects of okadaic acid and microcystin-LR on the ATP-dependent interaction between actin and myosin. J Biochem Tokyo 117:509-514

Hori K, Ishibashi G, Okita T (1994). Hypocholesterolemic effect of blue-green alga, ishikurage (*Nostoc commune*) in rats fed atherogenic diet. Plant Foods Hum Nutr 45:63-70

Kiviranta J, Abdel-Hameed A (1994). Toxicity of the blue-green alga *Oscillatoria agardhii* to the mosquito *Aedes aegypti* and the shrimp *Artemia salina.* World J Microbiol Biotechnol 10:517-520

Lahitova N, Doupovcova M, Zvonar J, Chandoga J, Hocman G (1994). Antimutagenic properties of fresh-water blue-green algae. Folia Microbiol Prague 39:301-303

Murphy J, Crompton CM, Hainey S, Codd GA, Hutchison CJ (1995). The rote of protein phosphorylation in the assembly of a replication competent nucleus: Investigations in *Xenopus* egg extracts using the cyanobacterial toxin microcystin-LR. J Cell Sci 108:235-244

Ohta T, Sueoka E, Iida N, Komori A, Suganuma M, Nishiwaki R, Tatematsu M, Kim SJ, Carmichael WW, Fujiki H (1994). Nodularin, a potent inhibitor of protein phosphatases 1 and 2A, is a new environmental carcinogen in male F344 rat liver. Cancer Res 54:6402-6406

Papadogiannakis N (1995). (-)-Indolactam V-induced mitogenesis in human fetal neonatal and adult T cells: Lower response of neonatal cells and possible regulatory role of monocytes in protein kinase C-mediated pathways. Cell Immunol 162:288-294

Pennings SC, Paul VJ (1993). Secondary chemistry does not limit dietary range of the specialist sea hare *Stylocheilus longicauda* (Quoy et Gaimard 1824). J Exp Mar Biol Ecol 174:97-113

Runnegar MT, Kong SM, Zhong YZ, Lu SC (1995). Inhibition of reduced glutathione synthesis by cyanobacterial alkaloid cylindrospermopsin in cultured rat hepatocytes. Biochem Pharmacol 49:219-225

Takai A, Sasaki K, Nagai H, Mieskes G, Isobe M, Isono K, Yasumoto T (1995). Inhibition of specific binding of okadaic acid to protein phosphatase 2A by microcystin-LR, calyculin-A and tautomycin: Method of analysis of interactions of tight-binding ligands with target protein. Biochem J 306:657-665

Williams DE, Kent ML, Andersen RJ, Klix H, Holmes CFB (1995). Tissue distribution and clearance of tritium-labeled dihydromicrocystin-LR epimers administered to Atlantic salmon via intraperitoneal injection. Toxicon 33:125-131

PHYSIOLOGY

Bonilla I, Bolanos L, Mateo P (1995). Interaction of boron and calcium in the cyanobacteria *Anabaena* and *Synechococcus*. Physiol Plant 94:31-36

Evans DJ, Evans DG, Lampert HC, Nakano H (1995). Identification of four new prokaryotic bacterioferritins, from Helicobacter pylori, *Anabaena variabilis*, *Bacillus subtilis* and *Treponema pallidum*, by analysis of gene sequences. Gene 153:123-127

Falkner G, Wagner F (1994). The blue-green alga *Anacystis nidulans* can store information about previous phosphate fluctuations in the kinetic and energetic properties of the high affinity phosphate uptake system. In: Gnaiger E, Gellerich FN, Wyss M (eds) *What Is Controlling Life?* Publisher: Innsbruck Univ Press, Publikationsstelle Univ, Innsbruck, Austria

Kashiwagi S, Irie J, Kanamaru K, Mizuno T (1994). Cloning and sequencing of a *Synechococcus* gene encoding a protein very similar to mammalian aldehyde dehydrogenases. Biosci Biotechnol Biochem 58:2299-2300

Muniz WH, Stevens SE (1994). Development of motility in cultures of the cyanobacterium *Mastigocladus laminosus.* FEMS Microbiol Ecol 15:259-264

Pena MMO, Burkhart W, Bullerjahn GS (1995). Purification and characterization of a *Synechococcus* sp. strain PCC 7942 polypeptide structurally similar to the stress-induced Dps/PexB protein of *Escherichia coli*. Arch Microbiol 163:337-344

Priya-Sethu KM, Prabha TN, Venkataraman LV (1994). Preparation of protoplasts from the cyanobacterium *Spirulina platensis* and a novel viability assay. Lett Appl Microbiol 18:241-244

Singh SP, Rai S, Rai AK, Tiwari SP, Singh SS, Samarketu Q, Abraham J (1994). Athermal physiological effects of microwaves on a cyanobactrium. Med Biol Eng Comput 32:175-180

Sudo H, Burgess JG, Takemasa H, Nakamura N, Matsunaga T (1995). Sulfated exopolysaccharide production by the halophilic cyanobacterium *Aphanocapsa halophytia.* Curr Microbiol 30:219-222

Waterbury J, Ostroumov SA (1994). Effect of non-ionogenic surfactant on cyanobacteria. Microbiol-Engl Tr 63:140-142

Wilhelm SW, Trick CG (1995). Effects of vitamin B-12 concentration on chemostat cultured *Synechococcus* sp strain PCC 7002. Can J Microbiol 41:145-151

Binder BJ, Chisholm SW (1995). Cell cycle regulation in marine *Synechococcus* sp strains. Appl Environ Microbiol 61:708-717

Huang TC, Grobbelaar N (1995). The circadian clock in the prokaryote *Synechococcus* RF-1. Microbiol UK 141:535-540

Liu Y, Golden SS, Kondo T, Ishiura M, Johnson CH (1995). Bacterial luciferase as a reporter of circadian gene expression in cyanobacteria. J Bacteriol 177:2080-2086

Roenneberg T, Carpenter EJ (1993). Daily rhythm of O_2-evolution in the cyanobacterium *Trichodesmium thiebautii* under natural and constant conditions. mar biol 117:693-697

MEMBRANES & LIPIDS

Avelange-Macherel MH, Macherel D, Wada H, Murata N (1995). Site-directed mutagenesis of histidine residues in the Δ12 acyl-lipid desaturase of *Synechocystis*. FEBS Lett 361:111-114

Hoiczyk E, Baumeister W (1995). Envelope structure of four gliding filamentous cyanobacteria. J Bacteriol 177:2387-2395

Kanervo E, Aro EM, Murata N (1995). Low unsaturation level of thylakoid membrane lipids limits turnover of the D1 protein of photosystem II at high irradiance. FEBS Lett 364:239-242

Malakhov MP, Los DA, Wada H, Semenenko VE, Murata N (1995). Characterization of the *murF* gene of the cyanobacterium *Synechocystis* sp PCC 6803. Microbiol UK 141:163-169

Mori K, Qian Z-H (1994). Synthesis of (3R,25R)-3,25-dihydroxyhexacosyl alpha -D-glucopyranoside, the heterocyst glycolipid of the marine cyanobacterium *Nodularia harveyana.* Liebigs Ann Chem 1994:35-39

Murata N, Wada H (1995). Acyl-lipid desaturases and their importance in the tolerance and acclimatization to cold of cyanobacteria. Biochem J 308:1-8

Rzama A, Dufourc EJ, Arreguy B (1994). Sterols from green and blue-green algae grown on reused waste water. Phytochemistry 37:1625-1628

Soriente A, Bisogno T, Gambacorta A, Romano I, Sili C, Trincone A, Sodano G (1995). Reinvestigation of heterocyst glycolipids from the cyanobacterium, *Anabaena cylindrica.* Phytochemistry 38:641-645

STRESS RESPONSES

Buck DP, Smith GD (1995). Evidence for a Na^+/H^+ electrogenic antiporter in an alkaliphilic cyanobacterium *Synechocystis*. FEMS Microbiol Lett 128:315-320

Nomura M, Ishitani M, Takabe T, Rai AK, Takabe T (1995). *Synechococcus* sp PCC 7942 transformed with *Escherichia coli* bet genes produces glycine betaine from choline and acquires resistance to salt stress. Plant Physiol 107:703-708

Rai AK, Abraham G (1995). Relationship of combined nitrogen sources to salt tolerance in freshwater cyanobacterium *Anabaena doliolum*. J Appl Bacteriol 78:501-506

Tadros MG, Smith W, Joseph B (1995). Yield and analysis of cyanobacteria *Spirulina maxima* in continuous culture in response to sodium chloride. Appl Biochem Biotechnol 51:2275-2281

Xie WQ, Tice D, Potts M (1995). Cell-water deficit regulates expression of *rpoC1C2* (RNA polymerase) at the level of mRNA in desiccation-tolerant *Nostoc commune* UTEX 584 (Cyanobacteria). FEMS Microbiol Lett 126:159-164

Campbell WS, Laudenbach DE (1995). Characterization of four superoxide dismutase genes from a filamentous cyanobacterium. J Bacteriol 177:964-972

Collier JL, Herbert SK, Fork DC, Grossman AR (1994). Changes in the cyanobacterial photosynthetic apparatus during acclimation to macronutrient deprivation. Photosynth Res 42:173-183

Hashemi F, Leppard GG, Kushner DJ (1994). Copper resistance in *Anabaena variabilis*: Effects of phosphate nutrition and polyphosphate bodies. Microb Ecol 27:159-176

Hill DR, Peat A, Potts M (1994). Biochemistry and structure of the glycan secreted by desiccation-tolerant *Nostoc commune* (Cyanobacteria). Protoplasma 182:126-148

Nicholson ML, Laudenbach DE (1995). Genes encoded on a cyanobacterial plasmid are transcriptionally regulated by sulfur availability and CysR. J Bacteriol 177:2143-2150

Singh DP, Singh N, Verma K (1995). Photooxidative damage to the cyanobacterium *Spirulina platensis* mediated by singlet oxygen. Curr Microbiol 31:44-48

Verma SK, Singh SP (1995). Multiple metal resistance in the cyanobacterium *Nostoc muscorum*. Bull Environ Contam Toxicol 54:614-619

Xu Xu-D, Li Ling-Y, Sun J, Jin P, Shi Ding-J, Ru Bing-G (1994). Cloning and expression of mouse metallothionein-I cDNA in cyanobacterium *Anabaena* sp. PCC 7120. Adv Biotechnol 14:39-42 [Chinese]

NITROGEN METABOLISM

Cohen-Kupiec R, Zilberstein A, Gurevitz M (1995). Characterization of cis elements that regulate the expression of *glnA* in *Synechococcus* sp strain PCC 7942. J Bacteriol 177:2222-2226

Forchhammer K, Demarsac NT (1995). Functional analysis of the phosphoprotein P_I (*glnB* gene product) in the Cyanobacterium *Synechococcus* sp strain PCC 7942. J Bacteriol 177:2033-2040

Jahns T, Schafer U, Kaltwasser H (1995). Heat-stable ureases from two filamentous cyanobacteria. Microbiol UK 141:737-741

Kashyap AK, Shaheen N, Prasad P (1995). Characteristics and regulation of the ammonium transport system in filamentous nonheterocystous cyanobacterium *Plectonema boryanum*. J Plant Physiol 145:387-389

Merchan F, Prieto R, Kindle KL, Llama MJ, Serra JL, Fernandez E (1995). Isolation, sequence and expression in *Escherichia coli* of the nitrite reductase gene from the filamentous, thermophilic cyanobacterium *Phormidium laminosum*. Plant Mol Biol 27:1037-1042

Mir NA, Salon C, Canvin DT (1995). Photosynthetic nitrite reduction as influenced by the internal inorganic carbon pool in air-grown cells of *Synechococcus* UTEX 625. Plant Physiol 108:313-318

Omata T (1995). Structure, function and regulation of the nitrate transport system of the cyanobacterium *Synechococcus* sp PCC 7942. Plant Cell Physiol 36:207-213

Reyes JC, Florencio FJ (1994). A mutant lacking the glutamine synthetase gene (*glnA*) is impaired in the regulation of the nitrate assimilation system in the cyanobacterium *Synechocystis* sp strain PCC 6803. J Bacteriol 176:7516-7523

Sarma TA, Khattar JIS (1994). Photoheterotrophic and chemoheterotrophic dinitrogen fixation and nitrate utilization by the cyanobacterium *Anabaena* torulosa. Folia Microbiol Prague 39:404-408

Singh S, Bisen PS (1994). Assimilation of ethylenediamine as nitrogen source by the cyanobiont *Nostoc* ANTH. world j microbiol biotechnol 10:477-478

Suzuki I, Horie N, Sugiyama T, Omata T (1995). Identification and characterization of two nitrogen-regulated genes of the cyanobacterium *Synechococcus* sp strain PCC 7942 required for maximum efficiency of nitrogen assimilation. J Bacteriol 177:290-296

Suzuki I, Sugiyama T, Omata T (1995). Regulation of nitrite reductase activity under CO_2 limitation in the cyanobacterium *Synechococcus* sp PCC 7942. Plant Physiol 107:791-796

NITROGENASE and DIFFERENTIATION

Lyons EM, Thiel T (1995). Characterization of *nifB, nifS,* and *nifU* genes in the cyanobacterium *Anabaena variabilis*: NifB is required for the vanadium-dependent nitrogenase. J Bacteriol 177:1570-1575

Prosperi CH (1994). A cyanophyte capable of fixing nitrogen under high levels of oxygen. J Phycol 30:222-224

Sarma TA, Singh DP (1994). Isolation and characterization of temperature-sensitive mutants of *Anabaena variabilis* impaired in nitrogen fixation. Folia Microbiol Prague 39:296-300

Apte SK, Prabhavathi N (1994). Rearrangements of nitrogen fixation (*nif*) genes in the heterocystous cyanobacteria. J Biosciences 19:579-602

Bauer CC, Buikema WJ, Black K, Haselkorn R (1995). A short-filament mutant of *Anabaena* sp strain PCC 7120 that fragments in nitrogen-deficient medium. J Bacteriol 177:1520-1526

Bauer CC, Haselkorn R (1995). Vectors for determining the differential expression of genes in heterocysts and vegetative cells of *Anabaena* sp strain PCC 7120. J Bacteriol 177:3332-3336

Carrasco CD, Buettner JA, Golden JW (1995). Programed DNA rearrangement of a cyanobacterial *hupL* gene in heterocysts. Proc Natl Acad Sci USA 92:791-795

Maldener I, Fiedler G, Ernst A, Fernandezpinas F, Wolk CP (1994). Characterization of *devA,* a gene required for the maturation of proheterocysts in the cyanobacterium *Anabaena* sp. strain PCC 7120. J Bacteriol 176:7543-7549

Meeks JC, Campbell EL, Bisen PS (1994). Elements interrupting nitrogen fixation genes in cyanobacteria: Presence and absence of a *nifD* element in clones of *Nostoc* sp strain Mac. Microbiol UK 140:3225-3232

Montesinos ML, Herrero A, Flores E (1995). Amino acid transport systems required for diazotrophic growth in the cyanobacterium *Anabaena* sp strain PCC 7120. J Bacteriol 177:3150-3157

Zahalak M, Beachy RN, Thiel T (1995). Expression of the movement protein of tobacco mosaic virus in the cyanobacterium *Anabaena* sp strain PCC 7120. Mol Plant Microbe Interaction 8:192-199

CARBON METABOLISM

Jensen TE (1994). Fine structure of elongate polyhedral bodies (carboxysomes) in two *Oscillatoria* (*Cyanophyceae*) isolates. Microbios 79:203-214

Konishi Y, Takahashi N, Muthuvelan B, Fujimori K (1995). Glycogen as primordial carbon reserve and alpha-glucosidase in the genera *Lyngbya-Phormidium-Plectonema,* thermophilic cyanobacteria. Biosci Biotechnol Biochem 59:546-548

Moezelaar R, Demattos MJT, Stal LJ (1995). Lactate dehydrogenase in the cyanobacterium *Microcystis* PCC 7806. FEMS Microbiol Lett 127:47-50

Scanlan DJ, Sundaram S, Newman J, Mann NH, Carr NG (1995). Characterization of a *zwf* mutant of *Synechococcus* sp. strain PCC 7942. J Bacteriol 177:2550-2553

Schwarz R, Reinhold L, Kaplan A (1995). Low activation state of ribulose-1,5-bisphosphate carboxylase oxygenase in carboxysome-defective *Synechococcus* mutants. Plant Physiol 108:183-190

Summers ML, Meeks JC, Chu S, Wolf RE (1995). Nucleotide sequence of an operon in *Nostoc* sp strain ATCC 29133 encoding four genes of the oxidative pentose phosphate cycle. Plant Physiol 107:267-268

PHOTOSYNTHESIS and PHOTOSYSTEMS

Govindjee (1995). Sixty-three years since Kautsky: Chlorophyll a fluorescence. Aust J Plant Physiol 22:131-160

Hovenden MJ, Seppelt RD (1995). Utility of modulated fluorescence in measuring photosynthetic activity of Antarctic plants: Field and laboratory studies. Aust J Plant Physiol 22:321-330

Lysenko ES, Ogarkova OA, Elanskaya IV, Tarasov VA, Shestakov SV (1995). A new open reading frame in the genome of the cyanobacterium *Synechocystis* sp PCC 6803. Genetika 31:162-169

Meyer TE (1994). Evolution of photosynthetic reaction centers and light harvesting chlorophyll proteins. Biosystems 33:167-175

Sasaki K, Marquez FJ, Nishio N, Nagai S (1995). Promotive effect of 5-aminolevulinic acid on the growth and photosynthesis of *Spirulina platensis*. J Ferment Bioeng 79:453-457

Sineshchekov VA (1995). Photobiophysics and photobiochemistry of the heterogeneous phytochrome system. Biochim Biophys Acta 1228:125-164

Takeuchi T, Yokoyama K, Kobayashi K, Suzuki M, Tamiya E, Karube I, Utsunomiya K, Imai O, Masuda Y (1993). Photosynthetic activity sensor for microalgae based on an oxygen electrode integrated with optical fibres. anal chim acta 276:65-68

Verma K, Singh DP (1995). Differential regulation of high light tolerance in the mutant and wild-type *Anacystis* cells. Curr Microbiol 30:373-379

Wilde A, Hartel H, Hubschmann T, Hoffmann P, Shestakov SV, Börner T (1995). Inactivation of a *Synechocystis* sp strain PCC 6803 gene with homology to conserved chloroplast open reading frame 184 increases the photosystem II-to-photosystem I ratio. Plant Cell 7:649-658

Dimagno L, Chan CK, Jia YW, Lang MJ, Newman JR, Mets L, Fleming GR, Haselkorn R (1995). Energy transfer and trapping in photosystem I reaction centers from cyanobacteria. Proc Natl Acad Sci USA 92:2715-2719

Jekow P, Fromme P, Witt HT, Saenger W (1995). Photosystem I from *Synechococcus elongatus*: Preparation and crystallization of monomers with varying subunit compositions. Biochim Biophys Acta 1229:115-120

Rodday SM, Schulz R, McIntosh L, Biggins J (1994). Structure-function studies on the interaction of PsaC with the photosystem 1 heterodimer. The site directed change R561E in PsaB destabilizes the subunit interaction in *Synechocystis* sp PCC 6803. Photosynth Res 42:185-190

Tsiotis G (1994) Photosystem-I from Cyanobacteria Isolated in Crystallizing Form by Preparative Isoelectric Focusing - Isoelectric Focusing. In: Vonjagow G, Schagger H (eds) *Practical Guide to Membrane Protein Purification.* Publisher: Academic Press Inc, San Diego

Bader KP (1994). Physiological and evolutionary aspects of the O_2/H_2O_2-cycle in cyanobacteria. Biochim Biophys Acta 1188:213-219

Barber J (1995). Molecular basis of the vulnerability of photosystem II to damage by light. Aust J Plant Physiol 22:201-208

Baron M, Arellano JB, Gorge JL (1995). Copper and photosystem II: A controversial relationship. Physiol Plant 94:174-180

Bartsevich VV, Pakrasi HB (1995). Molecular identification of an ABC transporter complex for manganese: Analysis of a cyanobacterial mutant strain impaired in the photosynthetic oxygen evolution process. EMBO J 14:1845-1853

Bernard MT, Macdonald GM, Nguyen AP, Debus RJ, Barry BA (1995). A difference infrared study of hydrogen bonding to the Z·tyrosyl radical of photosystem II. J Biol Chem 270:1589-1594

Boekema EJ, Hankamer B, Bald D, Kruip J, Nield J, Boonstra AF, Barber J, Rogner M (1995). Supramolecular structure of the photosystem II complex from green plants and cyanobacteria. Proc Natl Acad Sci USA 92:175-179

Engels DH, Lott A, Schmid GH, Pistorius EK (1994). Inactivation of the water-oxidizing enzyme in manganese stabilizing protein-free mutant cells of the cyanobacteria *Synechococcus* PCC 7942 and *Synechocystis* PCC 6803 during dark incubation and conditions leading to photoactivation. Photosynth Res 42:227-244

Fairweather MS, Packer JCL, Howe CJ (1994). The extrinsic proteins of photosystem II in photosynthetic organisms: Distribution, properties and evolutionary implications. Biochem Biophys Res Commun 205:1497-1502

Gleiter HM, Haag E, Shen JR, Eatonrye JJ, Seeliger AG, Inoue Y, Vermaas WFJ, Renger G (1995). Involvement of the CP47 protein in stabilization and photoactivation of a functional water-oxidizing complex in the cyanobacterium *Synechocystis* sp PCC 6803. Biochemistry 34:6847-6856

Golden SS (1995). Light-responsive gene expression in cyanobacteria. J Bacteriol 177:1651-1654

Golitsyn VM, Tetenkin VL, Elanskaya IV, Gulyaev BA (1995). Spectral properties of cyanobacterium *Synechocystis* sp. PCC 6803 mutants lacking photosystem II activity. Biochemistry-Engl Tr 60:359-362

Hess WR, Weihe A, Loiseauxdegoer S, Partensky F, Vaulot D (1995). Characterization of the single *psbA* gene of Prochlorococcus marinus CCMP 1375 (Prochlorophyta). Plant Mol Biol 27:1189-1196

Kless H, Vermaas W (1995). Many combinations of amino acid sequences in a conserved region of the D1 protein satisfy photosystem II function. J Mol Biol 246:120-131

Li RX, Dickerson NS, Mueller UW, Golden SS (1995). Specific binding of *Synechococcus* sp strain PCC 7942 proteins to the enhancer element of *psbAII* required for high-light-induced expression. J Bacteriol 177:508-516

Nagy L, Balint E, Barber J, Ringler A, Cook KM, Maroti P (1995). Photoinhibition and law of reciprocity in photosynthetic reactions of *Synechocystis* sp PCC 6803. J Plant Physiol 145:410-415

Shabana EF, Abouwaly H (1995). Growth and some physiological aspects of *Nostoc muscorum* in response to mixtures of two triazine herbicides. Bull Environ Contam Toxicol 54:273-280

Strasser RJ, Srivastava A, Govindjee (1995). Polyphasic chlorophyll alpha fluorescence transient in plants and cyanobacteria. Photochem Photobiol 61:32-42

Tanimura S, Kobayashi M, Terashita N, Takahashi M (1994). Sedimentation analysis of the state of aggregation of the oxygen-evolving photosystem II reaction center core complex and the extrinsic proteins. Biosci Biotechnol Biochem 58:2172-2177

PHYCOBILISOMES and OTHER PIGMENTS

Bastia AK, Adhikary SP (1995). A phycoerythrin-lacking mutant induced by DCMU in photoheterotrophically grown *Nostoc linckia*. J Basic Microbiol 35:63-71

Bhalerao RP, Collier JL, Gustafsson P, Grossman AR (1995). The structure of phycobilisomes in mutants of *Synechococcus* sp strain PCC 7942 devoid of specific linker polypeptides. Photochem Photobiol 61:298-302

Bradley KF, Chen SH, Bellissentfunel MC, Crespi HL (1994). The observation of structural transitions of a single protein molecule. Biophys Chem 53:37-43

Brejc K, Ficner R, Huber R, Steinbacher S (1995). Isolation, crystallization, crystal structure analysis and refinement of allophycocyanin from the cyanobacterium *Spirulina platensis* at 2.3 angstrom resolution. J Mol Biol 249:424-440

Jung LJ, Chan CF, Glazer AN (1995). Candidate genes for the phycoerythrocyanin alpha subunit lyase - Biochemical analysis of *pecE* and *pecF* interposon mutants. J Biol Chem 270:12877-12884

Maccoll R, Williams O, Eisele LE, Berns DS (1994). Spectroscopic changes for C-phycocyanin and phycoerythrin 545 produced by ferric ion. Biochim Biophys Acta 1188:398-404

Pinevich AV, Veprritskii AA, Gromov BV, Krautvald K, Titova NN (1994). Cellular and cultural properties and characterization of the pigment in *Nostoc* sp, a cyanobacterium unusually rich in c-phycoerythrin. Microbiol-Engl Tr 63:481-485

Sharkov AV, Kryukov IV, Khoroshilov EV, Kryukov PG, Fischer R, Scheer H, Gillbro T (1994). Femtosecond spectral and anisotropy study of excitation energy transfer between neighbouring alpha-80 and beta-81 chromophores of allophycocyanin trimers. Biochim Biophys Acta 1188:349-356

Sinha RP, Lebert M, Kumar A, Kumar HD, Hader DP (1995). Spectroscopic and biochemical analyses of UV effects on phycobiliproteins of *Anabaena* sp and *Nostoc* carmium. Bot Acta 108:87-92

Thomas BA, McMahon LP, Klotz AV (1995). N-5-methylasparagine and energy-transfer efficiency in C-phycocyanin. Biochemistry 34:3758-3770

Zhao JQ, Zhu JC, Jiang LJ (1994). Computer simulation on kinetics of primary process in photosynthesis (III). Sci China Ser B 37:1313-1320

Zhao JQ, Zhu JC, Jiang LJ (1995). Computer simulation on kinetics of primary process in photosynthesis of algae. 4. Excitation energy transfer in phycobilisomes from blue-green algae. Sci China Ser B 38:39-49

Zhao JQ, Zhu JC, Jiang LJ (1995). Study on the energy transfer processes in phycobilisomes from blue-green algae by the use of stochastic simulation approach. Biochim Biophys Acta 1229:39-48

Zhao KH, Haessner R, Cmiel E, Scheer H (1995). Type I reversible photochemistry of phycoerythrocyanin involves Z/E-isomerization of alpha-84 phycoviolobilin chromophore. Biochim Biophys Acta 1228:235-243

Zhao KH, Scheer H (1995). Type I and type II reversible photochemistry of phycoerythrocyanin alpha-subunit from *Mastigocladus laminosus* both involve Z, E isomerization of phycoviolobilin chromophore and are controlled by sulfhydryls in apoprotein. Biochim Biophys Acta 1228:244-253

Bohm GA, Pfleiderer W, Boger P, Scherer S (1995). Structure of a novel oligosaccharide-mycosporine-amino acid ultraviolet A/B sunscreen pigment from the terrestrial cyanobacterium *Nostoc commune*. J Biol Chem 270:8536-8539

Dolganov NAM, Bhaya D, Grossman AR (1995). Cyanobacterial protein with similarity to the chlorophyll a/b binding proteins of higher plants: Evolution and regulation. Proc Natl Acad Sci USA 92:636-640

Wachi Y, Burgess JG, Iwamoto K, Yamada N, Nakamura N, Matsunaga T (1995). Effect of ultraviolet-A (UV-A) light on growth, photosynthetic activity and production of biopterin glucoside by the marine UV-A resistant cyanobacterium *Oscillatoria* sp. Biochim Biophys Acta 1244:165-168

ELECTRON TRANSPORT and BIOENERGETICS

Dzelzkalns VA, Obinger C, Regelsberger G, Niederhauser H, Kamensek M, Peschek GA, Bogorad L (1994). Deletion of the structural gene for the NADH-dehydrogenase subunit 4 of *Synechocystis* 6803 alters respiratory properties. Plant Physiol 106:1435-1442

Kruip J, Nixon PJ, Osiewacz HD, Rogner M (1994). Nucleotide sequence of the *petB* gene encoding cytochrome b(6) from the mesophilic cyanobacterium *Synechocystis* PCC 6803: Implications for evolution and function. Biochim Biophys Acta 1188:443-446

Peschek GA, Obinger C, Fromwald S, Bergman B (1994). Correlation between immuno-gold labels and activities of the cytochrome *c* oxidase (aa_3-type) in membranes of salt stressed cyanobacteria. FEMS Microbiol Lett 124:431-437

Schmetterer G, Alge D, Gregor W (1994). Deletion of cytochrome *c* oxidase genes from the cyanobacterium *Synechocystis* sp PCC 6803: Evidence for alternative respiratory pathways. Photosynth Res 42:43-50

Shen JR, Vermaas W, Inoue Y (1995). The role of cytochrome c_{550} as studied through reverse genetics and mutant characterization in *Synechocystis* sp PCC 6803. J Biol Chem 270:6901-6907

Sone N, Tano H, Ishizuka M (1995). The genes in the thermophilic cyanobacterium *Synechococcus vulcans* encoding cytochrome *c* oxidase. Biochim Biophys Acta 1228:269 (Correction: vol 1183, pg 130, 1993)

Arudchandran A, Seeburg D, Burkhart W, Bullerjahn GS (1994). Nucleotide sequence of the *petE* gene encoding plastocyanin from the photosynthetic prokaryote, Prochlorothrix hollandica. Biochim Biophys Acta 1188:447-449

Chae YK, Markley JL (1995). Analysis of the hyperfine-shifted nitrogen-15 resonances of the oxidized form of *Anabaena* 7120 heterocyst ferredoxin. Biochemistry 34:188-193

Cheng H, Westler WM, Xia B, Oh BH, Markley JL (1995). Protein expression, selective isotopic labeling, and analysis of hyperfine-shifted NMR signals of *Anabaena* 7120 vegetative [2Fe-2S]ferredoxin. Arch Biochem Biophys 316:619-634

Collier JL, Grossman AR (1995). Disruption of a gene encoding a novel thioredoxin-like protein alters the cyanobacterial photosynthetic apparatus. J Bacteriol 177:3269-3276

Fukuyama K, Ueki N, Nakamura H, Tsukihara T, Matsubara H (1995). Tertiary structure of [2Fe-2S] ferredoxin from *Spirulina platensis* refined at 2.5 angstrom resolution: Structural comparisons of plant-type ferredoxins and an electrostatic potential analysis. J Biochem Tokyo 117:1017-1023

Heping D, Kentemich T, Schmitz K, Mueller B, Bothe H (1992). Distribution of thioredoxins in heterocysts and vegetative cells of cyanobacteria. j photochem photobiol b: biol 16:285-295

Hurley JK, Caffrey MS, Markley JL, Cheng H, Xia B, Chae YK, Holden HM, Tollin G (1995). Mutations of surface residues in *Anabaena* vegetative and heterocyst ferredoxin that affect thermodynamic stability as determined by guanidine hydrochloride denaturation. Protein Sci 4:58-64

Im SC, Lam KY, Lim MC, Ooi BL, Sykes AG (1995). First report of a 2-equiv reduction of [2Fe-2S] ferredoxins. J Am Chem Soc 117:3635-3636

Medina M, Gomez-Moreno C, Cammack R (1995). Electron spin resonance and electron nuclear double resonance studies of flavoproteins involved in the photosynthetic electron transport in the cyanobacterium *Anabaena* sp PCC 7119. Eur J Biochem 227:529-536

Varley JPA, Moehrle JJ, Manasse RS, Bendall DS, Howe CJ (1995). Characterization of plastocyanin from the cyanobacterium *Phormidium laminosum*: Copper-inducible expression and SecA-dependent targeting in *Escherichia coli*. Plant Mol Biol 27:179-190

Bendall DS, Manasse RS (1995). Cyclic photophosphorylation and electron transport. Biochim Biophys Acta 1229:23-38

Brown II (1994). Hypothesis - Is Ca^{2+} the third coupling ion? Biochemistry-Engl Tr 59:1321-1323

Steinemann D, Engelbrecht S, Lill H (1995). Reassembly of *Synechocystis* sp PCC 6803 F-1-ATPase from its over-expressed subunits. FEBS Lett 362:171-174

MOLECULAR GENETICS, EPISOMES, AND METABOLISM OF MACROMOLECULES

Churin YN, Shalak IN, Borner T, Shestakov SV (1995). Physical and genetic map of the chromosome of the unicellular cyanobacterium *Synechocystis* sp strain PCC 6803. J Bacteriol 177:3337-3343

Barten R, Lill H (1995). DNA-uptake in the naturally competent cyanobacterium, *Synechocystis* sp PCC 6803. FEMS Microbiol Lett 129:83-88

Moser D, Zarka D, Hedman C, Kallas T (1995). Plasmid and chromosomal DNA recovery by electroextraction of cyanobacteria. FEMS Microbiol Lett 128:307-313

Zaug AJ, Davilaaponte JA, Cech TR (1994). Catalysis of RNA cleavage by a ribozyme derived from the group I intron of *Anabaena* pre-$tRNA^{Leu}$. Biochemistry 33:14935-14947

Kim ST, Sancar A (1995). Photorepair of nonadjacent pyrimidine dimers by DNA photolyase. Photochem Photobiol 61:171-174

Nagaraja R, Haselkorn R (1994). Protein HU from the cyanobacterium *Anabaena*. Biochimie 76:1082-1089

Robinson NJ, Robinson PJ, Gupta A, Bleasby AJ, Whitton BA, Morby AP (1995). Singular over-representation of an octameric palindrome, HIP1, in DNA from many cyanobacteria. Nucl Acids Res 23:729-735

Kawaguchi R, Nagaoka T, Burgess JG, Takeyama H, Matsunaga T (1994). Sequence of a 2.6-kb cryptic plasmid from a marine cyanobacterium *Synechococcus* sp. Plasmid 32:245-253

Durner J, Boger P (1995). Ubiquitin in the prokaryote *Anabaena variabilis*. J Biol Chem 270:3720-3725

Mann NH (1994). Protein phosphorylation in cyanobacteria. Microbiol UK 140:3207-3215

Nakai M, Goto A, Nohara T, Sugita D, Endo T (1994). Identification of the SecA protein homolog in pea chloroplasts and its possible involvement in thylakoidal protein transport. J Biol Chem 269:31338-31341

Packer JCL, Andre D, Howe CJ (1995). Cloning and sequence analysis of a signal peptidase I from the thermophilic cyanobacterium *Phormidium laminosum*. Plant Mol Biol 27:199-204

Sugita M, Sugita C, Sugiura M (1995). Structure and expression of the gene encoding ribosomal protein S1 from the cyanobacterium *Synechococcus* sp strain PCC 6301: Striking sequence similarity to the chloroplast ribosomal protein CS1. Mol Gen Genet 246:142-147

Sarma TA, Singh R (1995). Characterization of ts-mutants of cyanophage N-1. By their inactivation by physical and chemical agents. Acta Virol 39:65-68

Duan Xue-Y, Shi Ding-J, Wu Xiao-Q, Wu Yu-H, Qiu Ze-S (1994). The effects of immobilization on the activity of glutamine synthetase and the expression of the *glnA* gene in *Anabaena* sp. strain 2B. Chinese J Bot 6:102-106

Miura Y (1995). Hydrogen production by biophotolysis based on microalgal photosynthesis. Process Biochem 30:1-7

Murphy RC, Stevens SE (1995). Development of a cyanobacterial biolarvicide. Mem Inst Oswaldo Cruz 90:109-113

Orduz S, Restrepo W, Patino MM, Rojas W (1995). Transfer of toxin genes to alternate bacterial hosts for mosquito control. Mem Inst Oswaldo Cruz 90:97-107

Shi D, Wu X, Hao Y, Qiu Z (1994). Effects of immobilization on ammonia secretion and the activity of glutamine synthetase in *Nostoc flagelliforme*. Bot Res 7:331-334 [Chinese; Engl Summary]

Soltes-Rak E, Kushner DJ, Williams DD, Coleman JR (1995). Factors regulating *cryIVB* expression in the cyanobacterium *Synechococcus* PCC 7942. Mol Gen Genet 246:301-308

Begum ZNT, Khan ZUM, Mandal R, Hossain MZ (1993). Distributional pattern of nitrogen fixing cyanobacteria in rice fields of Bangladesh. Phykos 32:109-114

Painter TJ (1995). Biofertilizers: Exceptional calcium binding affinity of a sheath proteoglycan from the blue-green soil alga *Nostoc* calcicola. Carbohyd Polym 26:231-233

Doumenge F, Durand-Chastel H, Toulemont A (eds) (1993) *Spirulina: Algae of Life*. Musee Oceanographique, Monaco

Kapoor R, Mehta U (1992). Iron bioavailability from *Spirulina platensis*, whole egg and whole wheat. Indian J Exp Biol 30:904-907

Kapoor R, Mehta U (1993). Iron status and growth of rats fed different dietary iron sources. Plant Foods Hum Nutr 44:29-34

Marquez FJ, Sasaki K, Kakizono T, Nishio N, Nagai S (1993). Growth characteristics of *Spirulina platenis* in mixotrophic and heterotrophic conditions. J Ferment Bioeng 76:408-410

Ogbonna JC, Yada H, Tanaka H (1995). Effect of cell movement by random mixing between the surface and bottom of photobioreactors on algal productivity. J Ferment Bioeng 79:152-157

Olguin EJ, Hernandez B, Araus A, Camacho R, Gonzalez R, Ramirez ME, Galicia S, Mercado G (1994). Simultaneous high-biomass protein production and nutrient removal using *Spirulina maxima* in sea water supplemented with anaerobic effluents. world j microbiol biotechnol 10:576-578

Singh G, Kothari RM, Sharma RK, Ramamurthy V (1995). Enhancement of *Spirulina* biomass productivity by a protein hydrolysate. Appl Biochem Biotechnol 50:285-290

Tanticharoen M, Reungjitchachawali M, Boonag B, Vonktaveesuk P, Vonshak A, Cohen Z (1994). Optimization of gamma -linolenic acid (GLA) production in *Spirulina platensis*. J Appl Phycol 6:295-300

Vonshak A, Torzillo G, Tomaseli L (1994). Use of chlorophyll fluorescence to estimate the effect of photoinhibition in outdoor cultures of *Spirulina platensis*. J Appl Phycol 6:31-34

Canizares RO, Dominguez AR, Rivas L, Montes MC, Traveiso L, Benitez F (1993). Free and immobilized cultures of *Spirulina maxima* for swine waste treatment. Biotechnol Lett 15:321-326

Canizares RO, Rivas L, Montes C, Traveiso L, Benitez F (1994). Aerated swine-wastewater treatment with K-carrageenan-immobilized *Spirulina maxima.* Bioresourc Technol Biomass 47:89-91

Canizares-Villanueva RO, Ramos A, Lemus R, Gomez-Lojero C, Travieso L (1994). Growth of *Phormidium* sp in aerobic secondary piggery waste-water. Appl Microbiol Biotechnol 42:487-491

Kuritz T, Wolk CP (1995). Use of filamentous cyanobacteria for biodegradation of organic pollutants. Appl Environ Microbiol 61:234-238 (Correction: vol 61, pg 234, 1995)

Sorkhoh NA, Alhasan RH, Khanafer M, Radwan SS (1995). Establishment of oil-degrading bacteria associated with cyanobacteria in oil-polluted soil. J Appl Bacteriol 78:194-199

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Late Breaking News!

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POSITIONS OFFERED: Two post-doc openings

CONTACT: Sabeeha Merchant, Department of Chemistry and Biochemistry, UCLA, 405 Hilgard Avenue, Los Angeles, CA 90095-1569. TEL: 310-825-8300, FAX: 310-206-1035, E-MAIL: Merchant@Chem.Ucla.Edu

RESEARCH (Position 1): Copper-responsive gene expression in the context of adaptation to copper-deficiency and the assembly of the photosynthetic apparatus [EMBO J (1991) 10:1383; EMBO J (1995) 14:857; Plant Cell 7:623]

REQUIREMENTS (Position 1): Formal education and research experience in biochemistry, molecular biology, or genetics.

RESEARCH (Position 2): Cytochrome biogenesis with an emphasis on the isolation and functional analysis of genes involved in the specification of cofactor (heme) -apoprotein assembly [EMBO J (1992) 11:2789; J Biol Chem 269:5824; Mol Gen Genet (1995) 246:156].

REQUIREMENTS (Position 2): Research experience in biochemistry, molecular biology or genetics.

SEND: CV, publication list, relevant reprints, and letters of recommendation

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MASAHIRO ISHIURA, TAKAO KONDO, and the rest of the circadian rhythm team formerly of National Institute for Basic Biology in Okazaki has moved to Nagoya University, where they will continue studying cyanobacterial clocks.

Department of Biology, Faculty of Science, Nagoya University, Furo-cho, Chikusa-ku, Nagoya, 464-01 JAPAN.
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