The PHYCOLOGIST

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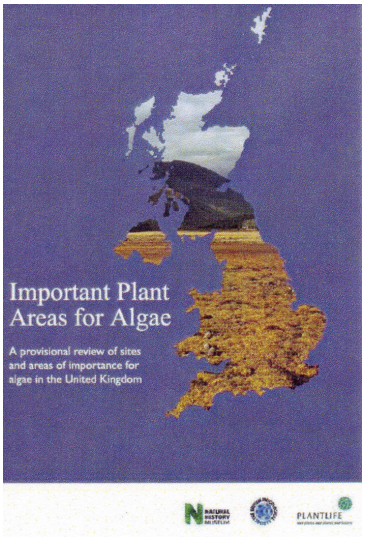
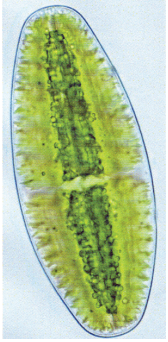
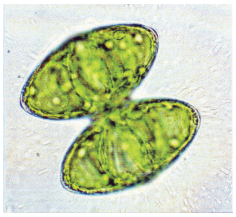
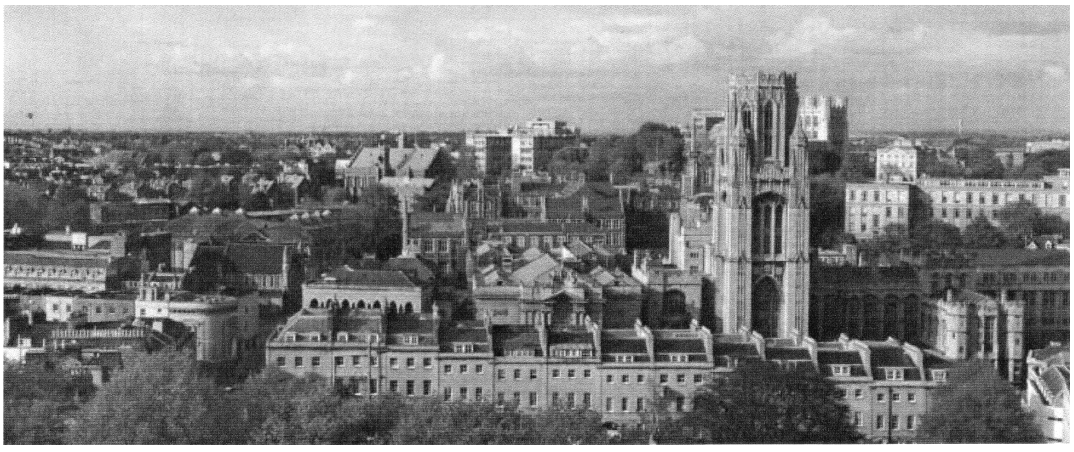






56th BPS Annual Meeting
Bristol, January 3-5, 2008



Bristol University Precinct.

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2008
British Phycological Society

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Editorial

This truly is a BUMPER issue! and in the words of Kylie Minogue 'Wow', so as a result I shall keep my ramblings short.

The Bristol winter meeting was yet another success for the Society - just read the reviews and views of some of the participants and organisers, and the photos speak for themselves! We have reports on the developments of FEPS (Federation of European Phycological Societies), the Manton and Poster prize winners provide their reviews, and we have a number of announcements not least further publicising the Important Plant Areas for Algae report, and there is also an announcement of the first Kathleen Drew-Baker and New Investigator Awards for best papers published in the *European Journal of Phycology* in 2007. There are also articles detailing the use of alginates in medical practice and algae within living aquatic vascular plant tissues, and a number of book reviews. The next winter meeting is going to be held in London - so see you there! (for a mixture of micro- and macro-algae talks). Details will appear on the web site http://www.brphycsoc.org.

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Do keep sending in your contributions. Write to us with your phycological views, news, work events, or any matter you wish to share with readers of *The Phycologist*. YOUR input is required; all relevant material will be considered (job adverts, science reports, book reviews, news items of topical interest, meeting announcements, research news, and suggestions for future articles are always welcome). Without YOU the newsletter would not exist.

As a reminder, previous issues of *The Phycologist* can be downloaded at

http://www.brphycsoc.org/phycologist.lasso

Jan Krokowski
Editor of *The Phycologist*

The 56th Annual Meeting of the BPS, Bristol Oral and Poster Abstracts

The meeting was sponsored by The Lady Emily Smyth Agricultural Research Station, University of Bristol; The School of Biological Sciences, University of Bristol; Taylor & Francis Group; and Leica Microsystems Office Depot UK.

ABSTRACTS FOR ORAL PRESENTATIONS

TWO PRIMARY AND ONE SECONDARY ENDOSYMBIOSIS AND THE ORIGIN OF THE DIATOMS

Klaus Valentin, Bank Beszteri, Ahmed Moustafa, and Debashish Battacharya

Alfred Wegener Institute

We have phylogenetically filtered the total genomes of two diatoms and grouped all genes according to their phylogenetic origin and their subcellular localisation. We could trace back about 400 genes to the red algal ancestor of the diatom plastid but surprisingly found that more than 1000 genes have a green algal ancestry. Based on these findings we propose a novel model for the composite origin and evolution of extant diatom plastids.

CYANOBACTERIA AND CYANOTOXINS IN WATERBODIES FROM 5 EUROPEAN COUNTRIES (2002-2005)

James S. Metcalf[1], Marianne Reilly[1], Lisa Spoof[2], Katrin Bornmann[3], Tomas Kull[2], Margarida R. Teixeira[4], Katarzyna Izydorczyk[5], Joanna Mankiewicz[5], Tore Lindholm[2], Maria J. Rosa[4], Jussi A. O. Meriluoto[2], Wido Schmidt[3], and Geoffrey A. Codd[1]

[1] Division of Molecular and Environmental Microbiology, University of Dundee, Dundee, UK; [2] Åbo Akademi University, Turku, Finland; [3] Technologiezentrum Wasser, Dresden, Germany; [4] Faculty of Marine and Environmental Sciences, University of Algarve, Faro, Portugal; [5] Department of Applied Ecology, University of Lodz, Lodz, Poland.

In order to better understand the occurrence and significance of cyanobacterial toxins, 15 waterbodies from across Europe were monitored for the occurrence of cyanobacteria and their toxins during a 3-year EU-funded research project (EC project TOXIC). The cyanobacterial toxins of principal interest were microcystins and anatoxin-a, with cylindrospermopsin also investigated as the range of this toxin may extend with the expansion of tropical cyanobacterial species into temperate latitudes as a result of climate change. Cyanobacterial toxins were assessed by a range of physiochemical and biochemical methods and the particulate and extracellular toxin pools were determined. Of the 15 waterbodies monitored, microcystins were identified in 14 (93%) at concentrations ranging from <1 μg l^{-1} to 500 μg l^{-1}. The neurotoxic alkaloid anatoxin-a was detected in two UK waterbodies with a maximum concentration of 19 μg l^{-1} whereas cylindrospermopsin was not detected. Although cyanobacterial toxins were mainly detected during spring and summer, in line with monitoring practices, when waterbodies were dominated by *Anabaena flos-aquae*, microcystins were also present in northern European waters throughout the winter. The concentration of microcystins during this period was also greater than the World Health Organization Guideline Value for microcystin in drinking water (1 μg l^{-1}). The results indicate that cyanobacterial toxins can occur for a greater part of the year at significant concentrations in respect to health risks.

TOXICITY OF ß-N-METHYLAMINO-L-ALANINE TO AQUATIC ORGANISMS

Esme L. Purdie, Syakirah Samsudin, James S. Metcalf, F. Brian Eddy, and Geoffrey A. Codd.

College of Life Sciences, University of Dundee, Dundee, Scotland

The toxicity of ß-N-methylamino-L-alanine (BMAA), a novel amino acid from cyanobacteria, has been characterised in vertebrates over the past 40 years. BMAA toxicity has recently been determined in vitro in dissociated mixed spinal cell cultures where selective motor neurone loss [(Rao et al., Exptl. Neurol. 201, 244 (2006)] and a potentiation of neuronal injury at 10 μM BMAA, induced by other insults occurred [Lobner et al., 25, 360 (2007)] . The investigation of BMAA production by free-living cyanobacteria, including bloom-, scum- and mat-forming species [PNAS 102, 5074 (2005)] raises the question of the toxicity of BMAA to aquatic organisms. Egg hatching of brine shrimp (*Artemia salina*) was not affected by purified BMAA at concentrations greater than environmentally-relevant concentrations of BMAA. BMAA caused time- and concentration-dependent mortality of *A. salina* nauplii, but only at concentrations greater than in environmental blooms. Early stages of *Danio rerio* (zebra fish) were more susceptible to BMAA. Embryo hatching was delayed, and larval mortalities occurred earlier due to BMAA exposure. BMAA increased larval heart rate over a 6-day developmental period during which larval deformities occurred, including: oedema, eye deficiency, head deformation, spinal curvature and helical body. The lowest observable adverse effect level (LOAEL) in *D. rerio* larvae (5 μg per litre; 42 nM), occurred at environmentally-relevant concentrations. This indicates: (i) that *D. rerio* may serve as a useful model to further investigate BMAA toxicity; and (ii) the bioavailability and toxicological significance of BMAA to aquatic biota requires further investigation, both alone and in combination with other toxicants.

MUCILAGE, CYANOTOXINS AND PHOSPHATASE ACTIVITY IN BENTHIC COMMUNITIES OF CALCAREOUS STREAMS

Marina Aboal[1], Sergio Marco[1], Alfonsa García[2], and Brian A. Whitton[3]

Departments of [1] Plant Biology and [2] Cell Biology, Biology Faculty, Murcia University, Murcia 30100, Spain; [3] School of Biological and Biomedical Sciences, University of Durham, Durham DH1 3LE, UK.

The production of mucilage by microalgae is usually related to nutrient deficiency and the construction of macroscopic colonies

adapted to the changing conditions of calcareous temporary streams. Several different taxonomic groups may form mucilaginous colonies and most of them seem to have high phosphatase activity and to be unpalatable for herbivores. Some morphological features are also shared by the colonies with a high frequency of hairs and stalks. The presence of toxins has also been reported in diatoms and rodophyte colonies, but nothing is known about their distribution throughout the colonies. The use of immunohistochemical methods and polyclonal antibodies have permitted us to observe a gradient of microcystins from inner to outer sheath layers in producing cyanophytes and the presence of microcystins in stalks of non producing species. Hairs and stalks are in all cases associated with high alkaline phosphatase activity. In order to know the key factors for the growth and success of these species, a comparison of the colonies from a morphological, ultrastructural and ecological points of view is presented.

CYANOBACTERIA WITH MORPHOLOGICAL FEATURES REFLECTING TWO DIFFERENT TYPES OF NUTRIENT LIMITATION

Brian A. Whitton

School of Biological and Biomedical Sciences, University of Durham

About 15 % species of filamentous cyanobacteria show vegetative growth stages characterized by morphological features associated with two different types of nutrient condition in their environment. The most clear-cut examples relate to the relative scarcity of combined nitrogen or of soluble phosphate. Based on past and new data, the relevance of this to their ecology and taxonomy is reviewed. The best studied are species of *Calothrix* and *Rivularia*, which shift from phosphorus- to nitrogen-limitation for short periods of their growth cycle. *Gloeotrichia* is more complex in that it shows a further response to limitation, akinete formation. The literature on nutrient-limitation in other genera is sometimes confusing, but *Hapalosiphon*, *Westiellopsis* and at least some *Aphanizomenon* probably also shift between the two types of limitation, though the relative importance of the two may differ. Comments are included on the implications of these observations for experimental design, taxonomy and the use of these organisms for environmental monitoring.

CYANOBACTERIA VS. MICROALGAE: WHO WINS IN THE CONSTRUCTION OF MODERN DAY STROMATOLITES?

Rupert G. Perkins, Jacco C. Kromkamp, and R. Pamela Reid

Cardiff University

Modern day stromatolites at Highborne Cay, Exuma, Bahamas, are formed in an high energy environment, where turbulent mixing of the water column supplies the sand particles which are trapped and bound by microbial phototrophs. One keenly debated question is: what are the comparative roles of the prokaryotic photosynthetic communities (cyanobacteria) compared to the comparatively recently evolved eukaryotes (microalgae, principally diatoms and green algae) in stromatolite "growth"? This study investigated the ability of both community types to tolerate the frequent natural burial events, common in such a dynamic habitat. Variable chlorophyll fluorescence was used to monitor PSII quantum efficiency and fluorescence kinetics during and post artificial and natural in situ burial. Cyanobacterial communities were observed to reactivate their quantum efficiency when exposed to both low light and oxygen, indicated by an increase in photochemical efficiency (F/Fm') after 7 - 9 days and 14 - 16 days of natural burial. Changes in fluorescence yields indicated probable state transitions and it is suggested that some form of oxygen dependent process(es) and light effectively "kick start" electron transport and hence protect against photodamage induced by exposure to light after burial. In contrast, surface communities of diatoms and green algae did not tolerate burial, with two out of three samples failing to reactivate after 7 days of burial. Results suggest that the ability of the cyanobacteria to tolerate natural burial accounts in part for their importance in stromatolite construction.

POST-FERTILIZATION Ca^{2+} SIGNALS CO-ORDINATE ZYGOTIC POLARIZATION AND EMBRYONIC CELL CYCLE PROGRESSION IN THE BROWN ALGA, *FUCUS SERRATUS*

John H. Bothwell[1], Jolanta Kisielewska[2], Martin R McAinsh[3], and Colin Brownlee[1]

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[3] *Department of Biological Sciences, Lancaster Environment Centre, Lancaster University*

The two most important events to occur during asymmetric cell division are cell polarization and cell cycle progression. Polarization rearranges the actin cytoskeleton to impose asymmetry on the parent cell, while cell cycle progression ensures that nuclear DNA is correctly replicated and partitioned into the resulting daughter cells. It is particularly important to understand how cell polarization and cell cycle progression may be co-ordinated during eukaryotic embryogenesis, because the first asymmetric cell division defines the embryonic axes which ensure correct multicellular patterning in the adult organism. To investigate this co-ordination, we have used high-throughput biolistic loading and 2-photon microscopy to study the role played by post-fertilization [Ca^{2+}] elevations in the externally fertilized gametes of the brown fucoid alga, *Fucus serratus*. Our results suggest that both polarization and DNA replication require distinct post-fertilization [Ca^{2+}] elevations, with cell polarization being dependent on S-phase entry, but not vice versa. The regulation of embryogenesis in the fucoid algae appears, therefore, to be intermediate between the morphogenesis checkpoint-dominated yeast model and the uncoupled polarization/cell cycle model of Drosophila embryos.

INTERACTIVE EFFECTS OF UV RADIATION AND TEMPERATURE ON MICROSTAGES OF LAMINARIALES (PHAEOPHYCEAE) FROM THE ARCTIC AND NORTH SEA

Ruth Müller[1], Christian Wiencke[1], and Kai Bischof[2]

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[2] *Department of Marine Botany, University Bremen, and Center for Tropical Marine Ecology, Leobener Straße, NW2, D-28359 Bremen, Germany*

Spores and gametophytes are considered to be the life history stages of kelps most susceptible to environmental perturbations including global changes of the temperature and UV radiation regime. Microstages of kelp species from the Arctic (*Saccharina latissima*, *Laminaria digitata*, *Alaria esculenta* from Spitsbergen) and the

North Sea (*S. latissima*, *L. digitata*, *L. hyperborea*) were exposed in two-factorial experiments to different temperature (2 - 18°C) and radiation conditions (photosynthetic active radiation, UV-A radiation, UV-B radiation). Our results reveal ecotypic differentiations in stress responses of zoospores of *L. digitata* and *S. latissima* from the two locations. UV-A radiation either enhanced the formation of gametes at elevated temperatures in *L. digitata* or impaired egg release and subsequent sporophyte formation in *L. hyperborea*. Microstages treated with additional UV-B radiation were strongly inhibited to a population-, species- and life phase- specific degree at (sub-) optimal temperatures. Furthermore, an inhibited egg release of *L. digitata* and *L. hyperborea* after 8 hours UV-B exposure resulted at suboptimal temperatures in long term detrimental effects since the gametophytes remained sterile and no sporophyte development was observed after 10 weeks of recovery. Only gametogenesis of *Laminaria* spp. was shown to be tolerant to UV-B exposure. Conclusively, in respect to a future scenario of elevated UV radiation regimes and higher summer temperatures in Arctic and North Sea waters, summer recruiting Arctic species and *L. digitata* from the North Sea might become endangered by a frequent disturbance of their microstages.

THE SELF CLEANING JETTY AT STAFFA AS AN EXAMPLE OF COASTAL ENGINEERING SUSTAINABILITY PRACTICE

Julian Clokie and John Peden

John Peden Associates, Askival, Glenmore Road, Oban, Argyll, PA34 4PG

When the landing jetty at Staffa (West Scotland, U.K.) was replaced the opportunity was taken to seek to mimic the mature overgrazed, in part sessile animal dominated, facies in the locality. In such facies, algal settlement and production is equalled or exceeded by consumption by herbivores. Surfaces which are largely free of algae tend to be less slippery and dangerous. This first short report describes the first 17 years of the new jetty's history. Since construction circa 1 million visitors have used the jetty and it is functioning as we intended. Design features were added at emplacement and post emplacement phases within the whole tide range, the structure being of unreinforced concrete cast within permanent steel facing. The aim was to obtain the best compromise between maintaining the integrity of the concrete and having the sought after effect on algal communities. Different levels of the shore presented different problems within the complicated micro-structured series of ecotones and gradients within the tide range. In the early years some biological interventions and transplanting of herbivores was performed. On the smallest scale, littorinid activity in older communities seems relatively more important than the literature suggests in augmenting patellid activity. Maintaining overgrazed facies relied on the boatmen users not using biocides when algal production was temporarily ahead of removal. They also took a great deal of care with the surface. This approach may have wider application wherever intertidal slipperyness is a problem whether of structures or armouring. Each situation will necessitate design for its own habitat.

IS INNATE IMMUNITY CONSERVED AMONG BROWN ALGAE?

Claire MM Gachon, Dieter G Müller, Martina Strittmatter, and Frithjof C Küpper

Scottish Association for Marine Science, Dunstaffnage Marine Laboratory Dunbeg, Oban

With the aim of obtaining a better understanding of defence reactions of brown algae against their pathogens, we have set up a pathosystem between the genomic model *Ectocarpus siliculosus* and the basal oomycete *Eurychasma dicksonii*. This pathogen is both of ecological and fundamental interest, being the most abundant eukaryotic pathogen of brown algae currently known, and also the most basal member of the oomycete lineage.

Certain algal / pathogen strain combinations do not lead to the development of disease symptoms. In all cases, this phenotypic resistance is associated with the early death of the challenged algal cell, which prevents further spread of the disease. The most frequent infection outcome, however, is an intermediate resistance phenotype, whereby a fraction of algal cells get successfully infected, whereas others undergo cell death before the pathogen completes its development cycle. Significantly, we have observed such responses in seven brown algal genera, encompassing four brown algal orders (Ectocarpales, Laminariales, Tilopteridales, Discosporangiales). This broad distribution suggests that this resistance-associated cell death might be a conserved immune mechanism of brown algae.

We are now focusing our efforts on the molecular characterization of this cell death response in *Ectocarpus* and related species, testing the hypothesis that it might be the outcome of a genetically-programmed mechanism similar to animal apoptosis or the hypersensitive response in terrestrial plants.

A REVIEW OF THE SPECIES OF CORALLINE ALGAE OF THE UK

Juliet Brodie

The Natural History Museum, London

The Corallinales is the third largest order of red algae and its species are found in marine environments throughout the world. Some large encrusting species form distinct zones on rocky shores and other species, such as *Corallina officinalis* are common components of the seaweed flora. Others, including species of *Phymatolithon* and *Lithothamnion*, can form maerl bed deposits, which have conservation status as extremely important habitats for the diversity of organisms that they support as well as being commercially exploitable as a source of lime and trace minerals in the agricultural, horticultural and medical industries. Despite their importance, coralline algae are frequently neglected by phycologists; of the c. 45 species of coralline algae recorded for the UK, approximately a third are under-recorded or rare or their status is data deficient. This is primarily due to the technical difficulties of collecting and examining specimens, particularly the coralline crusts, in order to identify them to species level based on morphology. We have had success in utilising molecular techniques in resolving the taxonomy of the geniculate (articulated) corallines from UK shores, including the discovery of pseudo-cryptic species, but we know very little about the identity of crustose corallines based on molecular data. Here we review the species of coralline algae found in the UK and explore possible approaches that could be used in their identification.

VISUAL INSPECTION OF *ULVA* THALLUS COLOUR AS A NOVEL BIOASSAY FOR EVALUATING AQUATIC TOXICITY

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A novel bioassay that uses visual inspection of reproduction of the aquatic green macroalga *Ulva* has been developed for testing toxic chemicals. The method employs a technique to quantify percentage reproduction based on thallus colour change during the progression of reproduction. The sensitivity of the method was assessed using a reference toxicant (sodium dodecyl sulfate; SDS; EC50 = 7.2 mg L^{-1}), metals Cu (0.080 mg L^{-1}), Cd (0.210 mg L^{-1}), Pb (0.950 mg L^{-1}), Zn (1.136 mg L^{-1}), formalin (1.458 mg L^{-1}), diesel fuel (3.7 ml L^{-1}) and is shown to be similar or better than more established aquatic toxicity bioassays. Toxicity data obtained by the Ulva bioassay for elutriates of sludge collected from nine different locations were directly compared with the commercially available Microtox® testing. *Ulva* reproduction was significantly inhibited in all elutriates with the greatest and least toxic effects, estimated by toxicity units (TU) observed in elutriates from industrial waste (13.1 TU) and a filtration bed (4.8 TU), whereas values ranging from 1- 4.5 TU were obtained from the Microtox® test, confirming that the Ulva bioassay is more sensitive. The new bioassay method is simpler to use, easier to interpret, economical and eco-relevant so would be a valuable addition to aquatic toxicity testing protocols for a wide range of toxicants. Moreover, since *Ulva* spp. have a wide geographical distribution and have similar reproductive processes the test method has worldwide application.

DISTRIBUTION OF CYANOBACTERIA ON EARTH. WHY ARE THEY ALMOST UBIQUITOUS?

Antonio Quesada

Universidad Autónoma de Madrid, Spain

Cyanobacteria are well known organisms widely distributed on Earth. They are typically aquatic organisms inhabiting almost every kind of marine and freshwater ecosystem. Cyanobacteria are also conspicuous in subaerophytic environments, such as soils, barks or rocks. They are an important part of the biota in extreme environments such as cold and hot deserts, extremely saline or highly alkaline environments, becoming in some cases the highest biomass in the complete ecosystems, as it is the case in non-marine aquatic ecosystems from polar regions. However, evidence for the occurrence of the same cyanobacterial genotypes all around the World is not very clear, although recently interesting advances have been published dealing with polar communities in relation to endemism and ubiquity. The apparent success of this extremely old group, from the evolutionary perspective, will be discussed and some data regarding their modest biological and ecological performance will be revisited as a life strategy. In this case, the very low level of adaptation seems to be the keystone for their worldwide distribution. Once again the non-perfect is the best in the long-term.

CHANGES IN PHYTOPLANKTON BIODIVERSITY, THE BIOLOGICAL PUMP AND CLIMATE CHANGE

Philip C. Reid

University of Plymouth, Sir Alister Hardy Foundation for Ocean Science (SAHFOS)

Rapid changes have occurred in chlorophyll and the composition of phytoplankton in the North Atlantic in recent decades based on the results of the Continuous Plankton Recorder survey. These changes have been linked to rising temperatures and to variability in the subpolar and subtropical gyres. The composition of the phytoplankton is a key determinant of the efficiency of the Biological Pump, the main route by which CO_2 from the atmosphere is utilised in primary production and then in part transported as organic carbon to the deep ocean carbon reservoir. Diatoms are one of the main organisms contributing to the efficiency of this process and have become less abundant in the North Atlantic in recent decades implying that the Biological Pump is now working less efficiently. The global annual net influx of C from the atmosphere to the ocean is estimated at ~1.3 Pg yr^{-1} against ~11 Pg yr^{-1} transported to the deep ocean by the Biological Pump. If these estimates are correct a continuing reduction in the efficiency of the Biological Pump could mean that the net ocean uptake of CO_2 might reduce to ~zero and that atmospheric CO_2 levels would increase sharply. Outside the North Atlantic information on the abundance and variability of phytoplankton is lacking except at a few single point time series stations. To address this gap in knowledge a comprehensive and sustained long-term plankton observing system, that includes a sediment trapping component to determine fluxes, needs to be put in place as part of the Global Ocean Observing System (GOOS).

MARINE CALCIFICATION IN A HIGH CO_2 WORLD

M. Debora Iglesias-Rodriguez

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Among society's most pressing concerns at the beginning of the 21st century are the impacts of elevated carbon dioxide (CO_2) in a changing climate. One consequence that we are only just beginning to recognize is ocean acidification caused by the absorption of CO_2, which lowers surface ocean carbonate, reduces surface water pH and the degree of supersaturation of calcium carbonate ($CaCO_3$). It has been hypothesized that marine calcification is directly affected by the increasing CO_2 partial pressure that drives a decrease in pH and the saturation state of $CaCO_3$. However, some of these studies have at least in part manipulated the carbonate system by the addition of acid or base to the growth medium. One problem with this approach is that it alters the total alkalinity, which is not the case when fossil fuel-derived CO_2 dissolves in the ocean. Here we show that calcification and photosynthetic carbon fixation in the coccolithophore species *Emiliania huxleyi* are significantly increased by high CO_2. These calcification trends are consistent with those seen in the geological record, where calcified algae are abundant in periods of past ocean acidification. Our findings have significant implications for biogeochemical modelling of future oceans, and highlight acclimation and evolutionary adaptation of a major calcareous group to past and future ocean acidification.

A GENOMIC PERSPECTIVE ON NICHE ADAPTATION MECHANISMS IN MARINE PICOCYANOBACTERIA

Dave Scanlan

Department of Biological Sciences, University of Warwick, Coventry, UK

Marine cyanobacteria are the most abundant photosynthetic organisms on Earth with only two genera numerically dominating most oceanic waters, *Prochlorococcus* and *Synechococcus*. Both genera are

genetically diverse e.g. the marine *Synechococcus* lineage contains at least ten genetically distinct clades and includes isolates with a wide range of pigmentation.

The availability of over a dozen complete or high-draft picocyanobacterial genomes is enabling the description of the 'core', genes common to all members, and the 'accessory' or 'dispensable' genome, genes present in a subset of strains, which together constitute the pan genome of a species.

By comparing the available *Synechococcus* genomes, along with representative *Prochlorococcus*, our goals were to explore the relationship between ribotype and genomic diversity and to estimate the importance and relative contribution of vertical inheritance, gene gain and gene loss in the core and accessory gene complements. Analysis of the functional genes associated with the accessory genomes and recently acquired genome islands provided insights into the biotic and abiotic factors influencing niche adaptation i.e. that account for vertical, horizontal and seasonal distributions of genetically distinct lineages.

Our data supports hypotheses for phosphorus, metals, light quantity and quality, and habitat 'stability' as defining factors of ocean niches which have clear imprints on the genomes of their *Synechococcus* inhabitants.

OBSERVING THE GLOBAL OCEANS DYNAMICS IN PHYTOPLANKTON

Oscar Schofield and Matt Oliver

Institute of Marine & Coastal Sciences, Rutgers University

Since the mid 1990s the concept of the biogeochemical "provinces" in the oceans has provided a framework to compare and contrast biogeochemical processes over broad regions of the global ocean. Province designations have been used to understand global distributions of primary productivity, DMSP fluxes, distributions of pelagic flora and fauna and other biogeochemically relevant parameters; however they have been largely determined subjectively. Recent developments in new satellite products and advanced new data analysis tools provide an opportunity for the science community to move beyond static biogeochemical pictures to dynamic objectively based global biogeochemical provinces. These advances coupled to new ecosystem based models and long duration autonomous vehicles are allowing the community to assess, over large spatial domains, if and how the overall phytoplankton productivity in the oceans is changing. Results suggest major regions of the oceans have exhibited large changes over the last few decades with the largest changes observed in polar and sub-polar seas. We will highlight some of those changes describing not only the changes in biomass but also the changes in the phytoplankton community composition. Additionally we will highlight the potential impact of those changes on higher trophic levels.

MOLECULAR MECHANISMS TRIGGERING PHYTOPLANKTON MORTALITY IN THE OCEANS

Kay D. Bidle

Institute of Marine and Coastal Sciences, Rutgers University

Steady-state maintenance of high production to biomass ratios implies that, on average, phytoplankton grow, die and are replaced weekly. Traditionally, lytic viral infection and autocatalytic cell death were thought to represent distinct modes of grazer-independent cell mortality. Yet, the molecular mechanisms regulating these modes of mortality have gone largely unexplored, even though they serve to effectively short circuit carbon export to the deep ocean and channel primary productivity to microbial foodwebs. The coherence of physiological, biochemical, and genetic evidence for programmed cell death (PCD) in diverse prokaryotic and eukaryotic lineages now suggests that it is a universal mortality mechanism in response to physiological stress, employing a core set of death proteins with deeply rooted origins. Recent findings place a central role on the expression and activation of metacaspases, specialized cysteine-specific death proteases, in the turnover of phytoplankton biomass. Metacaspase activation has not only been demonstrated for successful viral infection, but also in response to acute nutrient depletion. Results implicating iron depletion as a potent inducer of PCD are noteworthy, given chronic limitation in a variety of oceanic systems. The direct interaction between autocatalytic PCD and lytic viral infection through convergence on metacaspases provides important mechanistic insight and both ecological and evolutionary context for PCD execution. Nonetheless, questions still abound as to the ecological impact and evolutionary drivers of PCD in these unicellular photoautotrophs, as well as to how it is triggered and regulated in response to a variety of stressors.

CONNECTING ALGAE WITH CLOUDS

Gill Malin

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Dimethyl sulphide [$(CH_3)_2S$; DMS] is at the heart of the connection between algae and clouds. This volatile sulphur compound plays a key role in the global sulphur cycle because it is the main vehicle for the transfer of sulphur between the sulphur-rich oceans and terrestrial ecosystems. Substantial amounts of DMS are found in seawater and a portion is emitted to the air where it oxidises rapidly to form acidic sulphate aerosol particles. As well as influencing atmospheric chemistry, the aerosol particles cool the Earth's climate directly or indirectly by acting as cloud-condensation nuclei. DMS derives from a zwitterionic precursor compound known as dimethylsulphoniopropionate [DMSP; $(CH_3)_2S{+}CH_2\ CH_2COO^-$] which is found in a range of seaweeds and marine phytoplankton. DMSP appears to be a multifunctional compound: in living phytoplankton cells it may function as a compatible solute, grazing deterrent, in overflow metabolism under conditions of unbalanced growth and as an antioxidant. When cells die due to autolysis, grazing or viral lysis some of the DMSP released is released as DMS due to the action of algal or bacterial enzymes. In this talk I will give an overview of how DMS influences climate and the sulphur cycle, as well as the role algae play in DMS production. Examples will be drawn from research data gathered from laboratory and field studies by the DMS research community over the last decade or so. Finally I will indicate important gaps in current knowledge and highlight areas that warrant further research.

WHAT DOES HIGH DIVERSITY AT THE 10KM GRID SCALE MEAN?

Andrew J. Blight, Mark P. Johnson, Christine A. Maggs, and Louise Allcock

Queen's University Belfast

'Hotspots', areas with exceptionally high biodiversity, have been relatively understudied in intertidal zones. The focus of this project is a hotspot approach to the diversity of intertidal habitats, with a view to examining the patterns of algal and molluscan diversity at a

number of different scales. A relational database was constructed out of a number of UK biodiversity datasets. This contains details of the surveys that have taken place in each 10 km square. Potential hotspots were identified from the data and selected sites were surveyed to examine the extent to which the regional patterns of diversity are reflected at smaller scales. Preliminary analysis suggests that differences in regional algal diversity are evident at smaller scales whereas molluscan diversity is not. At the intraspecies scale, molecular analysis is used to elucidate some potentially cryptic species of *Ceramium* (Ceramiaceae, Rhodophyta) in order to test whether concepts at this scale map onto biodiversity at other levels.

PRODUCTION OF DIMETHYLSULPHIDE AND DIMETHYLSULPHONIOPROPIONATE BY DINOFLAGELLATES

Amandine Caruana, Michael Steinke, Sue Turner, and Gill Malin

University of East Anglia Laboratory for Global Marine and Atmospheric Chemistry

DMS (dimethylsulphide) is the major volatile sulphur compound in the ocean. After its emission to the atmosphere, DMS oxidation products affect climate by acting as cloud condensation nuclei and attenuating solar radiation. DMS derives from the degradation of DMSP (dimethylsulphoniopropionate) which is produced by some type of algae. DMSP has several possible roles including as an osmolyte, cryoprotectant, antioxidant and also as chemical defence against grazers and food location signal for higher trophic levels. Focusing on phytoplankton, senescence, grazing, and viral infection lead to cell lysis and DMSP release during which DMSP can be broken down by enzymes produced by algae and bacteria to release DMS. Thus, DMS production depends on DMSP-producing microalgae and marine food web activity. Dinoflagellates are recognised as an important source of DMSP but despite this our understanding of DMS and DMSP production in this group is surprisingly limited. DMSP is synthesized in the chloroplast of land plants and it is assumed this might also be the case for algae. Dinoflagellates have a fascinating evolutionary history which results today in five different plastid groups and some heterotrophic species without functional plastids. We are studying DMSP production by dinoflagellates species across the diverse plastid range to give a deeper insight into the role of plastid and the interspecific variability in dinoflagellates. This presentation will describe approaches and difficulties associated with obtaining reliable DMSP measurements for dinoflagellate cultures and show preliminary results for total DMSP production during the growth curve of a few species.

CYANOPHAGES ACTIVE AGAINST BLOOM-FORMING FRESHWATER CYANOBACTERIA

Li Deng and Paul K. Hayes

School of Biological Sciences, University of Bristol

Cyanobacteria are important members of phytoplankton communities both in marine and freshwater environments. Over the past two decades, many studies have shown that these cyanobacterial communities are infected by cyanophage. There is increasing evidence that lateral gene transfer within cyanobacterial communities and populations has a role in generating novel phenotypes. Very little is known about the role of cyanophage in regulating freshwater cyanobacterial population development and structure. In this study, a total of 35 cyanophages able to infect bloom-forming freshwater cyanobacteria from the genera *Microcystis*, *Anabaena* and *Planktothrix* were isolated from Lake Zürich, Switzerland and lakes in the Cotswold Water Park, U.K. The collection of isolated cyanophages encompassed a variety of morphotypes, including the first filamentous cyanophage. Some cyanophages were found to have a very broad host range and were able to infect *Anabaena*, *Microcystis* and *Planktothrix*. The ability to infect a wide range of host taxa extends the potential reproductive period for lytic propagation, and also has implications for the transfer of genetic information between deeply separated cyanobacterial lineages.

CHAROPHYTE DISTRIBUTIONS IN THE COTSWOLD WATER PARK

Chloe Onoufriou and Marian Yallop

School of Biological Sciences, University of Bristol

Charophytes are sparsely distributed in lakes within the UK and over 40% of species are classified as vulnerable, endangered or critically endangered in Great Britain. This group is ecologically important for a number of reasons. They are associated with clear water, which encourages the growth of other macrophytes and prevents lake state switching to turbid, phytoplankton dominated waters. Charophytes are also an important food resource for fish and waterbirds, in addition to supporting greater numbers of macroinvertebrates than other macrophyte species. The Cotswold Water Park (a complex of > 130 gravel pit lakes) supports nine species of charophyte, but their distribution and relative abundance varies considerably between lakes. We investigated a number of factors that may affect charophyte distribution in the pelagic and littoral regions of these lakes and oospore distribution has been quantified in a number of lakes. Charophytes play a key role in ecosystem functioning in shallow lakes and this study will contribute to the knowledge required to encourage and maintain charophyte beds.

ULTRASONIC PROBE EFFECTS ON GROWTH AND PHOTOSYNTHETIC ACTIVITY OF *MICROCYSTIS AERUGINOSA*

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Harmful algal blooms (HAB) can release toxins into water bodies posing a health risk to humans and animals. Although blooms are a natural phenomenon and occur globally their incidence rate has climbed rapidly in recent years. The sources of nutrients potentially stimulating algal blooms include sewage, atmospheric deposition, groundwater flow, as well as agricultural runoff and discharge. Increased usage of fertilisers and the anthropogenic effects of population growth in urban areas have led to considerable increases in nitrogen entering natural water bodies in the UK. To investigate alternatives to costly chemicals UK. water companies are now turning to alternative greener solutions to remove blooms, one of these is the use of ultrasound. Power ultrasound occurs between frequencies of 20 kHz-100 kHz. When applied to a liquid the sound waves compression and rarefaction create negative pressure within the liquid causing molecules to be pulled apart creating cavitation bubbles (cavities). When these bubbles collapse the local temperature reaches 50000C and 2000 atmospheres.

The response of cyanobacterial species *Microcystis aeruginosa* was tested using the Vir-sonic ultrasound probe at a frequency of 20 kHz and power of a 0-600 Watts. After sonication at 20 kHz, 414 Watts

for 30 seconds using a volume of 50 ml of $8x10^6$cells/ml, a 25% kill rate was observed; chlorophyll fluorescence was significantly reduced. The second experiment used, 20 kHz, 150 W, 100 ml and time of 60-150 seconds but decreasing cell concentration to $4x10^6$ cells/ml. Results produced a 20% kill rate and chlorophyll fluorescence showed a significant decrease.

THE TAXONOMY AND BIODIVERSITY OF ARTICULATED CORALLINE ALGAE IN BRITAIN AND IRELAND

Rachel Walker

Natural History Museum

In the seaweed flora of Britain and Ireland there are five currently recognised taxa of geniculate coralline algae. The current taxonomy is based primarily on morphology but species are difficult to identify using these characters alone. An integrative study using the cytochrome c oxidase (cox1) gene, 18S rRNA gene and additional morphological characters revealed that the taxonomy of this group requires revision.

The cox1 and 18S rRNA gene phylogenies supported the division of the tribes Janieae and Corallineae. Overall, cox1 gene sequences for the group had intraspecific variation of 0-24 base pairs (bp) (0-4.5%) and interspecific variation of 45-69 bp (8.4-12.8%) whereas the 18S rRNA gene sequences had intraspecific variation of 0-7 bp (0-0.4%) and interspecific variation of 14-27 bp (0.8-1.6%). *Jania rubens* var. *rubens* (Linnaeus) Lamouroux and *Jania rubens* var. *corniculata* (Linnaeus) Yendo clustered together. This suggested that for the genes studied, there was no genetic basis for the morphological variation. The 46-48 bp (8.6-8.9%) sequence difference between *Haliptilon squamatum* (Linnaeus) Johansen, Irvine & Webster and *Jania rubens* (Linnaeus) Lamouroux species in the cox1 phylogeny suggested that this was species level divergence and therefore the taxa should be merged into a single genus. *Corallina officinalis* Linnaeus formed two distinct clusters that differed by 45-54 bp (8.4-10.0%). The main morphological differences between the clusters were frond length and the number, banding and fusing of surmounting intergenicula. The two clusters were also observed occupying different intertidal zones on the shore. *Corallina elongata* Ellis & Solander showed intraspecific variation between Atlantic, British and Irish regions.

TOXICITY AND GENE EXPRESSION: HUNTING THE PSP TOXIN GENES IN THE DINOFLAGELLATE *ALEXANDRIUM MINUTUM*

Ines Yang, Uwe John, and Allan Cembella

Alfred Wegener Institute for Polar and Marine Research

Marine dinoflagellates of the genus *Alexandrium* are well known for their ability to produce the potent neurotoxin saxitoxin and other analogues responsible for paralytic shellfish poisoning (PSP). Dinoflagellates are the only known eukaryotes confirmed to produce these neurotoxins, but they are also synthesized by certain brackish and freshwater cyanobacteria, giving rise to speculations about their prokaryotic origin. Thus far, no distinct enzymes or genes involved in the actual synthesis of the toxins have been unequivocally identified in either dinoflagellates or cyanobacteria. However, detailed proposals for such a pathway exist, and the requirements for biosynthesis have been examined in vitro. In order to contribute to the search for genes involved in PSP toxin production, we developed a DNA microarray based upon an expressed sequence tag (EST) library from *A. minutum*. This species tends to produce a limited subset of PSP toxins, typically dominated by the sulfated carbamate derivatives known as gonyautoxins. The array was used in gene expression studies involving both toxic and non-toxic *A. minutum* strains, as well as different physiological conditions within one strain. We identified genes associated with the ability to produce PSP toxins in an inter-strain comparison. Here we compare these data to gene expression correlated with differences in toxicity under different physiological conditions.

DIATOM INDICES AND THE WATER FRAMEWORK DIRECTIVE

Martyn Kelly

Bowburn Consultancy

Most countries in the EU have chosen to use diatom metrics in order to fulfil their obligation to monitor phytobenthos as part of the Water Framework Directive (WFD). Most of these metrics are based on a weighted-average equation and are calibrated against a 'nutrient-organic gradient'. Status class boundaries are set by a variety of approaches, with simple mathematical divisions of the Ecological Quality Ratio gradient proving popular. This talk will summarise the outcomes of the EU's intercalibration exercise, which compared boundaries, looking, in particular, at how UK methods compare with those from elsewhere in the EU and questioning whether or not diatom indices truly reflect changes in the structure and function of ecosystems, as required in the WFD's own definitions of ecological status.

THE WFD AND LAKE PHYTOPLANKTON: DELIVERING TOOLS FOR DATA INTEGRITY, ECOLOGICAL UNDERSTANDING AND CLASSIFICATION

Laurence Carvalho

Centre for Ecology & Hydrology (CEH)

The Water Framework Directive (WFD) has fundamentally changed how the quality of European freshwater and coastal environments are assessed. New ecological tools are required that use biological data to indicate ecological health. Additionally, the new quality classifications must reflect how biological communities at individual sites have altered with reference to an "undisturbed" state, how we can identify thresholds between high, good and bad status classes and importantly how we quantify the level of uncertainty in the final reported classification.

This talk illustrates how these challenges have stimulated research on lake phytoplankton across Europe. It has delivered improved guidance on counting phytoplankton, large datasets to investigate drivers of phytoplankton communities and practical tools to encourage data integrity and the classification of ecological status. Further challenges to overcome in terms of comparing classifications across Europe and minimising uncertainty will also be discussed.

PHYTOPLANKTON ANALYSIS, SEPA AND THE WATER FRAMEWORK DIRECTIVE

K. Kennington and R. Park

Scottish Environment Protection Agency

Phytoplankton are one of four biological quality elements of the EC Water Framework Directive (WFD) encompassing taxonomic composition, abundance, biomass and plankton blooms which are considered for the ecological classification of transitional and coastal waters (Directive 2000/60/EC). The WFD along with other drivers such as the OSPAR strategy to combat eutrophication require member states to classify coastal and transitional waters against reference 'pristine' conditions so as to minimise the impact of nutrification and the 'undesirable disturbance' of marine ecosystems.

A suite of ecological tools has been proposed for UK and ROI waters These diagnostic tools aim to measure the potential consequences of marine eutrophication and link to the WFD's normative definitions that describe the state of the biological element in related to a classification gradient of high, good, moderate, poor and bad status.

Data is presented from the first year of surveying Scottish coastal waters utilising these ecological tools and a broad scale classification of Scottish coastal and transitional waters is provided.

USING MOLECULAR TOOLS IN ENVIRONMENTAL MONITORING: THE QUESTION OF ALIENS

Christine Maggs, Frédéric Mineur, and John Kelly

School of Biological Sciences, Queen's University Belfast

The increasing impacts of invasive species in the aquatic environment are of growing concern, particularly in the context of the Water Framework Directive (WFD; 2000/60/EC). The WFD requires member states to achieve at least good status for water bodies by 2015, judged using both ecological classification and chemical classification systems. While the text of the WFD does not explicitly mention alien species, it has been considered that what is listed in Annex II (1.4) under identification of pressures as 'estimation and identification of other significant anthropogenic impacts on the status of surface waters' includes alien species. For some organisms, identification of aliens and determining their impact is relatively easy, but for many seaweeds it is extremely difficult. This is particularly serious for the green seaweed genera *Ulva* and *Umbraulva*, as there are few morphologically useful characters, intraspecific morphological variation swamps interspecific differences, the origin of several species in Europe is cryptogenic, and the genera are major contributors to green tides, which are monitored under the WFD. Molecular tools are therefore crucial in the study of these genera and their impacts. In this talk, we will explore the possibility that several of the green tide-forming *Ulva* species are cryptic invaders into Europe from the Pacific, and therefore should be considered as invasives for the WFD.

REMOTE SENSING FOR THE MONITORING AND MANAGEMENT OF CYANOBACTERIAL BLOOMS IN LAKES

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Remote sensing has been used extensively to provide quantitative information on the distribution of phytoplankton in lakes and other inland waters through the retrieval of the chlorophyll-a concentration. However, whilst such studies demonstrate the efficacy of the remote sensing for the monitoring of phytoplankton in lakes, it is apparent that as chlorophyll-a is common to almost all species of phytoplankton, such an approach provides no information on the species composition of the target environment. The development of remote sensing techniques for the discrimination of specific phytoplankton taxonomic groups and, in particular, cyanobacteria, has long been a goal for both limnological and oceanographical remote sensing. This presentation discusses the results of some preliminary research examining the use of remote sensing for the discriminative mapping of cyanobacterial blooms in lakes.

Radiance reflectance measurements were acquired from experimental mesocosm simulations using cultured phytoplankton and were used to explore the spectral characteristics of various phytoplankton colour groups. In addition, high spatial and spectral time-series airborne imagery (CASI-2) was acquired of cyanobacterial blooms in the shallow lakes of the Norfolk Broads (UK). The results demonstrate that cyanobacteria are indeed spectrally unique. Furthermore, the formulation and validation of an algorithm for the quantification of the accessory biomarker pigment C-phycocyanin using the CASI-2 data enabled the diurnal and seasonal dynamics of cyanobacteria in the Norfolk Broads to be monitored using airborne reconnaissance. It is suggested that remote sensing could be a highly efficient and effective tool for the monitoring and management of cyanobacterial blooms in lakes.

A COMPARISON OF GLYCEROL LEAKAGE BY THREE STRAINS OF THE UNICELLULAR GREEN ALGA *DUNALIELLA* (VOLVOCALES, CHLOROPHYCEAE)

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One of the major costs associated with the commercial utilization of unicellular green microalgae belonging to the genus *Dunaliella* is that of harvesting. To improve the feasibility of commercial glycerol production using *Dunaliella*, leakage of glycerol into the medium was explored. Three strains of *Dunaliella* were tested; *D. parva* CCAP19/9 a brackish water strain isolated from a salt marsh in southern England; *D. parva* CCAP19/10 a strain isolated from the Dead Sea and *D. salina* CCAP19/30 a strain isolated from a salt pond in North Sinai. All three strains grew well over a wide range of salinities (0.1 to 4 M NaCl) with optimum growth for all strains at 0.1 to 0.4 M NaCl. All three strains leak significant amounts of glycerol into the medium and extracellular glycerol concentrations in the region of 3 - 4 micromoles ml-1 were found for cells grown at 4 M NaCl. Intracellular glycerol levels varied significantly between the three strains when presented on either a chlorophyll or cell number basis, emphasising the need for cell volume to be taken into account in assessing strains for commercial production. It appears that significant leakage of glycerol into the growth medium is an intrinsic property of the three strains tested.

DEVELOPMENT OF NEW DIATOM BASED MONITORING TOOLS FOR THE WATER FRAMEWORK DIRECTIVE- SOME OPTIONS AND ISSUES.

J. Fisher, A. Deflandre-Vlandas, M. Coste, F. Delmas, and H.P. Jarvie

Liverpool John Moores University

Benthic diatoms are routinely used to monitor water quality in rivers throughout Europe on a country by country basis. There is a need to develop diatom monitoring methods for the Water Framework Directive (WFD) which can monitor and quantify a range of environmental pressures, rather than the use of indices

which measure a single environmental variable. A number of communities which may act as indicators of eutrophication and which are not determined solely by altitude, temperature, pH and conductivity have been identified. These relationships were present even after the co-correlating effects of alkalinity, conductivity, pH, calcium and temperature had been partialled out. There were also statistically significant correlations between simple morphological-functional groups and nitrate, total nitrogen, ortho-phosphate and total phosphorus. Such methods may form the basis of new diatom based monitoring tools for the WFD though this needs to be considered in light of their reliability and ease of use.

THE ISOLATION AND CHARACTERISATION OF TWO BACTERIOPHAGES WHICH INFECT THE MARINE CYANOBACTERIUM *ACARYOCHLORIS MARINA*

Yi-Wah Chan[1], Remus Mohr[2], Wolfgang R. Hess[2], Antony W. D. Larkum[3], David J. Scanlan[4], Nicholas H. Mann[4], Anna L. Whitworth[5], and **Martha R. J. Clokie**[6]

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The cyanobacterium *Acaryochloris* is the most closely related genus to the highly abundant *Synechococcus* and *Prochlorococcus*, but is distinct in two main characteristics; (1) it is the only organism known to use chlorophyll d as its main light harvesting pigment and (2) it often has a symbiotic or epiphytic lifestyle, living on the underside of algae or marine sea squirts (*Ascidia*).

Bacteriophages which infect cyanobacteria are important in terms of biogeochemical cycling, population dynamics and horizontal gene transfer. The genetic characterisation of bacteriophages which infect cyanobacteria has increased our understanding of cyanobacterial and phage evolution demonstrated the close link between host-phage interactions. Seven cyanobacteriophages have had their genomes sequenced and published: six myoviruses and one podovirus. We present data for the first viruses from *Acaryochloris* to be isolated (A-HI1 and A-HI2); these are also the first cyanobacterial siphoviruses to be sequenced.

We obtained phages by scraping *Ascidia* from Heron Island, Australia and then filtering the scrapates. We isolated them using plaque assays and have characterised their physiological properties and genome size and content. Contrary to the situation with the other sequenced cyanophages, the *Acaryochloris* siphoviruses have relatively few recognisable genes (~15%). Amongst observations of interest is the finding that both phages contain two DNA polymerases, one is most similar to that of a cyanobacterium and the other to the eukaryotic polymerase family DNA polymerase A.

HIGH RATES OF PHOTOSYNTHESIS ON GLACIERS: IMPORTANCE TO THE GLOBAL CARBON CYCLE

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Life exists wherever there is water, including habitats such as glaciers which had previously been regarded as sterile environments. Cryoconite holes, which can cover in average 1.5% of the glacier surface, are small, water-filled depressions (typically < 1m in diameter and usually < 0.5 m deep) that form on the surface of glaciers when solar heated inorganic and organic debris melts into the ice. Recent studies show that cryoconites are colonized by a diverse range of microorganisms, including viruses, bacteria, fungi and algae. In this study, we measured net primary production and community respiration of cryoconite holes in 3 glaciers in Svalbard. Microbial activity in cryoconite holes is high despite the organisms being subjected to temperatures as low as 0.1°C. Primary production and respiration in cryoconite debris associated material was comparable to those found in soils and sediments in warmer and nutrient richer regions. Considering only glacial distribution outside Antarctica and the average cryoconite distribution on glacial surface, we scaled up the net metabolism of cryoconite holes on a global basis. Cryoconite holes have the potential to fix as much as 65 Gg of carbon on annual basis (i.e., photosynthesis minus community respiration). Inland waters are generally considered as heterotrophic systems, but our results suggest that glaciers, which contain 75% of the freshwater in the planet, are largely autotrophic systems.

COMPETITION OR COEXISTENCE? LAKE BAIKAL'S PLANKTONIC DIATOMS

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Plankton communities have been studied for many years but they are often complex and so we still know relatively little about how species interact with each other. In the world's oldest and deepest lake, Lake Baikal in Siberia, famous for its high biodiversity, there are some 'endemic' planktonic diatom species, which is unusual and increasingly debated. A multidisciplinary study for the last 15 years has investigated the ecology of the 'endemics' and their interaction with each other and more widespread species that also occur there. Although nearly all can be found growing together in spring, their survival largely depends on what happens at other times of the year, particularly during alternating periods of mixing and stratification. Culture and field studies will be used to show how two *Aulacoseira* species are adapted to living at low light and low temperatures, especially under the ice, where the cells of some species stay in suspension for up to 7 months, although they are amongst the largest found in freshwater plankton.

MOLECULAR MARKER DEVELOPMENT TO UNVEIL THE GENETIC DIVERSITY OF *PHAEOCYSTIS ANTARCTICA*

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The prymnesiophyte genus *Phaeocystis* contains three colony-forming species: *P. globosa* in warm water and two cold water species, *P. pouchetii* in the Arctic and *P. antarctica* in the Antarctic Ocean. Previous work on the genetic diversity of *Phaeocystis* using rRNA and ITS sequence analyses have shown substantial inter- and intraspecific variation. A comparison of ITS sequences were used to trace the biogeographical history of strains in Antarctic coastal waters and

showed that the strains from the ACC were ancestral to those in the continental gyres. To gain deeper insights into the population structure and bloom dynamics of this microalga, it is necessary to quantify the genetic diversity within populations of *P. antarctica* from each of the three major gyres in the Antarctic continental waters and to calculate the gene flow between them. Two methods will be used to quantify the genetic diversity in algae blooms of different locations: AFLPs and microsatellites. Preliminary results from microsatellites and AFLPs indicate that there is gene flow between the continental gyres. A final calibration of how much gene flow awaits our complete microsatellite analysis.

VARIATION IN DIMETHYLSULPHONIOPROPIONATE (DMSP) PRODUCTION AND DIMETHYLSULPHIDE (DMS) RELEASE IN COCCOLITHOPHORES

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Using the 'CODENET' culture collection of coccolithophores, we have made measurements of DMSP-lyase activity, DMSP and DMS in 10 species of coccolithophores and we have begun to relate our measurements to natural abundances of coccolithophores in nature. The work stemmed from the need to test the assumption that *Emiliania huxleyi* blooms are the dominant source of coccolithophore DMSP. Given that 75% of oceanic production occurs in non-bloom situations, we have made predictions about the relative contribution of different species using time-series data from the subtropics, where coccolithophores are both abundant and diverse. DMS was highly variable in our cultures, reflecting the complex production pathway of this volatile compound, but DMSP content increased linearly with cell size indicating the fundamental biochemical role of DMSP in the functioning of the cell. In vitro DMSP-lyase activity was restricted to *E. huxleyi* and *Gephyrocapsa oceanica* (Noelaerhabdaceae). We have also made preliminary measurements into the differences between life-history stages of one important species of coccolithophore (*Calcidiscus leptoporus*) i.e. between diploid heterococcolith cells and haploid holococcolith cells. Overall, our laboratory data indicate that although all coccolithophores accumulate DMSP, different species vary considerably in their propensity to produce DMS from DMSP.

FREE FATTY ACID RELEASE AS A DEFENCE PATHWAY IN THE MARINE DIATOM, *PHAEODACTYLUM TRICORNUTUM*

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Activated chemical defence pathways in microalgae have only recently started to attract attention. The best characterised are the dimethyl-sulphoniopropionate (DMSP) and oxylipin pathways, which are proposed to provide defence against grazers and pathogens, but such pathways may be absent in certain successful species. Using the model marine diatom, *Phaeodactylum tricornutum*, we have shown that large quantities of free fatty acids, probably released from cellular membranes, are liberated when the cell loses its integrity. These include mono- and poly-unsaturated fatty acids, such as palmitoleic acid and eicosapentaenoic acid. These free fatty acids have been shown to exhibit broad biological activities, including toxicity to grazers and inhibitory effects towards numerous Gram positive and negative bacteria. Importantly, these fatty acids are active at micromolar concentrations. Fatty acid release upon cellular disintegration is proposed as an elegant, broad-acting and metabolically inexpensive microalgal defence pathway against various biological threats including pathogens and predators. This pathway may further explain the success of microalgae, especially the diatoms.

ARCHIVED PLANKTON SAMPLES REVEAL CHANGES IN *EMILIANIA HUXLEYI* ASSEMBLAGES AND ASSOCIATED VIRUSES OVER A 32 YEAR PERIOD

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Changes in our climate and impacts upon the biological environment have been linked to increases in anthropogenic carbon dioxide production. Despite this, the response of planktonic ecosystems remains unclear due to the lack of long term marine biological datasets available to assess the impact over appropriate timescales. Denaturing gradient gel electrophoresis (DGGE) and sequencing was used to analyze DNA extracted from samples of the continuous plankton recorder (CPR) collected off the NW coast of France, dating from 1972 to 2003. In 1997, dramatic changes in the genetic structure of the *Emiliania huxleyi* population were detected, an organism believed to play an important role in climate control. Putative relationships of this observation with changes in environmental parameters such as sea surface temperature (SST) were investigated. For the first time, the extraction of *E. huxleyi*-infecting viral nucleic acids from CPR samples was achieved, with significant changes in viral genotypes detected over time. This ability to purify viral nucleic acids from CPR samples offers the unique opportunity to study marine plankton hosts and their co-occurring viruses over long time scales.

HOMEOSTASIS, REGULATION AND ACCLIMATION: ROLES IN ALGAL ECOLOGY AND EVOLUTION

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We define homeostasis as the maintenance of a (relatively) constant internal environment. Regulation we define as short-term adjustments of catalytic effectiveness of proteins without changes in the proteome but allowing for quantitative and qualitative changes in the metabolome. Acclimation is considered to involve changes in gene expression and hence involves quantitative and qualitative changes to the proteome and metabolome in relation to a changed environment during growth. Clearly strict (within ± 5%) homeostasis of some parameters is not consistent with the occurrence of the well-investigated phenomena of regulation and of acclimation. There is clearly a very significant degree of homeostasis of cytosolic free H^+, Ca^{2+} and, in some algae, intracellular osmolarity despite variations in external free H^+, Ca^{2+} and osmolarity. In other algae the difference between intracellular and extracellular osmolarity, and hence the cell volume, is maintained despite changes in extracellular osmolarity. Such homoeostasis of low molecular mass solutes often require not just regulation but also acclimation.

Can the concept of homeostasis be extended to macromolecular and lipid composition? It is known that the macromolecular and lipid composition of algae changes with their growth conditions, and that this is reflected in their C:N:P ratio since most of the cellular quota of these elements is in macromolecules and lipids. We report data on the protein, carbohydrate and lipid content, measured with Fourier Transform Infrared Spectroscopy, of a wide phylogenetic range on marine phytoplankton organisms subject to changes in inorganic carbon and nitrogen supply showing that there is significant diversity in the extent of homeostasis.

RAPID MEASUREMENTS OF CELL TURGOR PRESSURE BY GAS VESICLES OF *MICROCYSTIS* SP.

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According to Mitchell's chemiosmotic theory, all organisms generate ATP by establishing a proton gradient across the cell membranes and channelling the entry of protons through ATP synthase. The entry of protons may also drive exchange of other ions or molecules. In the walled cells of bacteria, algae and plants, a consequence of generating chemiosmotic gradients is the production of cell turgor pressure. Turgor in cyanobacteria has been determined from measurements of the pressures required to collapse gas vesicles and attempts are now being made to transfer gas-vesicle production to other cells for turgor measurement by genetic modification. We discuss the special requirements for a suitable system: the narrow, strong and uniform gas vesicles of *Microcystis* sp. can be used to measure pressures up to 0.6 MPa (6 bar). Modifications of the pressure nephelometer, used for determining critical collapse pressures, have been made that increase the accuracy and speed of measurement. They permit investigations of turgor changes that indicate the rate at which water and solutes are taken up by the cell and they provide information on the mechanical properties of cell walls.

GLIDING MOTILITY AND CELL WALL ULTRASTRUCTURE IN *OSCILLATORIA*

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The genus *Oscillatoria* contains filamentous cyanobacteria which exhibit gliding motility, a process that requires attachment to a surface. The mechanism of gliding is unknown, although there are two main theories. In the first, gliding is powered by the extrusion of slime from junctional pores that encircle each cell septum. The second proposes that gliding results from the progress of waves in the cell surface. Such waves might be created by an array of protein fibrils beneath the outer membrane. We have been using Atomic Force Microscopy (AFM) and Field Emission Gun Scanning Electron Microscopy (FEGSEM) to study the cell walls of *Oscillatoria* strains to identify structures that may be associated with motility. An array of parallel corrugations can be visualised on the cell surface of *Oscillatoria* sp. strain A2 and other motile cyanobacteria by AFM and FEGSEM. These corrugations result from the presence of an array of parallel fibrils beneath the outer membrane. However, this array is not visible by either technique in the very large *Oscillatoria princeps*, although we can show by other means that this cyanobacterium possesses fibrils. This talk will illustrate how FEGSEM and AFM imaging can reveal much about the ultrastructure of the *Oscillatoria* cell wall and will consider what the consequences are for theories about gliding motility.

COMPARISON OF THE CP12 PROTEIN SEQUENCE BETWEEN ALGAE AND HIGHER PLANTS

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The small nuclear-encoded chloroplast protein, CP12, plays an important role in the regulation of the Calvin cycle, where it forms part of a core complex linking phosphoribulokinase (PRK) and glyceraldehyde-3-phosphate dehydrogenase (GAPDH). Reversible oxidization and reduction of CP12 leads to conformation changes of the protein and therefore formation or dissociation of the PRK/GAPDH/CP12 complex. CP12 proteins have been characterized mainly in higher plants so far but have also been found in chlorophyte algae and cyanobacteria. The advent of numerous EST and genome projects allowed us to search for and analyse CP12 sequences in other algal classes. We were able to align more than 100 CP12 sequences from land plants, cyanobacteria and various eukaryotic algal classes (Chlorophyceae, Prasinophyceae, Rhodophyceae, Glaucocystophyceae, Bangiophyceae, Bacillariophyceae). Our analysis showed that the algal CP12 sequences had distinct characteristics from those of land plants. We were able to find a putative CP12 sequence in the genome of the diatom Thalassiosira pseudonana that nevertheless showed a number of differences from any other known CP12. This might have important consequences for its function and regulation. Interestingly, CP12 was found neither in the only other sequenced diatom genome from Phaeodactylum tricornutum, nor in the available EST or genome datasets from other phytoplankton species. Therefore, it is not clear yet if other phytoplankton classes, e.g. Dinophyceae or Prymnesiophyceae, possess CP12 or not.

COMPARISON OF REGULATION OF CALVIN CYCLE ENZYMES IN ALGAE

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The regulation of phosphoribulokinase (PRK) and glyceraldehyde-3-phosphate dehydrogenase (GAPDH) was investigated in a diatom, *Asterionella formosa*, and compared to the well studied chlorophyte *Chlamydomonas reinhardtii*. Unlike PRK from most photosynthetic organisms studied so far, PRK from *Asterionella*, was not regulated by reduction with dithiothreitol. However, NADPH-GAPDH was strongly activated when reduced, and in a similar way to GAPDH from other photosynthetic organisms. We thus studied the regulation of these two enzymes in other phylogenetic groups of algae. This confirmed that PRK was not regulated in diatoms but was regulated in green algae while GAPDH was regulated in all algal groups. We also found evidence, based on kinetic analysis and immunoblots, that CP12, a small linker protein involved in the formation of PRK/GAPDH complexes, might be present in *A. formosa*. Furthermore, a bioinformatic search in the *Thalassiosira pseudonana* genome revealed the presence of CP12. The behaviour of GAPDH was consistent with the presence of CP12. GAPDH was purified from *A. formosa*. Although the overall kinetic behaviour of GAPDH was the same in *A. formosa* and *C. reinhardtii*, the kinetic

parameters were different and probably reflect the different metabolism of these two algae. This work therefore provides further support for the differential regulation of Calvin cycle enzymes in diatoms, and also other types of algae, compared to chlorophytes and land plants.

SYSTEMATICS OF *DESMODESMUS* AND *SCENEDESMUS*: A CONUNDRUM?

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Desmodesmus and *Scenedesmus* are freshwater, green, non-motile and cosmopolitan algae. Originally, *Scenedesmus*, as described by Meyen (1829; Nova.Acta Physico-med. Ac. Caesareae Leop.-Carol. 14: 769-778), included coenobia that "are flat, rarely curved, plate of ellipsoidal to spindle shaped cells arranged in a single, alternating, or double series with their long axes parallel to one another and the number of cells in a coenobium is always a multiple of two and usually four or eight, though sometimes 16 or 32 and non-spiny or spiny" (Smith 1914; Trans. Wisc. Acad. Sci. 17: 1165-1220). However, it was observed that *Scenedesmus* also produced one-celled spiny morphs (Wood 1873; Smithsonian Contributions to Knowledge 19, 262p; Wolle 1887; The Comenius Press, Bethlehem, Pennsylvania, 364p). Uherkovich (1966; Akademiai Kiado, Budapest, 173pp) divided *Scenedesmus* into two subgenera: *Euscenedesmus* and *Desmodesmus*. Trainor et al. (1976; The Botanical Review 42: 5-25) postulated that the non-spiny and spiny morphs were distinctly different taxa, based on morphology (LM and TEM), physiology (culture studies) and ecology. An et al. (1999; Plant Biology 1: 418:428) provided molecular evidence that the spiny morphs were genetically different from the non-spiny morphs. Thus, *Desmodesmus* was erected as the new taxon for spiny morphs and *Scenedesmus* was designated for the non-spiny morphs. Trainor (1964; Amer. J. Bot. 51: 995-1001) had previously demonstrated that the spiny morphs also produce spineless morphs and unicells, which were morphologically similar to previously described taxa such as *Chlorella*, *Chodatella*, *Franceia* and *Lagerheimia*. We will present information on general features, which are important for distinguishing between the classification and systematics of *Scenedesmus* and *Desmodesmus*. It is our opinion that it will require a combination of culture studies, SEM analysis and molecular analysis (multi-phasic) to resolve the species complex of *Desmodesmus* and to understand its developmental cycle.

LIFE HISTORY STUDIES REVEAL THAT DIATOM SPECIES MAY NOT BE WHAT THEY SEEM TO BE

Dawn T. Rose and **Eileen J. Cox**

The Natural History Museum

Diatoms have traditionally been identified on the basis of wall morphology, many species having been described from single gatherings over 150 years ago. Names were often based on a very small part of the organism's morphological range, concepts often being subsequently broadened by inference based on perceived similarity. However, comparison of specimens from different gatherings is often complicated by allometric changes during the life cycle; smaller individuals are not exact copies of larger specimens.

Gomphonema parvulum is a well-known diatom that has been used as an indicator of organic pollution in water quality monitoring systems. Cultures of *G. parvulum* from several localities were established and studied over many months, during which some clones underwent sexual reproduction, thereby restoring maximum cell size for the clone. However the resultant large cells did not fit *G. parvulum*, but different clones were identified as *G. gracile* or *G. hebridense*. This talk will discuss the impact of size changes on morphology, taxon identification and species concepts in diatoms.

UBIQUITOUS DISPERSAL OF MICROBES: FACT OR FICTION?

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It is commonly assumed that because microbes are so small and so numerous, no mountain range, desert or ocean will be a big enough barrier to prevent their dispersal to every corner of the planet. There are several weaknesses in this theory of ubiquitous dispersal, including (1) an insufficiently discriminatory species concept: e.g. the freshwater benthic diatom *Sellaphora pupula* in its traditional sense is indeed found all over the world, but we know that "*S. pupula*" is composed of at least 40 different species and the key question is whether each of these is cosmopolitan or more restricted in its distribution, and (2) as yet no demonstrated mechanism of dispersal: it is generally assumed that microbes are blown around, or that birds or bugs carry them, but for many diatoms this does not seem feasible, because of their sensitivity to desiccation. Microsatellite markers can be used to investigate gene flow between populations of diatoms and hence can indicate their true dispersal capabilities. To date, microsatellite markers have only been applied to a few species of marine planktonic diatoms. We have developed microsatellites for the freshwater benthic diatom *S. capitata* and are using these, guided by barcode sequence data, to assess gene flow between Scottish, English, Belgian and Australian populations. If the ubiquitous dispersal theory is correct then we expect to find low levels of genetic differentiation between isolates from different lakes; on the other hand if dispersal is restricted we expect to find evidence for genetic divergence.

ABSTRACTS FOR POSTER PRESENTATIONS

A SUBSET OF GAF DOMAINS ARE EVOLUTIONARILY CONSERVED SODIUM SENSORS

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The ability of an organism or cell to maintain appropriate intracellular inorganic ion concentrations when challenged by extracellular fluctuations is among the most ancient and fundamental cellular processes. Despite the immense importance of inorganic ions in physiology, remarkably little is known of the molecular mechanisms by which the predominant inorganic ions of the cellular environment are detected. Here we describe work on the identification and characterization of a signalling domain responsive to sodium ions.

The ubiquitous GAF domain is an important site of signal perception in many eukaryotes and prokaryotes. GAF domains from diverse species have equally diverse ligands including NO in the NorR sensor of *Escherichia coli*, 2-oxoglutarate in NifA of *Azotobacter*

vinelandii, and the cyclic nucleotides cAMP and cGMP in cyanobacteria, unicellular parasitic eukaryotes, and mammals. The mammalian cyclic nucleotide phosphodiesterases (PDE) are integral to the regulation of cellular levels of cAMP and cGMP by controlling the rate of degradation. At least eleven distinct families of PDE exist whose activity can be regulated by their N-termini. Of these regulatory domains PDEs types 2, 5, 6, 10, and 11 possess GAF domains regulated by cyclic nucleotides. The CyaB1 and CyaB2 adenylyl cyclases (AC) of the model cyanobacterium *Anabaena* PCC 7120 also bind cAMP through one (CyaB1) or two (CyaB2) N-terminal GAF domains to mediate positive feedback regulation of the AC domain.

Na^+, but not other monovalent cations, regulates the function of CyaB1 by blocking cAMP mediated autoregulation. Mutation of the cAMP binding GAF domain of CyaB1 (GAF-B) blocks Na+ regulation while mutation of GAF-A has no effect. A chimera of the tandem GAF domain motif of CyaB2 with the AC domain of CyaB1 shows a similar response to Na^+. Na^+ was able to bind recombinant GAF domains with substantially greater affinity than K^+. Exogenous cAMP blocked Na^+ binding to the GAF domains but Na^+ had no effect on cAMP binding. Circular dichroism spectroscopy revealed that Na^+ maintains the domain in a conformation unable to signal and cAMP removes this constraint. Genetic ablation of the *cyaB1* and *cyaB2* genes gives strains defective in homeostasis at limiting Na^+ due to compromised Na^+/H^+ antiporter activity. To investigate whether Na^+ regulation of GAF domain function is of more global relevance we investigated a chimera of the cGMP regulated tandem GAF domain motif of mammalian PDE2 expressed contiguous with the CyaB1 AC catalytic domain. This experiment revealed that Na^+ inhibition of AC specific activity was now dependent upon cGMP and that Na^+ regulation of GAF domain function has been conserved since the eukaryotic/bacterial divergence. The GAF domain is therefore the first identified protein domain able to functionally sense and signal changes in environmental Na^+.

USING STABLE ISOTOPE ANALYSIS IN SEAWEED BIOMONITORING STUDIES

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Increased anthropogenic input of nutrients to water bodies can cause detrimental changes in habitat, food web structure and nutrient cycling. Difficulty in determining the source of nitrogen inputs can make environmental management of an area difficult. Nitrogen stable isotope analysis can distinguish between various 'point' and 'non point' sources of nitrogen input (sewage and agriculture). $\delta^{15}N$ values in macroalgae are expected to increase in relation to sewage nitrogen input. This elevated level distinguishes it from fertiliser nitrogen inputs which have $\delta^{15}N$ values close to zero. *Fucus serratus*, *F. ceranoides* and *Ascophyllum nodosum* were collected from sites around Strangford Lough, NI that are subject to agricultural and sewage input. Tissue samples were analysed for nitrogen and carbon stable isotopes. All species at all stations had $\delta^{15}N$ values in the range of sewage derived nitrogen. Plants from sites closer to sewage inputs had significantly greater $\delta^{15}N$ values than plants from control sites. Tissue of F.serratus was also collected at increasing distances from a waste water treatment input. The $\delta^{15}N$ value was significantly lower in plants sampled greater than 15 m from the input. Stable isotope analysis of macroalgal may be a useful tool in the environmental management of polluted areas.

INVESTIGATING BLOOMS OF MICROCYSTIS IN LUXHAY RESERVOIR IN THE UK: PRELIMINARY FINDINGS

Ana Castro

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Luxhay is an artificial eutrophic reservoir located within catchments of 30.5 k m^2 in the South West of England. Luxhay receives water from a number of sources. Water levels in the reservoir are subjected to fluctuations as some of the inputs are seasonal. Rainfall and farmland run-off could potentially be correlated to phosphorus/nitrate concentration in springs supplying the lake. Moreover, the reservoir is used for drinking water and abstracted on demand contributing to in-lake flux independent of seasonal variations in supply requirements. Intermittent artificial mixing was introduced in 1989 as a means of preventing lake stratification and to reduce manganese. In 2006, an intense bloom of *Microcystis* occurred with associated high concentrations of cyanotoxins and a research programme was instigated.

The aim of this research is to: a) calculate a nutrient budget from both internal and external sources, b) consider more effective mixing regimes to try to reduce the size of the blooms, c) develop a model of benthic-pelagic coupling to calculate the extent to which the overwintering benthic and pelagic populations of *Microcystis* contribute to the bloom in summer.

Preliminary results show that Luxhay has nutrient enriched sediments (Available P = 57.55 mg l^{-1}) and receives high concentrations (maximum TP = 240 µg l^{-1} and TON = 3.910 mg l^{-1}) from several springs. Despite artificial mixing oxygen profiles indicate some remaining stratification.

THE EFFECT OF MACROALGAL MORPHOLOGICAL COMPLEXITY ON SEDIMENT TRAPPING CAPACITY - PRELIMINARY FINDINGS

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The capacity of intertidal macroalgae to trap sediment is well documented and it has been recognised that the degree to which algae trap sediment varies between algal species. This has, in part, been attributed to the species' morphology. Morphological complexity of algae consists of a number of aspects of shape, space, texture, architecture and surface structure which may affect the alga's capacity to retain sediment.

In an attempt to assess which aspects of macroalgal morphological complexity affect their capacity to trap sediment, five replicates of each of nine morphologically different macroalgal species were collected from the lower mid shore at three sites near Scarborough, North Yorkshire. For each sample morphology complexity was quantified using the following methods: frond density, interstitial volume, branching organisation, algal volume and proportion of height before first branch were measured. The relationship between morphological complexity and mass of dried sediment g^{-1} dry algal weight was then assessed for each method.

This poster presents the preliminary findings from a single site, Holbeck, and outline the aims of further work.

CYANONET, A GLOBAL CYANOBACTERIAL BLOOMS AND CYANOTOXINS SITUATION EXERCISE, WITH RECOMMENDATIONS ARISING

Geoffrey A. Codd[1], Sandra M.F.O. Azevedo[2], Suvendra N. Bagchi[3], Michael D. Burch[4], Wayne W. Carmichael[5], William R. Harding[6], Tomasz Jurczak[7], Kunimitsu Kaya[8], Hans C. Utkilen[9], and Fiona M. Young[1]

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Recognising the occurrence, properties and risks presented by cyanotoxins proceeds at different paces in various parts of the world. This is due, e.g. to differences in national research interests and infrastructure, and to driving influences of poisoning events and disruption of water-based activities. A global situation exercise, CYANONET, was conducted within the International Hydrology Programme. This has included the establishment of a national network covering 69 countries throughout Africa, North and South America, Asia, Australasia and Oceania, and Europe. Data compilation and situation assessment for each country were carried out to determine: (i) cyanobacterial population occurrence; (ii) cyanotoxin occurrence; (iii) reported health incidents associated with cyanobacteria/cyanotoxins; (iv) surveys/epidemiological studies of associations between cyanobacteria, cyanotoxins and health; (v) effects on water supply, waterbody use and ecological status; (vi) management actions and instruments to reduce adverse effects of cyanobacteria/cyanotoxins; and (vii) available educational, training and awareness-raising materials and practices. A demonstration website was established (www.cyanonet.org). Criteria (i) to (iii) were fulfilled throughout all countries for which data were available. Major differences exist, even between neighbouring countries, regarding (iv) to (vii), from almost total lack of cyanotoxin awareness and risk management capacity , to relatively high levels including national policies, working groups and contingency plans. Recommendations arising, including further awareness-raising, education, technology transfer and sharing best practice are detailed (CYANONET, IHP-VI, Technical Documents in Hydrology No 76, UNESCO, 2005). These recommendations should require minimal administration, but maximal input from the multinational cyanobacterial/cyanotoxin research community which has already shown its capacity in this respect.

AN EMBEDDING AND ETCHING TECHNIQUE FOR EXAMINING THE 3D STRUCTURE OF DIATOMS WITH SEM

Andrew Carr and **Eileen J. Cox**

The Natural History Museum

SEM is the preferred tool for examining the wall structure of diatoms, both because of its ease of operation and the suitability of their cleaned siliceous walls for study. While traditional SEM allows the external and internal surface topography of valves to be readily investigated, details of the 3D valve and frustule architecture must often be inferred, unless fortuitous breaks in the wall are found. Girdle structure is often particularly difficult to determine, as vigorous cleaning techniques often cause frustule components to dissociate. On the other hand, gentle preparation may preclude internal examination of the frustule components.

In order to investigate girdle structure and arrangement, we revisited a simple embedding and etching technique to study frustule architecture. We present details of the modified protocol and show its value for revealing diatom wall structure in a variety of benthic taxa.

EFFECTS OF INCREASED CO_2 ON THE MARINE PHYTOPLANKTON: *THALASSIOSIRA PSEUDONANA* AND *EMILIANIA HUXLEYI*

Katharine Crawfurd[1,2], John Raven[2], Glen Wheeler[1], Martin Muhling[1] and Ian Joint[1]

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Diatoms and coccolithophores are important bloom forming phytoplankton groups which contribute to the biological pump of CO_2 to the deep ocean. The effect of increasing CO_2 on their growth rate and competitive abilities are incompletely understood. The International Governmental Panel on Climate Change models predict concentrations of between 550 ppm and 1000 ppm CO_2 by the end of this century.

In a series of laboratory and mesocosm experiments either single species or a mixed natural population of phytoplankton were bubbled with air containing CO_2 at 760 ppm or 380 ppm (present day concentration, control). An increase in CO_2 of this magnitude causes a drop in the pH from around 8.2 to 7.8.

Emiliania huxleyi, a coccolithophore, was the dominant bloom forming species in the mesocosm experiment; its growth rate was significantly decreased at increased CO_2 but no morphological changes to coccoliths were seen. In laboratory experiments growth rate was not significantly affected by increased CO_2.

To determine the effects of increased CO_2 on gene expression of *Thalassiosira pseudonana* primers were designed targeting the RuBisCO small subunit (rbcS), several carbonic anhydrases (CA), and actin as an endogenous control. RNA was extracted and quantitative reverse transcriptase polymerase chain reaction (qRT-PCR) showed increased rbcS and CA transcription in *Thalassiosira pseudonana* under increased CO_2. This species also shows consistently improved growth rate at 760 ppm CO_2, contrasting with some earlier reports. rbcS was also found to decrease with specific growth rate as cultures passed from exponential to stationary growth phase.

BIOINFORMATICS, GENOMICS AND THE CULTURE COLLECTION OF ALGAE AND PROTOZOA

J.G. Day, C.N. Campbell, C.M.M. Gachon, T. Pröschold, R. Saxon, and F.C. Küpper

Scottish Association for Marine Science

The Culture Collection of Algae and Protozoa (CCAP) is the UK national collection for marine, freshwater and terrestrial protists and cyanobacteria. It performs all the roles of a 21st century Biological Resource Centre (BRC) including: ex situ conservation of protistan and cyanobacterial biodiversity as well as provision of biological materials and their associated bioinformatic data to the scientific community. The Collection has had an online catalogue for over 10 years (www.ccap.ac.uk) and this is currently expanding to provide a wider ranging protistan bioinformatics resource.

In light of the increasing number of fully sequenced protists, the CCAP is striving to provide targeted services and support to workers involved in all aspects of genomic research. Our aim over the next two - five years is to increase the value of the Collection by reinforcing the representation of genome model species, and by

offering an integrated, up-to-date, easy-to-use resource that would provide curated information on our strain holdings. Over the past year the website has been expanded to display images and features an enhanced search facility. In the near future we will be incorporating an increased range of data to include molecular information such as Genbank accession numbers and a comprehensive reference lists of publications where CCAP strains have been used. Our longer term objective, in collaboration with other major Biological Resource Centres worldwide, is to build a virtual hub providing access to both protistan/ cyanobacterial cultures and their molecular and conventional bioinformatics data.

BIOACTIVE COMPOUNDS FROM A NOVEL EGYPTIAN CYANOBACTERIUM

Nermin Adel El Semary

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The taxonomic position of a filamentous, hair-like, non-heterocystous, benthic cyanobacterium isolated from the industrial region of Helwan district, Cairo, Egypt was investigated using both morphological and molecular (ssu rDNA) characters. The ssu rDNA sequence was < 91% similar to other cyanobacteria. Individual cells were 1-1.5 μm wide and 5 -7μm long with constrictions at the cross-walls. The cyanobacterium grew best at relatively high temperatures (35-50ºC) and was observed to dominate mixed cultures when co-cultured with *Oscillatoria*, another filamentous cyanobacterium. Additionally, it was observed to grow with very few contaminating bacteria on solid media. This novel cyanobacterial isolate was investigated for its ability to produce bioactive/antibiotic compounds. The lipophilic fraction was extracted using choloroform/methanol and bioassays for antimicrobial compounds were performed using six strains of pathogenic fungi/bacteria. Several fractions showed relative bioactivity against most of the pathogens but a single fraction was consistently bioactive against all of them.

DISTRIBUTION AND DISPERSAL OF THE INVASIVE MARINE ALGA, *SARGASSUM MUTICUM*: A MOLECULAR APPROACH TO A MANAGEMENT PROBLEM

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University of Glamorgan

The introduction of non-native species represents a key component of global environmental change and is now recognised as the second biggest threat to global biodiversity after habitat destruction. An understanding of the patterns and processes involved in exotic species introductions are pivotal in identifying potential invaders and susceptible locale, ultimately facilitating the development of appropriate management strategies. In this context the application of DNA technology is now becoming an important tool in invasive species research. The invasive brown alga, *Sargassum muticum*, native to the northwest Pacific, was first recorded in Wales in 1998 and since then has established several populations along the Welsh coast. Because of its rapid growth rate, high fecundity, ability for self-fertilisation and canopy-forming growth form, *S. muticum* can have profound influences on the structure and function of coastal ecosystems. This study aims to utilise molecular genetics to examine the phylogeography of *S. muticum* within Wales. This will involve the use of a combination of genetic markers including AFLPs and direct sequencing analysis. Specifically we aim to identify the relative contributions of both human activities e.g. aquaculture transfers and maritime traffic, and natural means of dispersal involved in the range expansion of *S. muticum*. Furthermore we aim to assess relative rates of gene flow between and within populations by examining population genetic structure at a range of spatial scales from kilometres to variation between individual plants. Another component of the study will involve the use of GIS to map the current distribution of *S. muticum* within Wales, upon which the genetic data will be overlaid providing a novel approach to the interpretation to population genetic structure.

AQUATIC BIOASSAY METHODS USING GERMINATION AND GAMETOPHYTE GROWTH OF THE GREEN MACROALGA *ULVA PERTUSA*

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Aquatic toxicity tests using spore germination and gametophyte growth of the green alga, *Ulva pertusa* Kjellman were developed and evaluated by assessing the toxicity of different organic and inorganic chemicals and elutriates of sewage or waste sludge. The toxic ranking of three metals was: Cu (EC50 of 17 μg L^{-1}) > Zn (378 μg L^{-1}) > Cd (789 μg L^{-1}) for spore germination and Cu (23-27 μg L^{-1}) > Cd (189-200 μg L^{-1}) > Zn (307-317 μg L^{-1}) for gametophyte growth. Spore germination (EC50 of 3.95 ml L^{-1}) was more sensitive to formalin than gametophyte growth (6.92-7.18 ml L^{-1}). The EC50 for TBTO differed between the endpoints, showing the value of 586 μg L^{-1} for germination and 391-396 μg L^{-1} for growth responses. After exposure to three different sludge elutriates the greatest and least toxic effects for all the endpoints were found for urban sewage (7.6-8.3%) and filtration bed (>61%), respectively. The sensitivity of the *Ulva* methods are similar to, and in many cases better than, commonly available or well-established, bioassay methods. As germination and gametophyte growth are essential means by which population recruitment is facilitated, the measured end-points are ecologically significant. The bioassays are simple, inexpensive and can be conducted all year round with artificial induction of spores from adult vegetative thalli. The cosmopolitan distribution of *Ulva* means that the test would have a potential application worldwide.

DETECTION AND CONTROL OF CYANOBACTERIA IN YORKSHIRE WATER RESERVOIRS

Robert S. Iredale[1], David G. Adams[1], and Adrian T. McDonald[2]

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The presence of excessive cyanobacterial growth in water resources can present a variety of problems to humans, including the production of toxic secondary metabolites. The range of problems is likely to become more severe in the future, with anthropogenic eutrophication and the threat of climate change driving an increase in cyanobacterial proliferation in temperate regions throughout the world. With this in mind, improved methods of detecting potentially toxic organisms are required, together with the means to control

such populations in an environmentally sound manner.

In collaboration with Yorkshire Water plc we have been employing Polymerase Chain Reaction (PCR) amplification to identify cyanobacteria and their toxin genes, in Yorkshire Water reservoirs. Preliminary results of this study will be presented.

The potential of decomposing barley straw as a cyanobacterial growth control agent has been known for over twenty years. Although fairly detailed hypotheses have been suggested, the mode of action is still unclear. Laboratory studies previously carried out have been somewhat limited, particularly in terms of the variation of conditions under which straw is decomposed. We are employing a specially designed decomposition chamber to test the effect of environmental conditions, particularly light intensity and wavelength, and aeration, on the efficacy of rotting straw as a growth inhibitor of a variety of cyanobacteria isolated from Yorkshire Water reservoirs. Preliminary results will be discussed in the poster.

PHYTOPLANKTON OF LOCH LOMOND

Jan Krokowski

Scottish Environment Protection Agency

The phytoplankton of Loch Lomond - the largest waterbody in terms of surface area and the third deepest in Great Britain - have been studied since the mid 1980s, and are dominated by diatoms with annual maxima in spring, followed by a larger maxima throughout late summer-early autumn consisting of cyanobacteria, green algae and desmids. Recent studies on the phytoplankton of Loch Lomond highlighted differences in total phytoplankton biomass (measured as chlorophyll a) and total phytoplankton abundance between the northern and southern basins, with relatively higher biomass and abundance in the southern than the northern basin. Moreover, an increase in the trophic state of the loch was highlighted in the early 2000s, with an increase in diatom taxa indicative of more enriched conditions. Recent changes in phytoplankton abundance and biomass are presented, in addition to a list of common phytoplankton species encountered which are compared to data from the mid 1980s.

PHYTOCHELATIN AND GLUTATHIONE PRODUCTION IN *FUCUS SERRATUS* (PHAEOPHYCEAE) ON EXPOSURE TO ELEVATED CADMIUM CONCENTRATIONS

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The production of phytochelatins (PCs) and glutathione (GSH) in *Fucus serratus* (Phaeophyceae), from two sites with different contamination histories, in response to cadmium (Cd) exposure is reported. PC and GSH were determined by high pressure liquid chromatography (HPLC) and cadmium concentrations of thalli measured by inductively coupled plasma mass spectrometry (ICP-MS). Discrimination between total and intracellular bound metal was determined by pre-treating material with a solution of 5 mM EDTA. The growth rates of *F. serratus* with Cd (1~10 mg L^{-1}) were much lower than controls in both of the populations after 7 d and 14 d. The concentration of PC synthesised depended on the population, external Cd concentration and length of exposure. There were significantly higher concentrations and longer chains of PC in *F. serratus* from the contaminated site at 5 and 10 mg Cd L^{-1}, especially after 14 d. Unlike PC production, GSH synthesis differed only with Cd concentration and this was sustained throughout the experiment. This is the first report of differences in PC production between populations of *F. serratus* in response to Cd exposure. Cd resistance in *F. serratus* involves both an exclusion mechanism and effective cellular detoxification of the metal. Faster synthesis and greater production of PC, and the maintenance of GSH, are responsible, at least in part, for tolerance.

CALCIUM SIGNALLING IN THE REGULATION OF GLIDING MOTILITY AND DIRECTION REVERSAL IN A BENTHIC DIATOM

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Motility in response to light allows organisms to maximise photosynthetic efficiency while avoiding deleteriously high irradiance. Many types of motile microalgae have been observed to accumulate in areas with moderate fluence-rates and disperse from areas of high fluence. Two distinct motile responses to light were defined in the pennate diatom *Navicula perminuta*. Confocal scanning laser microscopy and fluorescent indicators were used to image intracellular Ca^{2+} dynamics during the response to high intensity blue light. Calcium transients were involved in stimulus-induced reversal of cell direction. The calcium signal was to the cell apex, occurred 4 s after the cell was exposed to the light stimulus and corresponded with reversal of cell direction. Inhibitor experiments suggested that the calcium required for this response originated from intracellular stores whereas calcium-dependent motility required influx from the external medium. The results suggest that regulation of the cytoskeletal organisation that underlies directional secretion and motility is under the control of calcium signalling.

THE IMPACTS OF ENVIRONMENTAL CHANGE IN TWO MAJOR IRISH LAKES ON THE OCCURRENCE OF ALGAL TOXINS

Karen Mooney, Chris Elliott, Bob Foy, and Jack Hamilton

Queen's University, Belfast

Lough Neagh is the largest waterbody in Northern Ireland, and is the main source of potable water. Lough Erne is a major site for tourism and recreation, and both are Areas of Special Scientific Interest, Special Protection Areas, Ramsar sites and have a number of important nature reserves. Lough Erne is also designated a Special Area of Conservation. Since the 1950s, the nitrogen and phosphorus budgets of the lakes have been increasing, presently at an all-time high. With the introduction of the Nitrates Directive attempts are being made to reduce inputs. Combined with increasing temperatures and the invasion of zebra mussels which are hypothesised as being preferential filter feeders, this is changing the phytoplankton balance of the lakes. The main species present are all toxin producers, forming blooms in spring (minor) and late summer (major). Of these species, *Microcystis aeruginosa* is one of the most toxic (MC toxin) and it is highly prevalent in Lough Erne, which has also been extensively invaded by zebra mussels. The purpose of the current project is to determine the inter-relationships between nutrient regimes, temperature and zebra mussel invasions. This will be done using HPLC, Mass Spectrometry and feeding trials, with a view to predict if cyanobacteria dominance will increase, thereby

potentially adversely influencing water toxicity. The WHO set a guideline total MC limit of 1μg L^{-1} - currently levels in Lough Neagh are around 0.8μg L^{-1}. If this increases, it will have serious implications for human health and how potable water must be treated.

INFLUENCE OF SALINITY, TEMPERATURE, DISSOLVED INORGANIC CARBON AND NUTRIENT CONCENTRATIONS ON THE PHOTOSYNTHESIS AND GROWTH OF *FUCUS VESICULOSUS* FROM THE BALTIC AND IRISH SEA

Charlotta A. Nygård[1,2], and Matthew J. Dring[2]

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The photosynthesis and growth of *Fucus vesiculosus* from the Gulf of Bothnia (northern Baltic, 5 psu) and from the Irish Sea (35 psu) were compared after cultivation at different temperatures, salinities and concentrations of dissolved inorganic carbon (DIC) and nutrients. The maximal electron transport rate (ETR) and the relative growth rate (RGR) of Irish Sea plants in their natural seawater were significantly higher than those of Baltic plants in their natural seawater. When Baltic *F. vesiculosus* was cultivated at a DIC concentration similar to that of the Irish Sea, the ETR and RGR increased, but were not as high as those of *F. vesiculosus* from the Irish Sea. *Fucus vesiculosus* from the Baltic had a higher ETRmax and RGR at low salinities (5-10 psu) than *F. vesiculosus* from the Irish Sea, but plants from both sites performed better at low salinities when nutrient and DIC concentrations were high. Nevertheless, Irish Sea plants were particularly sensitive to high irradiance at low salinities (5 and 10 psu). The temperature optimum for Baltic plants was 4-10 °C, while that for plants from the Irish Sea was 15-20 °C. Across all treatments, there was a strong positive correlation between ETRmax and RGR, indicating that the same amount of energy from photosynthesis is used for growth in plants from both localities at different salinities. The photosynthesis of *F. vesiculosus* in the northern Baltic Sea is close to the minimum required for positive growth, and this probably accounts for the much smaller size of these plants.

THE DISTRIBUTION OF *ALEXANDRIUM* SPECIES IN THE BRITISH ISLES - AN UPDATE

Linda Percy, Don Anderson, and Jane Lewis

University of Westminster

The coastal waters of the United Kingdom and Ireland are some of the most stimulating for the phycologist interested in taxonomy of the dinoflagellate genus *Alexandrium*. This region is home to an expanding record of presence and distribution of species, so far *A. andersoni*, *A. tamutum*, *A.ostenfeldii/peruvianum*, *A. minutum* and *A. tamarense* have been confirmed. Of further interest is the presence of two genetically distinct clades of *Alexandrium tamarense*, the North American (NA) and Western European (WE).

The genus *Alexandrium* is of importance worldwide due to production of paralytic shellfish toxins (PSTs) by various member species, resulting in economical impacts on shellfish production. In the case of *Alexandrium tamarense* the molecular ribotype is useful as a marker for the production of PSTs. For example, members of the Western European clade are not recorded to produce PSTs, whereas members of the North American clade do. Alongside molecular and morphological evidence this has raised questions on species definition within the *A. tamarense* complex. The UK is particularly interesting from an ecological standpoint since not only are there distinct regions containing sole ribotypes of either the WE and NA clade, in addition, in Belfast Lough we report for the first time that both ribotypes have now been found to co-occur.

As part of the EU funded SEEDS project we have been investigating the occurrence of *Alexandrium* species and mating capability of *Alexandrium tamarense* isolated from around the British Isles. In this poster we will present an update of our work in the field.

HOW SONICATION EFFECTS THE GROWTH AND PHOTOSYNTHETIC ACTIVITY OF *MICROCYSTIS AERUGINOSA*

Diane Purcell, Simon Parsons, and Bruce Jefferson

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Eutrophication in lakes and reservoirs and consequently the formation of algal blooms are worldwide problems. Summer blooms in eutrophic lakes are usually cyanobacteria. Cyanobacteria are also known as blue-green algae, but are not true algae; they are actually bacteria or prokaryotes. *Microcystis aeruginosa* is considered one of the most successful blooming cyanobacterial species. The abundance of cyanobacteria leads to increased water treatment costs, a degradation of recreational value (Codd, et al. 1994), taste/odour issues (Izaguirre. et al, 1982), and possible toxin accumulation (Carmichael 1992). Ultrasound has only recently been recognized as a control method for cyanobacterial blooms. It works by concentrating the energy of sound waves through cavitation causing the compression, rarefaction, and finally implosive collapse of bubbles in a liquid) (Suslick 1990), This collapse by cavitation produces intense local heating (5,0000C) and high pressure (2000 atm) and is very short lived (Mason, et al. 2003).

The cyanobacterial species *Microcystis aeruginosa* (cell concentration 5.5x106) were sonicated in an ultrasonic probe model Vir-Tis at (low frequency) 20kHz and (high power) 404 watts for 6-11mins.

The cell concentration dropped immediately to 40% of the control after 72 hrs no cell recovery was observed and the cell number had dropped to even further to 25% of the control. Chlorophyll fluorescence measurements give an indication of the photosynthetic ability of the surviving cells. After 24 hrs chlorophyll fluorescence dropped to 0% of control, after 72 hrs no recovery in chlorophyll fluorescence occurred. Ultrasonic probe is effective at cell removal and damaging photosystem II in *Microcystis aeruginosa* at laboratory scale.

C_4 PHOTOSYNTHESIS IN A MARINE DIATOM?

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Animal and Plant Sciences, University of Sheffield, Sheffield S10 2TN, UK

Diatom productivity is enhanced by a CO_2-concentrating mechanism, but whether it is based solely on active transport of inorganic carbon or protons, or if single-cell C_4 photosynthesis has a role in some cases, is still a matter of controversy. In a C_4 pathway phosphoenolpyruvate carboxylase (PEPC) could act as primary carboxylase in the cytoplasm and phosphoenolpyruvate

carboxykinase (PEPCK) or malic enzyme (ME) as decarboxylase in the chloroplast, releasing CO_2 for Rubisco. Whole genome sequencing of the marine diatom *Thalassiosira pseudonana* has revealed the presence of essential genes for a C_4 pathway, including two PEPCs, PEPCK, ME and pyruvate, phosphate dikinase. These genes were cloned, and gene transcripts were measured by quantitative RT-PCR. Furthermore, antibodies were raised against some of the corresponding proteins, and used for immunoblotting. To test the C_4 pathway hypothesis, changes in transcript and protein amounts were measured when the diatom was grown under light-dark cycles and different levels of C and N limitation. These experiments showed rather limited effects of altered inorganic C, but significant diel variations. Expression of Rubisco large subunit was much greater and showed very strong diel oscillations, but was also not influenced by inorganic C supply. These findings suggest that *T. pseudonana* has C_3 photosynthesis and that the C_4-metabolic enzymes have only anaplerotic roles, in agreement with photosynthetic ^{14}C labelling studies (Roberts et al. 2007 Plant Physiol. 145: 230-235).

DIFFERENTIAL SUSCEPTIBILITY OF *ECTOCARPUS* (PHAEOPHYCEAE) TO THE OOMYCETE PATHOGEN *EURYCHASMA DICKSONII* - A REAL TIME PCR STUDY

M. Strittmatter, C.M.M. Gachon, and F.C. Küpper

Scottish Association for Marine Science, Dunstaffnage Marine Laboratory Dunbeg, Oban

Real-Time PCR is a fast method to amplify and quantify DNA simultaneously. The method is based on the monitoring of amplified target DNA after each cycle during PCR by measuring fluorescence emission, which also allows working with a limited amount of template DNA, as it is often the case in phycopathology.

Here we describe the application of Real-Time PCR to detect oomycete infections in brown algae - using our model system of *Ectocarpus siliculosus* and the pathogen *Eurychasma dicksonii*: we have observed that different degrees occur in the severity of *Eurychasma* infection in *Ectocarpus*, depending on the combination of host and pathogen strains used. In m icroscopic observations, this ranges from complete absence of infection symptoms (resistant *Ectocarpus*) over intermediate phenotypes to complete sensitivity of the alga. We have designed a Real-Time PCR assay suitable to rapidly screen a number of various *Ectocarpus* strains for the presence and severity of *Eurychasma* infection. First developed on defined laboratory cultures, this technique also has the potential of accurately monitoring the prevalence and abundance of pathogens in natural algal populations in the field.

EFFECT OF pH ON THE PRODUCTION OF CARBOHYDRATES BY A MARINE PLANKTONIC DIATOM (*CHAETOCEROS MUELLERI*)

Daniel C. O. Thornton

Department of Oceanography, Texas A&M University, USA

Seawater is becoming more acidic. The objective of this preliminary experiment was to determine how low pH affects the growth and allocation of carbon to different types of carbohydrate in a planktonic diatom. *Chaetoceros muelleri* was grown in batch culture at a range of pHs between 6.8 and 8.2. Growth was followed and measurements were made of the allocation of carbohydrates into extracellular and intracellular pools. Both growth and carbohydrate production were affected by pH. Cultures grown at pH 6.8 grew at a slower rate than those at higher pH. The quantum yield of photosystem II was correlated with pH. There was more carbohydrate production in cultures grown at the pre-industrial pH of 8.2. With decreasing pH a greater proportion of the total carbohydrate was extracellular rather than intracellular. These data indicate that the allocation of carbon to different carbohydrate pools in planktonic diatoms is affected by pH. This has implications for processes affected by primary production, including the microbial loop in the surface ocean and efficiency of the biological carbon pump.

COMPARISON OF EUKARYOTIC SEA ICE COMMUNITIES BASED ON 18S LIBRARIES

Susann Haase, **Klaus Valentin**, Gerhard Dieckmann, and Kai Bischof, Andreas Krell

Alfred-Wegner-Institut

One of the most extreme environments in the polar regions is sea ice. Low temperatures, high salinities and high pH values together with extreme fluctuations in irradiance have lead to the development of a unique community in sea ice brine channels. The aim of the present project is to study the eukaryotic fraction of this community and to answer two main questions "What is the (hidden) biodiversity in sea ice microbial communities?" and "What is the connection between diversity and transcriptional activity?"

To describe the molecular biodiversity of selected sea ice communities we established environmental 18s rDNA libraries, in order to unravel the identity of known and unknown, or unculturable species, "hidden biodiversity". The transcriptional input of eukaryotic sea ice organisms to ecosystem functioning was determined by randomly sequencing environmental cDNA libraries ("ESTs"). Using recently developed phylogenetic tools we will determine function and phylogenetic affiliation of ESTs and so link sea ice biodiversity with transcriptional activity of major groups. Assigning taxonomic groups to EST sequences is the most crucial and most innovative aspect of this project.

Here we do present data from the first part of the project, the analyses of eukaryotic species composition in sea ice.

POOR QUALITY SHORES TO CALIBRATE THE EC WATER FRAMEWORK DIRECTIVE

Martin Wilkinson[1], Emma Wells[2], Paul Wood[1], Clare Scanlan[3], and Sharon Woolsey[1]

[1] Heriot-Watt University, Edinburgh, [2] Wells Marine Surveys, Kings Lynn, [3] Scottish Environment Protection Agency, Aberdeen

The Water Framework Directive (WFD) requires assessment of ecological quality of water bodies with emphasis on biological indicators. On British intertidal rocky seashores the only biological indicator being used is macroalgae based on species richness of an area of shore under defined sampling conditions, with categorisation of species totals by colour group, ecological status group and opportunist species. These were shown in a database of 300+ British shores to relate to quality classification based on pressures. A transformation (deshoring factor) is applied to species totals to account for variation in species richness owing to natural features and subhabitat diversity. A problem in establishing this tool was the relatively few poor shores with published species lists. Consequently, as authors of the tool, we undertook field work on especially badly impacted shores. The areas with the most impacted shores, west Cumbria and Co. Durham with the former practice of depositing colliery spoil in the intertidal zone. With erosion of spoil a new

mining related problem is appearing to inhibit shore recovery; the seepage of acid mine drainage water from abandoned mines into the intertidal zone. Additionally in west Cumbria there are shores with an artificial substratum, slagcrete, formed by tipping of molten chemical industry waste into the intertidal zone and a shore where mine seepage includes possibly aged, metal-enriched, detergent factory effluent. These conditions have produced the most altered seashores in Britain ranging from shores devoid of macroalgae to those with only a few opportunist species, supporting the WFD species richness tool.

EMILIANIA HUXLEYI AND ITS VIRUSES: A NOVEL INFECTION STRATEGY REVEALED

Charlotte Worthy, Matt Hall, Keith Ryan, Roy Moate, and Declan C. Schroeder

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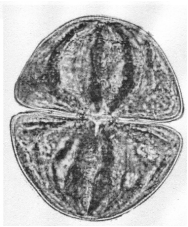
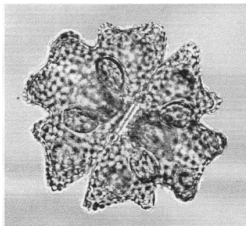
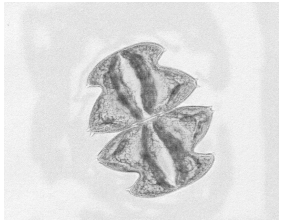
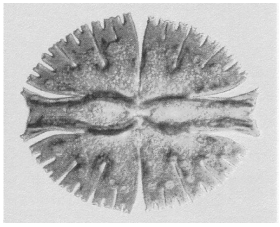
Emiliania huxleyi is a unicellular alga found throughout the world's oceans. They frequently bloom in the upper stratified oligotrophic waters in temperate and tropical regions. These blooms can easily be viewed by satellite since they are characterised by high light backscatter caused by coccoliths (calcium carbonate scales); produced intracellularly but presented externally on the outer surface of the cell. Significant genetic variation in populations enables *E. huxleyi* to be a quite successful species that plays a central role in environmental processes such as nutrient cycling and energy transfer, which enables it to exert a strong influence on ocean alkalinity and global carbon budgets. The causes of *E. huxleyi* mortality have important ecological and biogeochemical consequences. In recent years viruses have been identified as the main agent for *E. huxleyi* bloom demise. Our understanding of the mechanism of virus entry in eukaryotic algae is limited and currently is based on one example, the freshwater *Chlorella* alga-virus phage-like entry mechanism. Transmission Electron Microscopy (TEM) was successfully used to describe how soon after attachment of the virion to the algal cell wall, a hole is formed through which viral DNA enters the alga. Here we present TEM data describing a novel infection strategy by an algal virus, EhV-86, on its host, *E. huxleyi*. This is done with particular interest as *E. huxleyi* has a seemingly impenetrable calcium carbonate shield.

Federation of European Phycological Societies Developments

The first AGM of FEPS is due to be held on 18 July in Brussels. The FEPS AGM will be held shortly after the next meeting of the BPS Council. One aim of the FEPS AGM will be to formally adopt the FEPS Constitution, which has operated in draft form since the foundation of FEPS last July. The draft Constitution is amenable to amendment and is available for scrutiny on the BPS website.

The Federation of European Phycological Societies continues to develop. The second Meeting of the FEPS Council was held on 30 January 2008 at the National Herbarium of the Netherlands in Leiden. Actions included:

- **Agreement to hold the next European Phycological Congress (EPC V), scheduled for 2011, on the island of Rhodes, Greece, under the auspices of FEPS.**
- **Admission of the Hungarian Phycological Society to FEPS membership. The Hungarian phycologists were welcomed by the FEPS Council which currently includes representatives of the Dutch-Belgian, German, Greek, Italian, Polish and Spanish Societies/Groups, and the BPS.**
- **Progress on development of the FEPS website.**
- **Initiation of awareness-raising of FEPS and phycology in Europe in the European Parliament.**

Geoffrey Codd
BPS President, FEPS President

Manton Prize Winner

Li Deng
PhD in Microbial Ecology,
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I have loved Biology since helping my grandpa in his beautiful garden when I was a little girl. My passion for our environment took me to the best university in China (Tsinghua University; double major in Environmental Engineering and Biological Science), where I honed that passion to focus on water-based scientific disciplines during my bachelor's degree through my coursework and two research experiences in each a molecular biology lab and an environment simulation and pollution control lab.

My introduction to graduate school consisted of a one year masters course at the University of Nottingham, School of Environmental Science. My chosen research project led me to my favourite research topic - aquatic virology. I investigated natural and perturbed (experimentally varied the dissolved carbon concentrations and temperature) bacterial and viral abundance in Beaver Lake, a large ultra-oligotrophic epishelf lake in eastern Antarctica. I found that the ratio of virus to bacteria was significantly higher in Beaver Lake than previously described in Antarctic lakes and other average aquatic systems. In spite of the lack of mechanistic understanding of these findings, such results suggest that viruses play a crucial role in this extreme system, perhaps even more important than in other investigated aquatic systems.

After the work with Antarctic viral systems, I found myself captivated by the vastness of viral diversity and their potential roles in aquatic biogeochemistry. To further explore such topics, I brought my limited virus expertise into the laboratory of a cyanobacterial expert, Prof Paul Hayes at the University of Bristol, School of Biological Sciences to investigate how viruses (cyanophages) impact bloom-forming toxic cyanobacteria in freshwater systems. Specifically, I isolated 35 phages that infect a variety of such host strains, including the first published filamentous cyanophage. Host-range analyses of cyanophage isolates showed that some were even capable of infecting cyanobacterial hosts across three genera. Since phage commonly package and transfer host genetic material (e.g., via transduction), such a broad-host-range cyanophage could considerably impact the evolutionary trajectory of the host genome. In fact, we found a phycocyanin-like host cyanobacterial gene in the cyanophage isolate A-CP1. In these cyanobacteria, phycocyanin is ubiquitous accessory photosynthesis gene thought to be important in host metabolism during phage infection, but also previously hypothesized to have been horizontally transferred - is my phage a 'smoking gun' for a mechanism? Finally, I also used multiple genetic loci (T4-phage portal protein, major capsid protein) to examine the diversity and dynamics within natural phage communities to investigate the potential for phage mediated gene transfer within populations.

Once I have completed my PhD I intend to deep my understanding of how phage and host genomes evolve and how viruses influence global biogeochemical cycling.

I would like to thank the British Phycological Society for giving me the opportunity to present my work in such a friendly, supportive and inspiring atmosphere.

Poster Prize Winner

Kate Crawfurd,
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Sometime, soon after the millennium, I had either a millennial or a turning 30 crisis. I left London where I had been working as a theatre scenery artist, moved to Plymouth and started a marine biology degree. I have often wondered whether this was a good thing to do but now as I near the end of my PhD it is all coming together and feels right. I must admit to now having two undergraduate degrees, the first in fine art and psychology from Middlesex Poly. My supervisor, John Raven did 'out' me as an art graduate at the BPS meeting and it is true that this is a rather unfair advantage in a poster competition! I see art and science as closely linked subjects; they are both concerned with observation and understanding how things work. When you sit down and draw a specimen, landscape or whatever, you see so much more in it than you usually do.

My deck incubation experiment aboard STS Lord Nelson Jan '08, a scientific voyage aboard a tall ship organised by the Challenger Society for Ocean Science and the Jubilee Sailing Trust. This fantastic trip was a combination of things I love; sun, sea, sailing and science.

I loved my work as a scenic artist; I painted sets for Riverdance, My Fair Lady, lots of pantomime and even a month of operas at the Sydney opera house. It sounds very glamorous but was often monotonous (brown usually!) and I began to go crazy because I was only using one side of my brain. That's the psychologist talking, but I am very proud to be able say that I turned from a psychologist into a phycologist!

This PhD has been really interesting; the title is 'Marine phytoplankton in a high CO_2 world' which is broad and has given it the opportunity to evolve. I have been looking at the responses of single species cultures in the lab and natural communities in the field. Most of my results have shown no effect of CO_2 at the levels predicted for the end of this century; no evidence of CO_2 fertilisation or adverse effects of ocean acidification.

The BPS meeting was great, a really good way to start the year. The global processes morning was particularly useful and inspiring for me. Thank very much to the BPS for funding me to attend, for the great line up of speakers and for the very enjoyable evening entertainment.

A Special Commendation was awarded by the Poster Adjudication Committee to

Charlotte Worthy for her poster

Charlotte Worthy
Marine Biological Association, Plymouth
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It was during my second year studying Biological Sciences at the University of Plymouth that I decided as a mature student there was a need to be able to incorporate authentic laboratory research experience into my undergraduate dissertation. In January 2007 I began to prepare myself for the assignment and spoke to Dr Roy Moate at the University of Plymouth's Electron Microscope Centre (EMC). I explained how I wanted to use the dissertation as an opportunity to obtain a wide range of skills, to increase my versatility and further my knowledge base in a marine field of research utilising the EMC. Here Dr Moate directed me to the Marine Biological Association (MBA) and particularly to Dr Declan Schroeder, a Research Fellow at the MBA, who had two projects available studying phytoplankton utilising Transmission Electron Microscopy (TEM) analysis.

The project involved the viral-host relationship of the coccolithovirus, EhV-86, and its host alga, *Emiliania huxleyi*. This species of coccolithophore is thought to be a quite successful species that plays an important role in environmental processes such as nutrient cycling and energy transfer, which enable it to exert a strong influence on ocean alkalinity and global carbon budgets. The causes of *E. huxleyi* mortality have important ecological and biogeochemical consequences. In recent years viruses have been identified as the main agent for *E. huxleyi* bloom demise. Laboratory work began in the summer of 2007 and was only timetabled to last between 3-14 days before continuing the practical element at the EMC for a further 14 days. In total the project took three months at the Marine Biological Association to grow and prepare E. huxleyi in varying nutrient conditions with EhV-86 for TEM analysis and a further 14 days of image analysis on the Joel 1200 EX II TEM at the EMC.

The focus of the dissertation was to characterise the first stages of viral adsorption of EhV-86 onto its host alga and the subsequent host physiological responses. The laboratory work allowed me to make use of skills learnt during my university practicals as well as to expand upon these with training of new techniques and procedures in an active research laboratory environment. As there wasn't a validated protocol for the process of preparing samples grown on nutrient-rich agarose for TEM analysis there was an opportunity to trial different extraction, fixing and embedding methods in order to optimise the technique for reproducible and hopefully authentic micrographs. This took a little time and it was something of an achievement when it was finally developed and refined.

Dr Schroeder had asked me to attend the 56th Annual Meeting of the British Phycological Society in October 2007 and by that December there were hundreds of images of *E. huxleyi* clearly demonstrating a stress response to viral infection, but up to this point I had so far been unsuccessful in characterising how viral adsorption occurred. My poster was prepared with the data available at the time and it was a disappointment not to have achieved my full dissertation goal. The MBA kindly paid my attendance fee and thanks to funding from the British Phycological Society I was given the fantastic opportunity to attend my first scientific conference.

The Winter Meeting was spread over 3 intense days and integrated 52 lectures and 27 scientific posters given by guest speakers including researchers and experts in phycology, and PhD and undergraduate students from a wide range of international institutions. There was particular emphasis this year on understanding, characterising and controlling cyanobacteria in addition to many lectures concentrating on changing environmental parameters and the effects on phytoplankton function and diversity. Professor Oscar Schofield gave an attention-grabbing lecture titled 'Observing the Global Oceans Dynamics in Phytoplankton' that was both fascinating and illustrative of how each highly focused field of research feeds back into the 'bigger picture' of phytoplankton dynamics and can facilitate exciting future projects.

Overall the conference was exhilarating, exhausting, and tremendously stimulating. Since attending the Winter Meeting I have been able to image micrographs of the virus EhV-86 and its host alga *Emiliania huxleyi*. It is very likely that the impetus to continue imaging came from the enthusiasm captured from the meeting. Marine systems have always captured my imagination and through my undergraduate dissertation I have gained an insight into a fascinating part of the marine environment and have found direction for future academic study once my first degree has been completed.

I would like to thank the British Phycological Society for the commendation and I am also very grateful to the BPS for the financial support that enabled me to attend this meeting. For the dissertation I would like to thank Dr Declan Schroeder who was an encouraging and supportive supervisor, Matt Hall for his technical and supportive efforts and also to Dr Keith Ryan (retired, formerly of the MBA) who guided and sectioned ultra-thin micrographs for the TEM analysis on the very expensive diamond knives possessed by the MBA. From the University of Plymouth EMC, I give my thanks to Dr Roy Moate for the time and patience he has given to this over keen undergraduate student.

Reviews of the 56th Annual Meeting of the BPS, Bristol 3-5th January 2008

Jane Pottas, Centre for Environmental and Marine Sciences, University of Hull
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The 56th Annual Winter Meeting of the British Phycological Society was held in January at the University of Bristol - thanks go to Professor Paul Hayes and the local organising committee for all their hard work. This year the meeting ran over 2 ½ days and attracted nearly 100 delegates from as far afield as Krakow, Korea, Texas, Spain, Germany, France and Sweden as well as the UK. The BPS was able to offer financial assistance to 11 students to enable them to attend the meeting. There were 27 posters and 50 oral presentations including 7 given by students in the Manton Prize session.

This year the emphasis was on the microalgae - diatoms, cyanobacteria, dinoflagellates. Presentations about seaweeds, which were much appreciated, were few and far between. As always the content of the meeting is determined by the subjects offered by the participants and interesting though it may be scrubbing stones with toothbrushes more talks on macro scale organisms would result in a more balanced programme. So, macro people take note for next year!

The Founder's Lecture was delivered by Professor Antonio Quesada who introduced his lecture with pictures of the Mini Cooper - the original and the updated version. His impression of a second hand car salesman ended there and he went on to describe the biology and ecology of cyanobacteria - an ancient group of organisms which is being investigated using modern molecular tools to identify genetic variation and he concluded by suggesting that low levels of adaptation may explain their evolutionary success and worldwide distribution.

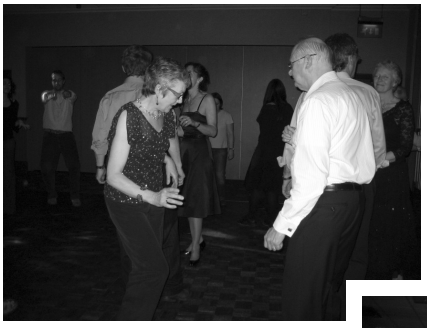
Two Special Sessions, Algae and Global Processes chaired by Gill Mallin and Debora Iglesias-Rodriguez, and The Use of Novel Phycological Tools chaired by Jan Krokowski highlighted the significance of phycology in environmental monitoring and the importance of phytoplankton as indicators of climate change and their potential in mitigating its effects. These important messages surely deserve to be brought into the public domain and how this is to be achieved is perhaps something which could be considered at future meetings.

The Manton Prize as usual attracted an interesting and wide ranging selection of presentations which must have given the judging panel a difficult task in choosing a winner. The prize was awarded to Li Deng for her talk on "Cyanophage active against bloom-forming freshwater cyanobacteria." The Poster Prize winner was Katherine Crawfurd for "Effects of increased CO_2 on growth rate, on gene expression in *Thalassiosira pseudonana* and on calcification in *Emiliania huxleyi*." The judges of the poster prize also recommended that a special commendation be made to Charlotte Worthy for her eye-catching poster.

Taylor and Francis sponsored the Poster session and reception and manned an information stand with journals and books including the new book Green Seaweeds of Britain and Ireland edited by Juliet Brodie, Chris Maggs and David John. Not only was the book available to buy (great value at £25) but all the editors and two of the authors, Martin Wilkinson and Barbara Rinkel were on hand to sign copies! Have you bought yours yet?

The venue for the meeting provided an ideal and welcome opportunity to mingle between sessions in the Chemistry foyer and catch up with old friends and colleagues over coffee and the tasty buffet lunches. The buffet and quiz night proved popular and the questions by quizmaster Geoff Codd exposed our ignorance of world geography and political leaders although I think we all managed to name 12 books by Roald Dahl. The Conference Dinner at Jury's Hotel was followed by the auction and the persuasive Elliot Shubert, who in his role as auctioneer, raised £240 which will help to support students attending future BPS courses and meetings. Graham Underwood was denied the opportunity to display his dancing skills at the BPS ceilidh which this year was replaced by a disco. However, there was no shortage of willing participants and accomplished dancers; Eileen Cox and Elliot Shubert were almost eclipsed by Jackie Parry and Babs Rinkel strutting their stuff on the dance floor. This year they were joined by another lively exhibitionist, Tony Walsby, who ably demonstrated that his area of expertise extends beyond the measurement of turgor pressure in gas vesicles of *Microcystis* sp.

So another successful meeting drew to a close. Next year's winter meeting will be held in Greenwich and I look forward to another stimulating and thought provoking few days - macro people permitting!



Peter Hunter, University of Stirling
p.d.hunter@stir.ac.uk

I am a post-doctoral researcher in the School of Biological and Environmental Science at the University of Stirling. My main research interests lie in the use of remote sensing in ecology and, in particular, in the study of aquatic and wetland ecosystems, although more recently I have become involved in work on the molecular ecology of cyanobacteria and the socio-economics effects of algal blooms in inland waters.

The 56th Annual Meeting of the British Phycological Society was hosted by the University of Bristol and was attended by over 90 delegates from the UK and overseas. It was my first experience of the BPS Annual Meeting and, as such, it was with much regret that I was unable to attend the first day of the meeting which saw talks on a variety of topics including cyanobacteria toxicology, self-cleaning jetties and seaweed bioassays. The second day of the meeting began with a fascinating and thought-provoking session on "Algae and Global Processes" organised by Gill Malin and Débora Iglesias-Rodríguez. The opening talk from Philip Reid (University of Plymouth) explored how recent climate-driven changes in the biodiversity of phytoplankton in the North Atlantic have affected the efficiency of the Biological Pump for CO_2. Indeed, global climate change was a recurrent theme in several of the talks that were to follow throughout the morning. In a talk that touched closely upon my own research interests, Oscar Schofield from Rutgers University spoke about the value of integrating data from earth-observing satellites, autonomous vehicles and ground-based measurements for improving our understanding the effects of environmental change at local, regional and global scales. The afternoon special session for the Manton Prize saw presentations from the student members of the BPS. Once again, it was impossible not to be impressed by the quality of the science presented and it was encouraging to see so many postgraduates using the BPS meeting as forum for disseminating their research.

The final day of the meeting began with a special session on organised and chaired by Jan Krokowski on the "Use of Novel Phycological Tools". The opening talk by Martyn Kelly (Bowburn Consultancy) discussed the use of diatom metrics in the Water Framework Directive (WFD) and, in particular, how UK methods have compared with those of other EU Member States in the recent intercalibration exercise. The two subsequent talks also discussed tools developed under the pretext of the WFD. Laurence Carvalho (CEH) gave a presentation on uncertainties in the assessment of ecological status under the WFD in which he imaginatively used the Eurovision Song Contest as a means of highlighting some of the challenges we currently face with the implementation of this legislation. The following talk by Christine Maggs (Queen's University Belfast) looked at the use of molecular tools for aiding the identification of cryptogenic alien species in those problematic groups where conventional morphological approaches are alone seldom sufficient. The final talk of the session saw a shift in emphasis from the molecular to macro scale with my own presentation on the use of remote sensing technologies for monitoring potentially-toxic cyanobacterial blooms in inland waters.

The meeting concluded in the afternoon with two parallel sessions which saw the presentation of papers on topics ranging from algal photosynthesis in the cryoconite holes of glaciers, to the production and release of DMSP and DMS in coccolithophores. Overall, and despite having to miss the conference dinner on Sunday night (always the highlight of any event), I left having been very impressed by my first BPS Annual Meeting. Whilst I was not always overly familiar with the science being presented, the quality spoke for itself, and I admit to being pleasantly surprised by the breadth of research being untaken by the phycological community both in the UK and overseas. The special sessions in particular provided an excellent forum for the discussion of several topical issues and I greatly appreciated the opportunity to present some of my own research in the second of these sessions. I would therefore like to extend my thanks to all the organisers for making the Bristol meeting such a resounding success.

Kev Kennington, Scottish Environment Protection Agency, Edinburgh
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The BPS annual winter meeting held two special sessions, the first session entitled algal and global processes and the second was on novel phycological tools.

The first of these special sessions was kicked off with an excellent talk from Dr Chris Reid (Plymouth University) former director of the Sir Alistar Hardy Foundation for Ocean Science (SAHFOS). Chris's presentation outlined the oceans response to global climate change and was crammed full of information on how climate change will impinge upon ocean circulation patterns and plankton biogeography. Following on from Dr Reid's talk Dr Deborah Iglesias-Rodriguez (University of Southampton) gave a stimulating presentation on the effects of ocean acidification on marine algae calcification. Further presentations on algal genomics (Dave Scanlan, Warwick University), global ocean phytoplankton dynamics (Oscar Schofield, Rutgers University) and genetically programmed cell death in marine phytoplankton (Kay Bidle, Rutgers University) followed before Gill Malin (UEA) rounded off the session with a fascinating insight into marine phytoplankton's role in the global sulfur cycle and cloud formation.

The second special session was a look into novel plankton tools developed for the EU Water Framework Directive (WFD). The session started with Martyn Kelly (Bowburn Consultancy) who outlined tools developed for the assessment of river water quality using diatoms. This was followed by Laurence Carvalho (Centre for Ecology & Hydrology) who followed the theme with a look into how freshwater diatoms are used to classify the water quality of lacustrine systems across Europe. Laurence gave an insight into the statistics involved in such analysis with humorous comparisons with the voting results in the European song contest. It then came to my presentation (my first for the BPS, but hopefully not my last!) which outlined the phytoplankton tools developed for coastal and transitional waters by the UK's marine plants task team. Two further talks in the session were given by Christine Maggs (Queen's University, Belfast) and Peter Hunter (Stirling University) on the use of molecular tools in environmental monitoring and the use of remote sensing in monitoring cyanobacterial blooms in lakes, respectively.

These special themed sessions were in my opinion a great success, for me personally it was interesting to see how the freshwater community have progressed with tool development for WFD purposes and how different their approach was from those adopted for the marine realm. I certainly learnt a lot and came away with lots of ideas for future work. This was my first BPS meeting and I was impressed by the high standards of presentation especially from the many student presentations and posters which I thought were first class. It was also good to catch-up with old friends and colleagues as well as meeting new ones. The meeting ran very smoothly which is thanks to Prof Paul Hayes and his organisational team at Bristol University, a big THANKYOU from all who attended I am sure.

Special Session - Algae and Global Processes

Gill Malin, Laboratory for Global Marine and Atmospheric Chemistry, School of Environmental Sciences, University of East Anglia

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The path to this Special Session began in January 2007 with a suggestion from Paul Hayes, the local organiser for the 2008 annual BPS meeting. My research and that of co-Organiser Débora Iglesias-Rodríguez (University of Southampton) relates to how algae influence the Earth System, so it would have been hard to say no to Paul's request to organise a session around this topic. It was easy to assemble a long list of potential speakers and we were delighted that most of them were able to make time to come to Bristol for the meeting. We were keen to include a broad range of topics that would appeal across the BPS membership, but with fairly recent BPS key talks and sessions on freshwater topics we did stick with a marine theme.

Chris Reid (University of Plymouth) opened the session with a fascinating overview of the Continuous Plankton Recorder Survey of the Sir Alister Hardy Foundation for Ocean Science. Samples have been collected on transects of the North Atlantic and North Sea since 1931, and the unique dataset provides a window onto changes in plankton populations in the context of environmental change. For example diatoms, which generally sink faster than other types of phytoplankton taxa, have become less abundant in the North Atlantic and this will have reduced the efficiency of the biological pump that moves CO_2 from the atmosphere to the deep ocean carbon reservoir. We know all too well that with our dependence on fossil fuels CO_2 levels in the atmosphere will continue to increase. As a consequence the oceans are becoming more acidic and various studies have suggested that this could decrease the abundance of coccolithophores. These are bloom-forming phytoplankton that make elaborate calcium carbonate scales or liths and they are important for the global carbon cycle because they accumulate in deep sea sediments. Débora Iglesias-Rodríguez and colleagues have been growing coccolithophore cultures under different CO_2 partial pressures and looking for affects on calcification and photosynthesis. Contrary to other studies on this algal group, they have found that under more acidic conditions more carbon is incorporated into coccoliths.

Sadly, due to cancellation of a Paris to Bristol flight, Chris Bowler (Ecole Normale Supérieure, Paris, and Stazione Zoologica, Italy) didn't make it to the meeting so we didn't get to hear the talk he had planned on 'New insights from analyzing diatom genomes'. There is no doubt that the genomics approach has opened the route to advancing our understanding of algae and will do so more and more in the future. We hope that Chris will come to a future BPS meeting to tell us about his research.

Dave Scanlan's talk (University of Warwick) focussed on marine cyanobacteria of the genera *Synechococcus* and *Prochlorococcus* that are the most abundant members of the picophytoplankton size category in the sea. The availability of several complete and draft genome sequences has allowed for rapid progress in understanding the ecology of algae of this group. Core genes and genes that appear more dispensable, and gene gain and loss processes, allow cyanobacteria to fully exploit the numerous niches available in the large vertical gradients of light and temperature typical of marine systems.

After the coffee break, Oscar Scholfield (Rutgers University, U.S.A.) began by emphasising how chronically under-sampled the oceans are relative to the dynamic nature of surface ocean phytoplankton populations clearly seen in satellite images. A new 'dawn in the phycological century' is advancing with 'adaptive' sampling, and the use of miniature sensors and instruments, moorings and autonomous underwater vehicles. The vast arrays of data that can be collected will be important in feeding local and global scale ecosystem models.

Kay Bidle (Rutgers University, U.S.A.) followed with his presentation on grazer-independent mortality in marine phytoplankton. Until recently this process was essentially ignored, but now we know that unicellular phytoplankton can be infected by viruses or undergo programmed cell death when nutrients are limiting and this will impact on ecosystem dynamics and global biogeochemical cycles. Kay's research group have shown that some of the enzymes involved are very similar to those occurring in animals and humans.

The final talk was my own and I felt some trepidation following these excellent speakers! The connection between algae and clouds is via the volatile sulphur trace gas dimethyl sulphide - a key compound in the global sulphur cycle. The precursor to DMS is made by some types of algae and DMS oxidation in the atmosphere can lead to cloud condensation nuclei and the formation of clouds that cool the Earth. I covered the evidence for the microalgae-related processes that lead to DMS emissions from seawater and the gaps in knowledge that we still need to fill.

Overall the session was really well received and stimulated lots of discussion during the breaks and evening events. I would like to extend my thanks to all of the speakers for their great talks - we hope to see you, and maybe also your students and colleagues at future BPS meetings.

Helen Churchill, Centre for Environmental and Marine Sciences, University of Hull

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My supervisor originally described the BPS winter meeting to me as a belated New Year party. I never have been sure if that comment was made in order to encourage me to go, or to make the idea of meeting all the famous phycologists whose papers I had been reading for years seem slightly less intimidating. That was in 2007 and, although I wouldn't quite describe the Meeting as a belated New Year party, it was definitely a worthwhile and enjoyable experience. Therefore, when I was offered the opportunity to attend this year's meeting in Bristol, I jumped at the chance.

I was, admittedly, slightly disappointed when I initially looked at the programme. The predominance of papers about microalgae and cyanobacteria in the sessions was somewhat daunting when, after all, I work on general intertidal ecology with my experience of algae generally limited to macroalgae. Undeterred however, I trotted down from Scarborough to Bristol.

Attending the conference was, once again, a really valuable experience. Mixed in with the microalgae and cyanobacteria papers, (which I must admit I found far more understandable and interesting than I had previously imagined), was a good smattering of more applied papers. I found the special session 'Use of Novel Phycological Tools' especially interesting.

Although the presentations were all of interest, by far the most valuable aspect of attending the BPS winter meeting was the opportunity to network with both experienced phycologists and fellow postgraduates. This provides an ideal opportunity to share ideas, pick other people's brains, and get a fresh perspective of where your own research is going in relation to what other people are doing. Having said that, the quiz and final conference dinner with disco provided a more relaxed end to each day and an opportunity to meet people socially. Maybe that original description of a belated New Year party wasn't so inaccurate after all.

Annual Report for the year ended 30 September 2007

The British Phycological Society

Registered Charity No. 246707

The Society is an unincorporated association governed by its constitution and administered by its Council (trustees). The addresses of the current office bearers are set out in the *European Journal of Phycology*.

Membership of the Council of the Society:

Executive Members

President:	Professor G.A. Codd	Treasurer:	Dr M.L. Tobin
Vice President:	Dr J. Brodie	Eds (*Eur. J. Phyc.*):	Dr E.J. Cox
Overseas Vice President:	Professor A. Quesada de Corral		Dr J. Day
Immediate Past President:	Professor M.D. Guiry	Ed. (*The Phycologist*):	Dr J. Krokowski
Secretary:	Dr J.D. Parry	Webmaster:	Professor M.D. Guiry
Membership Sec:	Dr S. Marsham		

Ordinary Members

Dr D.M. John	Dr M. Clokie	Dr L. King	Professor D. Mann
Professor M. Wilkinson	Dr G. Malin	Dr J. Brodie	Dr T. Proeschold
Professor G. Underwood	Professor J. Anderson	Mr S. Fielding	Dr B.S.C. Leadbeater

Principal bankers:	Bank of Scotland, 39 Albyn Place, Aberdeen
Solicitors:	Wolferstans, 60/64 North Hill, Plymouth
Independent Examiner:	Flannigan, Edmonds and Bannon, 2 Donegal Square East, Belfast

This is the fourth Annual Report presented by the current Treasurer. It is made in this form to meet the requirements of the Statements of Recommended Practice (SORP), issued by the Charity Commission and serves as an annual record of the resources entrusted to the Society and the activities it has undertaken.

The Society has continued to give financial support to activities that promote phycological research, disseminate phycological knowledge and assist young phycologists to present their findings at scientific meetings. The 2007 annual winter meeting and AGM were hosted by Queen's University Belfast and thanks go to Matt Dring and Chris Maggs for organising a highly successful meeting. The range and standard of presentations was excellent and congratulations go to Darryl Holland whose contributions were of such high quality that he received both the 2007 Manton Prize and the Poster Prize. Ten students received support to attend this meeting from the Scientific Meetings Fund (SMF) (thirteen in 2006). The auction and quiz raised £155, with thanks going to the quiz organisers and Elliot Shubert for their enthusiasm. The meeting returned a surplus of £1760 and this money has been used to support the 2008 meeting.

The society supported three students to attend identification courses (Durham and Kindrogan) and two summer studentships were awarded in 2007.

During 2007 honoraria were awarded to the following council members: the Membership Secretary, Secretary and the Editor of The Phycologist each received £750, the Treasurer received £1000 and the Editors of the European Journal of Phycology received a total of £1500.

Members should note that the status of the bank account at the end of the financial year partly reflects the fact that money was transferred to the short term deposit account after the end of this financial year.

The Journal has again performed well financially and the balance to the Society from Volume 41 was £26,714.19 (£27230.42 for Volume 40) due to the current guaranteed annual income of at least £20,000 from the publishers, Taylor and Francis.

The Society's financial situation remains good. Membership payments have been monitored carefully and the new online payment system appears to be working well in most cases. A small number of 2007 subscriptions have been processed after the end of this financial year due to some technical problems with processing and late applications, these will appear in next year's report. The Scientific Meetings Fund was topped up to a total of £25000 to allow the Society to support students with travel awards, summer bursaries and field courses from the interest it receives.

Finally, I would like to thank all Council and Society members for their co-operation and support during this financial year.

The British Phycological Society

Registered Charity No. 246707

Statement of Financial Activities for the Year ended 30th September 2007

	Note	Unrestricted General	Designated S.M.F.	Restricted Manton	Total 2007	Total 2006
		£	£	£	£	£
Income and Expenditure						
Incoming Resources						
Subscriptions 2005						1,638.50
Subscriptions 2006		143.00			143.00	8,596.00
Subscriptions 2007		9,273.00			9,273.00	
Surplus from Journal		26,724.19			26,724.19	27,320.42
Auction proceeds		-	55.00		55.00	751.00
FW Atlas		597.87			597.87	-
Interest		2,836.93			2,836.93	3,406.45
Winter Meeting 2006 surplus					-	3,911.00
		1,975.00			1,975.00	
					-	85.00
Miscellaneous (cash return)			220.00		220.00	
Total Incoming Resources		**41,549.99**	**275.00**		**41,824.99**	**45,708.37**
Resources Expended						
Grants, studentships & awards	**2**	2,105.00	1,990.00	250.00	4,345.00	8,097.00
Publications expenditure	**3**	11,234.81			11,234.81	11,848.01
Meetings & Committee Expenses	**4**	8,392.31			8,392.31	5,562.72
Administration Costs	**5**	6,452.00			6,452.00	6,607.19
		28,184.12	**1,990.00**	**250.00**	**30,424.12**	**32,114.92**
Net Incoming (Outgoing) Resources for the Year		**13,365.87**	**-1,715.00**	**-250.00**	**11,400.87**	**13,593.45**
Fund at 1 October 2006		57,931.87	25,000.00	5,194.09	88,125.96	74,532.51
Transfer (General to SMF)		**-1,715.00**	1,715.00			-
Fund at 30 September 2007		**69,582.74**	**25,000.00**	**4,944.09**	**99,526.83**	**88,125.96**

Balance Sheet as at 30 September 2007

		2007 £	2006 £
Current Assets			
Debtors	**7**	4,330.97	4,725.00
Prepayments		-	4,161.00
Short term deposits		82,043.30	57,149.21
Cash at bank		24,915.47	35,222.64
		111,289.74	101,257.85
Liabilities: amounts falling due within one year	**8**	11,762.91	13,131.89
Net Assets		**99,526.83**	**88,125.96**
Funds	**9**		
Unrestricted		69,582.74	57,931.87
Restricted		4,944.09	5,194.09
Designated		25,000.00	25,000.00
		99,526.83	**88,125.96**

Signed on behalf of the British Phycological Society
Dr Michelle Tobin
Treasurer

The British Phycological Society
Notes to the Account for the Year ended 30 September 2007

1 Accounting Policies

The accounts have been prepared in accordance with applicable Accounting Standards and the SORP - Accounting and Reporting by Charities issued in March 2005. A summary of the more important policies, which have been applied consistently, is set out below:

Basis of Accounting
The Accounts are prepared in accordance with the historic cost basis of accounting.

Subscriptions
Subscriptions include amounts received from members during the year. No amount is included in respect of subscriptions outstanding at the year end. Subscriptions received in advance for future years are included in deferred income.

Funds
Restricted funds comprise unexpended balances of donations and interest to be applied for specific purposes. At 30 September 2007, the Society's only restricted fund was the Manton Fund. Designated funds are those set aside out of unrestricted funds for specific purposes. At 30 September 2007, the designated fund of the Society was the Scientific Meetings Fund ("S.M.F.").

Cash Flow Statement
The Society has taken advantage of the exemptions provided in FRS 1 "Cash Flow Statements" for small entities and has not prepared a cash flow statement.

	Unrestricted General £	Designated S.M.F. £	Restricted Manton £	Total 2007 £	Total 2006 £
2 Grants, Studentships & Awards					
Travel awards for Winter Meeting		1,990.00			2,825.00
Awards for courses, travel, Summer Bursary	1,955.00				4,052.00
Manton Prize			250.00	250.00	250.00
Poster prize at Winter Meeting	150.00			150.00	150.00
Special Project Grants				-	1,000.00
Old cheque written off					-180.00
	2,105.00	**1,990.00**	**250.00**	**4,345.00**	**8,097.00**
3 Publication expenditure					
Journal	6,905.25			6,905.25	6,102.00
Hon. Editor's Honorarium (2007)	1,500.00			1,500.00	-
Editor's Honorarium (2006)	750.00			750.00	750.00
E.J.P. Management Committee	179.18			179.18	219.27
The Phycologist	1,900.38			1,900.38	4,660.74
Miscellaneous (Brochures)				-	734.00
Old cheques written off				-	-618.00
	11,234.81	**-**	**-**	**11,234.81**	**11,848.01**
Meetings & Committee Expenses					
4 Council Meeting 2005					
Council Meeting 2006	-			-	813.50
Council Meeting 2007	195.25			195.25	2,558.85
Biodiversity Committee Expenses	3,116.08			3,116.08	**-**
Winter Meeting 2006	349.06			349.06	-
Winter Meeting 2007	2,003.00			2,003.00	-
Old cheque written off	-100.67			-100.67	
	5,562.72	**-**	**-**	**5,562.72**	**3,372.35**
5 Administration Costs					
Public liability insurance	367.50			367.50	367.50
Independent Examiner's Fee	1,019.38			1,019.38	921.25
Credit Card Charges	614.39			614.39	580.65
Bank Charges	75.00			75.00	82.79
Executive Honoraria (2006)				-	3,250.00
Executive Honoraria (2007)	3,250.00			3,250.00	
Web page maintenance				-	1,065.20
Federation of Bioscience Federation Subscription	552.00			552.00	-
Attendance at Biosicence Federation	79.60			79.60	339.80

The British Phycological Society
Notes to the Account for the Year ended 30 September 2007 (cont.)

	Unrestricted General	Designated S.M.F.	Restricted Manton	Total 2007	Total 2006
	£	£	£	£	£
5 Administration Costs (cont.)					
Miscellaneous (membership refund)	35.00			35.00	
General Expenses	387.91			387.91	
FEMS subscription	71.22			71.22	
	6,452.00	**-**	**-**	**6,452.00**	**6,607.19**

6 Reimbursment of Council members' expenses

Seventeen (2006: Fourteen) Council members received £2,716.32 (2006: £3,417.18) as reimbursment of travel and overnight accommodation or expenditures incurred during the year on Society business. No monies were paid to any Council member in respect of subsistence.

7 Debtors	2007	2006
	£	£
Interest receivable	1,959.97	4,725.00
Membership receivable	2,371.00	
	4,330.97	**4,725.00**

8 Liabilities: Amounts falling due within one year		
Accruals	1,262.91	2,631.89
Provision for the Journal and The Phycologist	10,500.00	10,500.00
	11,762.91	**13,131.89**

9 Analysis of Net Assets between Funds

	Unrestricted Funds	Restricted Funds	Designated Funds	Total Funds
	£	£	£	£
Fund balances as at 30 September 2007 are represented by				
Current assets	81,345.65	4,944.09	25,000.00	111,289.74
Current liabilities	-11,762.91			-11,762.91
Total Net Assets	**69,582.74**	**4,944.09**	**25,000.00**	**99,526.83**

Report of the Independent examiner to the Members of the British Phycological Society

We report on the accounts of the Society for the year ended 30 September 2007, which are set out on pages 30 to 32.

Respective responsiblities of trustees and examiner:

The Council Members are responsible for the preparation of the accounts. The Council Members consider that an audit is not required for this year (under section 43 (2) of the Charities Act 1993 (the 1993 Act)) and that an independent examination is needed.

It is our responsibiliy to:

* examine the accounts (under section 43 (3) (a) of the 1993 Act):
* to follow the procedures laid down in the General Directions given by the Charity Commissioners (under section 43 (7) (b) of the 1993 Act); and
* to state whether particular matters have come to our attention.

Basis of independent examiner's report:

Our examination was carried out in accordance with the General Directions given by the Charity Commissioners. An examination includes a review of the accounting records kept by the charity and a comparison of the accounts presented with those records. It also includes consideration of any unsual items or disclosures in the accounts, and seeking explanations from the Council Members concerning any such matters. The procedures undertaken do not provide all the evidence that would be required in an audit, and consequently we do not express an audit opinion on the view given by the accounts.

Independent examiner's statement:

In connection with our examination, no matter has come to our attention which gives us reasonable cause to believe that in any material respect the requirement:

* to keep accounting records in accordance with section 41 of the 1993 Act and;
* to prepare accounts which accord with the accounting records and comply with the accounting requirements of the 1993 Act; have not been met.

Flannigan Edmonds Bannon;
Chartered Accountants and Registered Auditors
Belfast, Northern Ireland
21 December 2007

Biodiversity and Conservation Committee update

Juliet Brodie, Natural History Museum, London
j.brodie@nhm.ac.uk

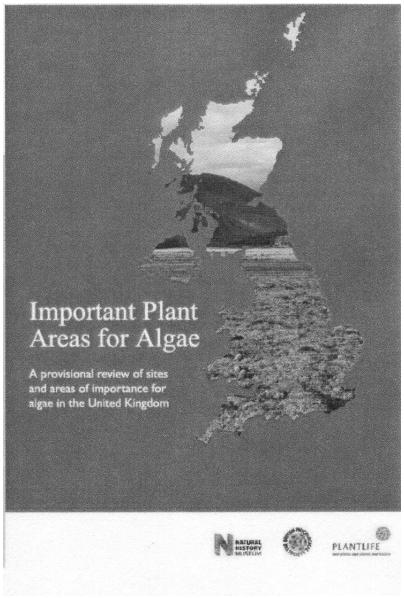
Following on from the report of the Biodiversity and Conservation Committee in last edition of *The Phycologist* (October 2007, 73:11), here is a brief update on recent outputs and notice of some future projects. In addition to the publication of Further publicity for the algae - the Important Plant Area report online (see article in this edition), a major achievement has been the production of Green Seaweeds of Britain and Ireland (Eds: Brodie, J., Maggs, C.A. & John, D.M.) in December 2007. The book, from its inception in 2004 to publication three years later, has been an excellent example of bringing together an international team of specialists who did a great job in a short period of time. So what is next? David John and Brian Whitton are about to embarked on a new edition of The Freshwater Flora of the British Isles. We are also planning to revise the red seaweed books, particularly given that the first one in Seaweeds of the British Isles series was published over 30 years ago and the changes that have taken place in the taxonomy of these organisms. Another idea that we are exploring is a project to investigate temporal change in seaweeds by using public knowledge and records; e.g. identifying seaweed cover on shores from old photographs and holiday snaps, and then comparing them with today's coverage. We would very much welcome any thoughts that you have on this subject. You can send these to Juliet Brodie (j.brodie@nhm.ac.uk).

Further publicity for the algae - the Important Plant Area report online

Juliet Brodie and David John, Natural History Museum, London
j.brodie@nhm.ac.uk and d.john@nhm.ac.uk

The launch of the first network of Important Plant Areas (IPAs) for the UK, which included seaweed and freshwater algal sites, was reported in the autumn 2007 edition of *The Phycologist* (73: 20), along with some of the background to the IPA project. The report in which the process of the selection of IPAs for algae was made (Brodie et al. 2007 - details below) went live on the Plantlife International website on 29 January 2008. At the same time, Plantlife International sent out a press release entitled 'Celebrate our seaweeds and their freshwater relatives: top UK spots pinpointed for the first time'. This provided much additional background to the report in a form suitable for the media and announced its availability as a download on its website. As a result of the press release, algae received some very welcome attention in the media including articles by Simon Barnes in *The Times* and Paul Eccleston in the *Telegraph*, a report in *The Western Morning News* and a radio interview (for Radio 4 Wales) with one of the report's authors (Ian Tittley). The information was also reported on several websites, including the Natural History Museum, BBCNews and FISHupdate.com. The press office of Robert Key, MP for Salisbury, also requested a copy of the report.

Dr Deborah Long, Plantlife Scotland's Conservation Officer, is quoted as saying "This new report is a great tool. We now know where the really important sites are and why they are important. This is the sort of information that helps us identify appropriate site management and also to recognise when activities could be detrimental. The UK is hugely rich in algae, both the seaweeds around the coast and the algae in our freshwater pools and lochs, and we hope this report will make more people aware of this."



In addition to the authors of the report - Juliet Brodie, David John, Mary J. Holmes, Ian Tittley and David B. Williamson, other experts who contributed to this work were Christian Boedeker, Yvonne Chamberlain, Robert Fletcher, Linda Irvine, Frederik Leliaert, Christine A. Maggs, Fabio Rindi and Barbara Rinkel.

The full citation of the report is Brodie, J., John, D. M., Tittley, I., Holmes, M.J. and Williamson, D.B. (2007) Important Plant Areas for algae: a provisional review of sites and areas of importance for algae in the United Kingdom. Plantlife International, Salisbury, UK.

The report can be downloaded as a PDF from the Plantlife website: http://www.plantlife.org.uk/portal/plantlife-news-algaereport.htm. Further information is available on the NHM website: http://www.nhm.ac.uk/about-us/news/2008/january/news_13320.html

Freshwater algal training courses in Durham, England

Two freshwater algal training courses organised by Professors Brian Whitton and David John since 1992 at Durham will be running again this year. Others contributing to the courses are Dr Alan Donaldson (consultant), assists with both courses, and Dr Martyn Kelly (Bowburn Consultancy) and Dr Gordon Beakes (Newcastle University) who help with the main course.

The courses will be held at Hild-Bede College and the School of Education, University of Durham (buildings on adjacent sites). The College is on a hill overlooking the River Wear and has a fine view of the river and city; it also has an excellent reputation for food and drink. Course fees cover training, accommodation, meals, drinks and various handouts during the course. A manual is sent out one month before each course to provide the background needed to get the most out of the course. Hild-Bede College can provide accommodation for anyone wanting to stay extra nights at the beginning or end of the course (cost about £32 for bed and breakfast) - Durham is a major tourist city!

Introductory Course on Freshwater Algal Identification Sunday 29 June - Friday 4 July 2008

The course aims to train staff in water management organizations, researchers needing to learn more about algae and PhD students in the identification of the commoner and environmentally important microscopic and macroscopic freshwater algae. Some related topics are also introduced, including monitoring, nuisance algae, and implications of the European Water Framework Directive. The course is a mixture of lectures and practicals, together with an afternoon field trip. Members should arrive before 1700 on the Sunday, while the daily programme runs from 0900 to 2120. The course ends formally after lunch on Friday, though there is an optional trip to sites along the River Wear in the afternoon.

The inclusive cost is £850 (no VAT charge), but there is £100 discount for full-time students and also for participants from outside Europe.

Advanced Course on Blue-green and Green Algae Sunday 6 July - Thursday 10 July 2008

The course provides training on identification of blue-green algae (cyanobacteria) and green algae at a more advanced level than the Introductory Course. It is planned especially for those who have attended one of the introductory courses, but also welcomes others with considerable experience of field samples or who want to refresh their knowledge. The course is a mixture of lectures and practicals, together with a visit to field sites on Tuesday. Members should arrive before 1700 on the Sunday, while the daily programme runs from 0900 to 2120. The course ends formally after breakfast on Thursday.

The inclusive cost for all participants is £360 (no VAT charge).

Members attending the courses should bring boots for the field visit (especially important for the Advanced Course). UK members should also bring laboratory coats. Laboratory coats can be loaned to people coming from overseas. Everything else is provided, including access to The Freshwater Algal Flora of the British Isles and identification CD-ROMs.

Students who are members of the British Phycological Society may apply directly to it for some support, but any decision rests with the Society (details on the BPS website).

Anyone wanting further information is welcome to contact Prof. Brian Whitton:

b.a.whitton@durham.ac.uk
phone +44-191-3867504 or +44-191-3341347; fax +44-191-3860619

Participants from the Introductory Course, Durham 2007 (right).

Participants gaining sampling tips at the Introductory Algal Course, Durham 2007 (bottom).

Freshwater algae course 2008

Where and when?

Kindrogan Field Centre, Enochdhu, Blairgowrie, Perthshire, Scotland (near the tourist area of Pitlochry), **Friday, 30 May - Friday, 6 June, 2008**. This is the 13th year that the course has been offered, http://www.field-studies-council.org/kindrogan/

Immediately following the Freshwater Algae course, the **Algal Culture Collections** meeting will take place at the Dunstaffnage Marine Laboratory, Oban, Argyll / West Highlands, Scotland, 8-11 June, 2008. You might like to consider combining both the course and the meeting in your travel plans.

What is the course about?

The course takes full advantage of the excellent range of aquatic and terrestrial habitats in this beautiful area of Highland Perthshire to provide a sound introduction to the recognition, identification and ecology of freshwater algae. Emphasis will be placed on the use of the microscope and taxonomic keys (print and electronic) for the identification to generic and species level and their ecological importance. For those with some prior knowledge of the algae, we hope that the opportunity to study samples from a range of habitats will broaden their knowledge and/or allow them to focus on particular groups. Field trips, on foot or by vehicle, will be varied, but not strenuous and will be complemented by laboratory work, illustrated talks and class discussion.

The course focuses on how to get to grips with identification, and the broader aspects of algal morphology, structure, reproduction, and classification (morphological and molecular).

Who are the participants?

The course is open to individuals with different backgrounds ranging from beginners to those who would like to refresh their knowledge of particular groups of algae or experience collecting in a different region of the world.

What is the full cost of the course?

The course costs **£455** per person (approx **€ 665** or **$924**), which includes accommodation, all meals (please notify the Centre if you have any special dietary needs) and tuition. This is excellent value for money and costs significantly less than other freshwater algal courses on offer.

Who are the course tutors?

The course tutors, Dr Eileen Cox and Prof Elliot Shubert, have taught this course for the past twelve years and they have a wide-ranging expertise on freshwater algae. Eileen and Elliot conduct research at The Natural History Museum, London, specialising in diatoms and green algae respectively. Eileen has published a key to live diatoms and is Co-Editor-in-Chief of the *European Journal of Phycology*. Elliot has published a key to the non-motile coccoid and colonial green algae and is Editor-in-Chief of *Systematics and Biodiversity*.

Is there support for students?

Yes, support for a student stipend is available from:

The British Phycological Society, http://www.brphycsoc.org/funding.lasso. The deadlines for applications are: 30 September, 1 December, 1 March and 1 June. The sooner you apply, the better are your chances are of receiving a stipend.

Graduate students who are members of the Phycological Society of America are eligible for financial support to attend a phycology course at a field station from the Hannah T. Croasdale Fellowship, http://www.psaalgae.org/student/stugrants.html. The deadline for applications is 1 March 2008.

How do you get to Kindrogan?

Edinburgh and Glasgow have international airports. The airports have a coach connection to the main railway station in the respective cities. The nearest mainline railway station is Pitlochry, which is on the London Kings Cross-Edinburgh-Inverness route. Participants will be met at Pitlochry by Kindrogan staff.

Where can I find more information?

For detailed information about the Kindrogan Field Centre: http://www.field-studies-council.org/kindrogan/. A url for the booking form will be available by the end of October 2007.

A non-refundable deposit of £50 (approx € 73 or $102) is required (credit cards are accepted). If you have any other queries, please contact:

e.shubert@nhm.ac.uk. Prof Elliot Shubert, Department of Botany, The Natural History Museum, Cromwell Road, London SW7 5BD, United Kingdom. Tel 020 7942-5606 (UK), Tel +44 207 942-5606 (international); Fax 020 7942-5529 (UK), Fax +44 207 942-5529 (international).

57th Annual General Meeting

The next winter meeting of the BPS will be held in **London** at the **Natural History Museum**, from **5-8th January 2009**.
Local organisers: Elliot Shubert, Eileen Cox.
Details will be posted on the BPS web page later in the year.

Algal Culture Collections 2008
June 8-11, 2008 - Dunstaffnage Marine Laboratory, Oban, Scotland, UK

Outline programme

This conference, hosted by the Scottish Association for Marine Science (SAMS), will assemble representatives of the major algal/protistan culture collections in the world. The programme includes presentations and discussion on the following themes:

- The role of culture collections in the development of DNA barcodes
- Bioinformatics
- Current curatorial developments (in particular, cryopreservation)
- Taxonomy, biodiversity and biogeography
- Natural products and biodiversity

A one day excursion and conference dinner will also be arranged.

Venue

Dunstaffnage has been the home of the Culture Collection of Algae and Protozoa (CCAP) since 1986. With around 3,000 protistan strains and housed in a state-of-the-art facility, it is one of the premier such centres in the world. The conference site is located in one of the most scenic parts of Scotland, and June is the perfect travel season for this region. The surrounding marine environment has a rich biodiversity, and seaweeds have long been part of the culture and livelihood of the region. The clear waters of the West coast of Scotland are highly rated among scuba divers, and the Highland wilderness is very attractive for hiking. The region also boasts many famous whisky distilleries. Oban is an ideal base to explore the wider region with convenient ferry links to the Hebrides and frequent bus and train connections to Glasgow, Edinburgh and Perth.

Algal Culture Collections 2008 will be held back-to-back with the following, thematically related conference, at the same conference site:

***Ectocarpus* 2008 - June 4-8, 2008**
www.ccap.ac.uk/ectocarpus2008.htm

Key Dates

April 15th Submission deadline for contributed oral presentations
Early registration closes
May 31st Submission deadline for poster presentations
June 8th Meeting opens in Oban

Registration & Contact

£150 full delegate / £100 concession*

Package price when booked together with registration for ***Ectocarpus 2008***

£250 full delegate / £175 concession*

The registration fee includes:

- Full participation at the conference
- All travel costs associated with the algal field excursion / day trip
- Lunches at the conference site / packed lunch during field excursion / tea and coffee breaks
- Ice breaker / Opening reception
- Liability insurance for field excursion

Full details and registration / abstract forms are available on the conference website, as well as information on accommodation and how to get to the conference site:

www.ccap.ac.uk/algalculturecollections2008.htm

Or contact us at the address below:

Algal Culture Collections 2008
c/o Mrs Rachel Saxon
CCAP
Dunstaffnage Marine Laboratory
Oban, Argyll, PA37 1QA
Scotland, UK
Phone: +44 (0)1631 559268
Fax: +44 (0)1631 559001
Email: algalcc2008@sams.ac.uk

* concessions: student, retired scientist, non-employed scientist

Ectocarpus 2008

June 4-8, 2008 - Dunstaffnage Marine Laboratory, Oban, Scotland, UK

Outline programme

The filamentous brown alga *Ectocarpus* has recently become the first seaweed of which the entire genome has been fully sequenced. To mark this event and with the annotation well under way, we would like to invite you to Oban, one of the centres of European phycology with the Culture Collection of Algae and Protozoa (CCAP). The programme will focus on:

The *Ectocarpus* genome

- Biodiversity, biogeography and taxonomy
- Biochemistry
- Ecology
- Development and cell biology
-

A one day excursion and conference dinner will also be arranged.

Genome annotation consortium meeting

A two-day meeting before the official opening of the conference will assemble the members of the *Ectocarpus* genome annotation consortium (by invitation only). At this time, the manual / expert annotation of the *Ectocarpus* genome is expected to be at a fairly advanced stage, with a draft manuscript in preparation.

Venue

The Scottish Association for Marine Science (SAMS) is Scotland's premier marine research institution and among the oldest in Europe, it is also the home of the CCAP. CCAP has recently accessed 300 fully characterised *Ectocarpus* strains that have been the centrepiece of decades of research, making this prime resource available to the public domain. The conference site is located in one of the most scenic parts of Scotland, and June is the perfect travel season for this region. The surrounding marine environment has a rich biodiversity, and seaweeds have long been part of the culture and livelihood of the region. The clear waters of the West coast of Scotland are highly rated among scuba divers, and the Highland wilderness is very attractive for hiking. The region also boasts many famous whisky distilleries. Oban is an ideal base to explore the wider region with convenient ferry links to the Hebrides and frequent bus and train connections to Glasgow, Edinburgh and Perth.

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- Liability insurance for field excursion

Full details and registration / abstract forms are available on the conference website, as well as information on accommodation and how to get to the conference site:

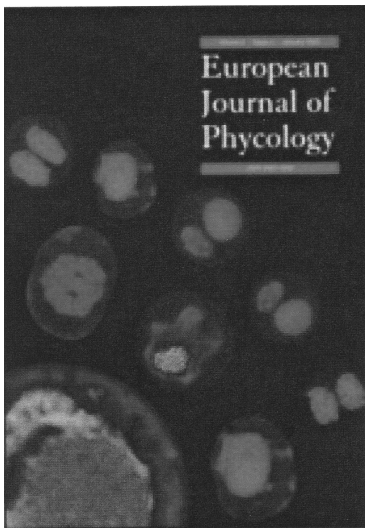
www.ccap.ac.uk/ectocarpus2008.htm

Or contact us at the address below:

***Ectocarpus* 2008**
c/o Mrs Rachel Saxon
CCAP
Dunstaffnage Marine Laboratory
Oban, Argyll, PA37 1QA, Scotland, UK
Phone: +44 (0)1631 559268/Fax: +44 (0)1631 559001
Email: ecto2008@sams.ac.uk

* concessions: student, retired scientist, non-employed scientist

Announcing the first Kathleen Drew-Baker and New Investigator Awards for the best papers published in the *European Journal of Phycology* in 2007



We are delighted to announce that Taylor & Francis, publishers of the *European Journal of Phycology*, have sponsored two prizes that have been be awarded to the author(s) of outstanding papers published in Volume 42 of the *E. J. Phycol.*

Prize I: The Kathleen Drew-Baker Award

This prize (£500.00) was awarded for the paper that was considered by the Editorial Board of the Journal to be the "best" paper published in the *European Journal of Phycology* in 2007.

It was awarded to Dr Alison Taylor, currently of the Department of Biology and Marine Biology, University of North Carolina -Wilmington, USA for her paper:

Taylor, A.R., Russell, M.A., Harper, G.M., Collins T.F.T. & Brownlee, C. (2007) Dynamics of formation and secretion of heterococcoliths by *Coccolithus pelagicus* ssp. *braarudii*. *European Journal of Phycology* 42(2): 125-136.

Prize II: New Investigator award

Prize II (£150.00, in vouchers to purchase Taylor & Francis publications) was awarded for the paper that the Editorial Board of the Journal considered to be the "best" paper, published in the journal in 2007 by a "new" investigator. A new investigator was defined as; the lead author who undertook the work on which the paper is based and did so whilst they were an undergraduate, post-graduate, or during their first post-doctoral appointment.

This prize has been awarded to Dr. Sebastian Meier, currently of the Institut für Geowissenschaften, Christian-Albrechts-Universität, Kiel for his paper:

Meier, K.J.S., Young, J.R., Kirsch, M. & Feist-Burkhardt, S. (2007) Evolution of different life-cycle strategies in oceanic calcareous dinoflagellates. *European Journal of Phycology* 42(1): 81-89.

The prizes commemorate the contributions to phycology made by Dr. Katherine M. Drew-Baker. She was the first president of the British Phycological Society, and was particularly distinguished for her elegant studies on the cytology and life histories of red algae. Her work on *Porphyra* spp. was to be of fundamental importance for developing Nori cultivation methods in Japan.

(Acknowledgement; ©1996 - 2007 Prof. M Guiry
http://www.seaweed.ie/aquaculture/PorphyraLifeHistory.lasso)

We would like to congratulate the winners for their excellent papers and to encourage all the readers of *The Phycologist* to submit high quality manuscripts to the journal.

E.J. Cox & J.G. Day

Dr Kathleen Drew-Baker of Manchester University with her son.

Alginates and medical practice

Dr Michael Carpenter, Aldershot, Hampshire

Definition

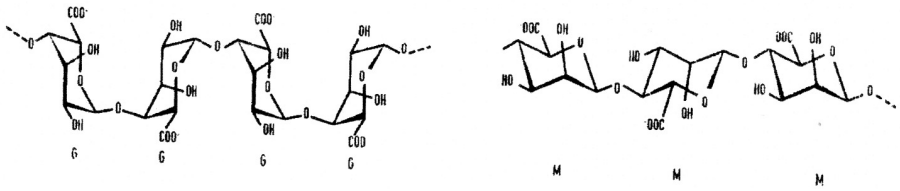
In general alginates represent an example of 'valorisation', a term(1) which has come to be used to describe the raising or enhancement of a natural product by the application of technical and scientific processes.

Alginates are found naturally in considerable quantity in brown seaweeds where the plant derives its supportive structure from alginic acid in much the same way as land plants use cellulose and provide resilience and protection in tidal and stressful current situations. From the aspect of stability, however, there is a paradox(2), to be discussed below, that the species yielding the best source of alginate may show a brittleness of its stipe (stem) though this feature may not be of disadvantage to its commercial collection.

Alginates are salts of alginic acid and are linear polysaccharides of blocks of guluronic(3) and mannuronic acids, known as G-blocks and M-blocks:

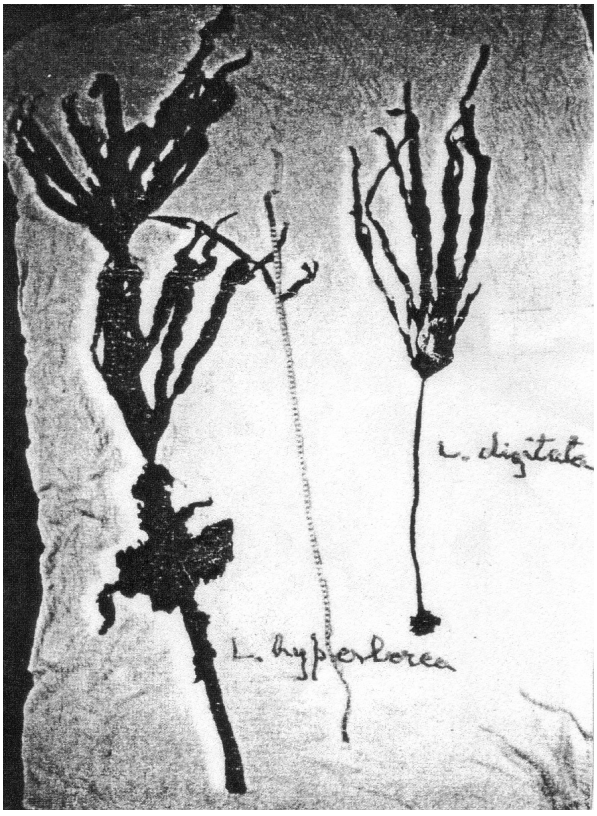
The main sources of alginic acid have been the brown algae *Laminaria hyperborea*, *Macrocystis* and *Ascophyllum*; and of these the best source, both in quantity and quality has been *L. hyperborea*. This, when mature, is a large plant with a yield of the highest ratio of guluronic (up to 65%) to mannuronic (35%) acids compared with that of other species. The ratio of the salts of these two acids is of importance from the chemical and pharmacological aspect to be discussed later.

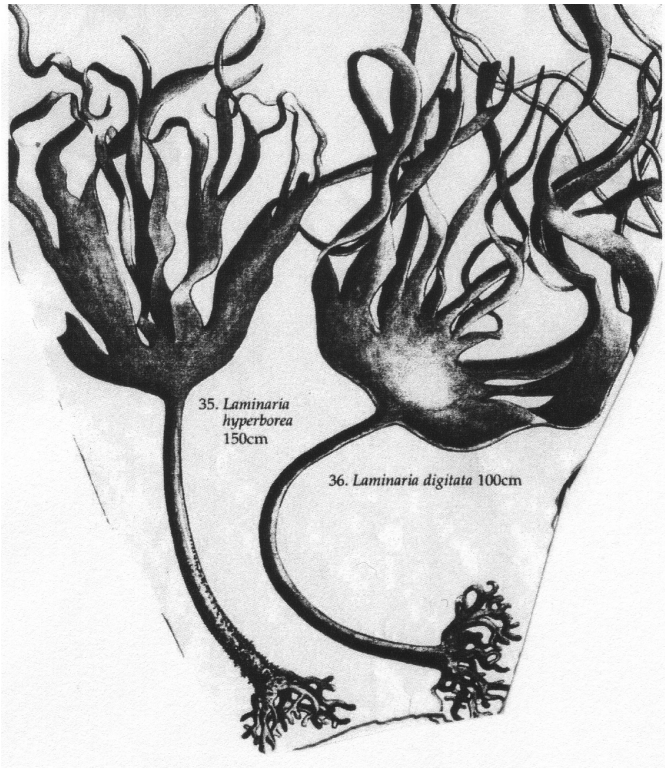
A closely related species, *L. digitata*, has a similar distribution to *L. hyperborea* but does not grow to as great a size and has a smoother more flexible stem (stipe) whereas *L. hyperborea*(4) has a thicker rougher (rugose) stipe which affords a plentiful attachment site to epiphytes, especially red algae which take advantage of the generally deeper habitat of the larger plant. But *L. hyperborea* suffers the penalty of this characteristic by the increased fragility



Poly-guluronate (G-block) Poly-mannuronate (M-block)

Alginates rich in poly-guluronate blocks form strong gels with calcium, whereas alginates rich in poly-mannuronate blocks form weaker gels





of its stipe and the leverage effect of strong currents which can break it from its holdfast base and thus often cause the major part of the plant to be washed ashore as drift. However this does not interfere with its commercial harvesting which is mainly done by dredging. The comparison and contrast of the two species are shown in the dried specimens (page 39).

Also in the illustration:

These are the principal constituent species of the so-called Kelp Forests found profusely a few metres below the sea surface.

Historical Origin

Alginates, as derived from the brown algae, were first prepared and patented by E.C.C. Stanford(5) in 1881, and it was gradually realised that adequate extraction could be achieved by the combination of the insoluble alginic acid with alkaline metals thus rendering it water-soluble. This proved to be the origin of its commercial usage after a less important water-soluble extraction by sodium bicarbonate had been found by Stanford and termed by him 'Algin'. This product however was a nitrogenous compound, whereas the preparations of soluble alginates combining the metallic elements with alginic acid contained virtually no nitrogen.

It is the combination of these features with the high proportion of guluronate (G-block) to mannuronate (M-block) referred to above which accounts for the particular value in the medical usage of alginates.

Properties and medical uses

Alginic acid has a particular affinity to metallic cations, especially those of bivalency of which Calcium has proved to be of especial usage medically. The other main property is that this combination has a strong tendency to gel formation when in aqueous solution.

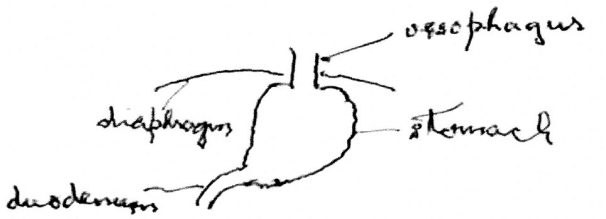
External Application

Calcium alginate is processed to form a woven type of dressing 6) which is applied directly to exuding wounds such as abrasions, weeping areas, ulcerating surfaces or deep cavities, abscesses, pressure sores etc. The dressing forms a gel which is ion-active, Calcium ions from the fibre undergoing an exchange with Sodium from the exudates. The gel thus formed has a high capacity for absorption of the exudates and is haemostatic so that the dressing is comfortable for the patient, needs less frequent changing than does a more conventional type of dressing with a result that the floor of the surface has less disturbance of the granulation tissue of repair and thus a more rapid healing.

Case Example: A 61 year old woman suffered burns affecting about 70% of the anterior surfaces of both lower legs when her dress caught fire from an exploding after-shave canister which had been left in rubbish of a bonfire. Within four days the damaged areas showed weeping surfaces which were treated with a calcium alginate fibre dressing ('Kaltostat') which was able to be renewed, after cleansing with a sterile normal saline solution every few days. This resulted in steady and complete healing by two months from the time of injury. It is to be noted that this treatment was carried out by the General Practitioner at the latter's surgery, and without the necessity of hospital, or burns unit's intervention and without the occurrence of any infection at the site of the burns. Also there were no complications such as the need for skin grafting or post-surgical scarring which one might otherwise have envisaged to have been required.

Gastro-oesophageal Reflux Disease ('GORD')

Alginates in combination with antacids have a considerable value in the treatment of this condition, a very common cause of dyspepsia with symptoms such as heartburn, sour waterbrash, belching and sometimes nausea, all of which are aggravated by the supine position and bending forward allowing the trunk to flex at the hips rather than bending at both knees and hips with maintenance of an erect posture of the trunk. In this position the stomach and its junction with the lower oesophagus from a J-shaped combination normally immediately below the diaphragm: In order to counteract the



reflux tendency, with its inherently irritative effect upon the oesophageal mucosal lining (normally unaccustomed to the HCL-rich stomach juice) the alginate (7) forms a strong raft which layers across the upper surface of the stomach contents, preventing this regurgitating action, bringing a rapid relief of the patient's symptoms. The alginate used in this type of preparation is a sodium salt of alginic acid and is combined with types of antacid bicarbonate of sodium or potassium which help form a gel whilst the release of carbon dioxide provides the necessary buoyancy in the maintenance of the strong raft. For optimal effect the medication is taken after food.

The currently high usage of these preparations such as 'Gaviscon', 'Gaviscon Advance', 'Gastrocote' etc., both as prescription medications or bought 'over-the'counter' without a Doctor's prescription bears witness to the effect of these preparations. However in medical practice more potent medicines such as drugs to reduce gastric acidity or output of gastric juice are available on prescription for more severe cases.

Alginate Beads in the Treatment of Diabetes

In the past three decades considerable interest has been shown by research into the possible use of insulin-producing cells from pancreatic tissue combined with alginate gel beads(8) for treatment of type 1 (i.e. insulin dependent) diabetics. Initially the process involved the leaching out of insulin through the capsules of the beads which were of a specific formulation involving a sufficiently narrow pore size to allow a constant supply of insulin whilst preventing immunogenic attack from the body's immunoglobulins.

The research was carried out in rats and dogs which were suffering from spontaneous diabetes, but subsequently some human research was done (9). The beads were inserted in various ways such as into the peritoneal cavity, or the portal vein of the liver; and whereas it was successful in animals, so that previously required repeated insulin injections were no longer necessary, it does not seem to have been used by clinical diabetologists to the author's recent research.

However, a parallel line of research using a non-alginate containing gel, consisting of insulin-secreting tissue alone is being investigated under the name of 'Capsulin' which could be taken orally by type 1 diabetics.

Binding of Radionuclides

The binding power of alginic acid for cations has been found not only for ions such as sodium, potassium and calcium, but also for radionuclides such as strontium and cerium (10). Cerium in seawater and in contact with alginic acid was taken up as alginate in a higher concentration that that in the seawater itself. It follows from this work that there is a possible therapeutic application in the treatment of radionuclide contamination e.g. the accidental ingestion of these substances. However, this does not seem to have been developed perhaps because in order for it to be effective the administration would have to be given very rapidly after the exposure to contamination.

Summary

Alginic acid and alginates have stimulated an immense study both in vivo of the various natural species, and experimentally in the imitation and extension of their natural development. While the industrial utilisation of alginates has spread widely into many areas especially food, cosmetics and agricultural production, it is the therapeutic usage in human medicine which has been reviewed in the sections above. Qualities such as binding power, gel and bead formation with selective pore size, and the ability to be woven into an ion-active dressing for external application; also the gel and raft effect of its gastric medication, are all indications of its versatility.

Alginates are not drugs which can be absorbed into the body's blood system, though the normal gastric juice does contain a small amount of guluronic acid. There do not appear to be any harmful side effects to alginate administration either externally or internally, though a newer form of the gastric preparation 'Gaviscon Advance' has substituted potassium for the previous sodium with regard to reduction in the latter ion on general grounds having in mind the benefits for patients with actual or potential hypertension and heart disease.

A bio-medical application in alginate bead usage for production of monoclonal antibodies in cancer treatment and antibiotic synthesis are yet more examples of this remarkable facet of marine nature and its usage by man.

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Acknowledgements

Much help with guidance on the structure of the paper has been given by Dr. R.L. Fletcher of the Institute of Marine Science at Eastney, Portsmouth; also on the taxonomy of the Laminaria species by Dr. W. Farnham of the same Department. Maureen Sims, Senior technician has been most helpful with liaison skills.

Locally in Aldershot, Mr. H. Drake of Boots The Chemists and the pharmacist at Messrs Lloyds the Chemist have given helpful information.

Dr Alison Keys (see ref. 6 above) who was consultant chemist to BritCair gave me an initial acquaintance with Kaltostat, and Mr. Ian Neal of Reckitt Benckiser has provided backing in the use of alginates in GORD (see ref. 7 above).

Throughout the study Drs. Michael Guiry and Gerald Blunden's book 'Seaweed Resources in Europe' (see ref.7 above) has been invaluable for information and references to articles on original work. The Health Sciences Library staff at Frimley Park Hospital, Surrey have been most attentive to the need for article reprints and Colonel Nigel Hoad RAMC and the Postgraduate Medical Centre at the same hospital have enabled me to give two lectures on the subject.

Finally, but not least I would thank my wife, Heather, for her forbearance and support throughout the project.

Algae within living Aquatic Vascular Plant Tissues

Dr Jack Oliver, Lockeridge, Wiltshire

Certain plant tissues, mainly young roots considered here, are sufficiently translucent to permit digital photography of underlying living structures through the microscope, at magnifications ranging from x40 to x1500 (using the Nikon Coolpix 4500 Camera). The human eye is very sensitive to green, but even so, what may be seen merely as a green blob can have some structural features when viewed and further enlarged on the monitor.

Twelve host plant vascular species are shown on the table. As well as Water Fern and the four Duckweed species, included are Nuttall's Waterweed, 3 Water Starworts, Hornwort, Great Yellow-cress, and (with doubtful confidence) Water-soldier.

Genera such as *Lemna* and *Spirodela* (Duckweeds) and *Azolla* (Water Fern) have well developed root caps. A great variety of algae can flourish inside these. Figure 1 shows a plaque of *Entocladia* on the inside of a *L. minuta* root cap.

Through a lens, or even to the naked eye, the appearance is of a tiny green test tube. Root caps can be colonized, even before they become loose (thereby permitting free-floating algae just to float in around the unsealed rims). Duckweeds of the *Lemna* genus from roof gutters occasionally have their root caps invaded by algae of the *Desmococcus/Pleurococcus/Apatococcus* types in singles (4-10μ) or groups of 2, 3, 4 or more in irregularly cuboidal clumps. However clearly more diverse algal species sometimes invade.

Moving to views inside the root cortex, there are 4 considerations (at least) which often led me astray.

1. Strong greening of small host cells in meristematic tissues, which I now attribute to phytochrome (see Table, line 1).

2. Many, perhaps most aquatic plants can have chloroplasts within their root tissues. These host root cortex cell chloroplasts may be well organized, (see table, line 2) but often appear to be scattered or even extracellular, along with grana-like green fragments 0.5-8μm (see table, line 3). If too much cover slip pressure is applied, there is increased likelihood that these host-plant root chloroplasts and grana may be further extruded from the cells. (Some, however of these 0-5-8μm extracellular green bodies could be invading algae?).

3. Sectioning or coverslip pressure on the roots may carry epiphytic algae into deeper tissues.

4. Diffusing iodine into the living root (sunlit conditions) may give improved contrast for invading chlorophyte algae, but extruded minimally damaged host chloroplasts and host tissue starch granules also appear as diverse black shapes of 1-9μm in size.

Root cortex tissues are less often invaded than the root caps, perhaps mainly in special conditions such as frost or mollusc rasping (see table lines 4 & 5, & also right hand column). Considering the very great variety of non-filamentous algae which can be seen stuck onto root surfaces, some at least may have attributes which enable them sometimes to penetrate more deeply. In particular I have pictures of algal ovoids and spheroids (sometimes with gelatinous-looking surrounds), 3-30μm, stuck onto root surfaces of 5 of the 12 host species shown on the table. Often there can be seen a brown glue-like adhesive mass at the junctures, and sometimes (presumed) enzyme action has caused a collapse of host root cells so that the adherent alga sits in a depression. On the rarer occasions of subsurface tissue invasions by non-filamentous algae there may be slight distortion of the regular architecture of the host root cortex cells. Examples of deeper penetration are seen in below, Figure 2 and 3.

Filamentous algal invaders of root cortex tissues are detailed (Lines 6-8 of table). Protoplasmic bristles of *Entocladia endophytica* are arrowed, but it seems that many of the invasions may also be attributable to *E. cladophorae*, and sometimes different genera. For *Entocladia* at least, there is unequivocal evidence of deeper invasions of living vascular plant root tissues, to form meshes around the stele (central vascular tissues) of sections of living root of species from 2 genera within the Lemnaceae family (Table line 8). An interesting observation concerned *Spirodela polyrhiza*, one of its previous binominals having been "*S. atropurpured*". By mid or late summer, a magenta pigment diffuses from the floating frond half way down the rootlets. Wherever this pigment reaches any invading algae, including *Entocladia*, all are killed, along with host chloroplasts. Agglomerations of brownish debris form within the root tissues. Even at low light levels, *Entocladia* can flourish inside growing aquatic root tissues, but capable of continuing on to colonize the frameworks of dead roots. I have also

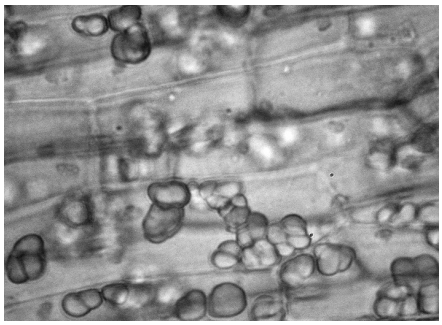

Figure 1. Within the root caps. Inside *Lemna minuta* root cap. Green bodies (?*Desmococci*) 5-10 μm

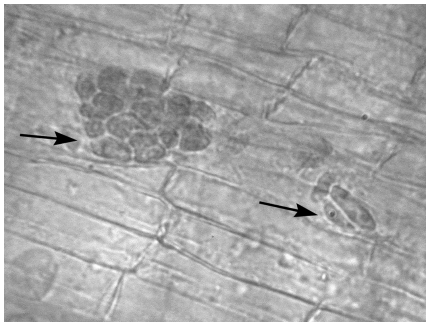

Figure 2. Within the root cortex. Green plaque (width 30μm) in root cortex. Arrows show slight host tissue distortion, and green outliers

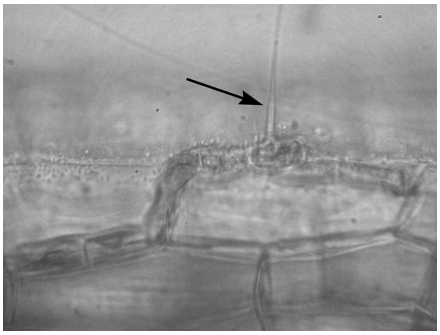

Figure 3. Within the root cortex. *Entocladia endophytica* filament tracking into deeper Lemna minor root cortex layers. Arrow indicates protoplasmic bristle.

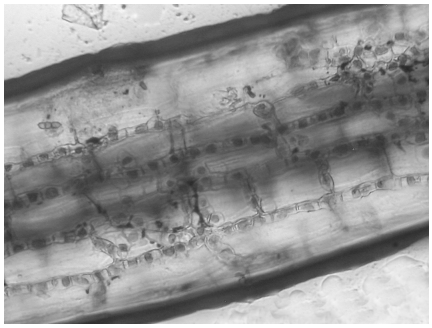

Figure 4. Within the rot cortex. *Entocladia* enmeshing growing *Lemna* minor root stele.

twice seen *Entocladia* plaques in the central lumen of living (and dead) *Ceratophyllum* (Hornwort) underwater stems.

All so far concerns algae outside host tissue cells, the *Entocladia* in particular tracking along and between the regular lines of root cortex cell "boxes". On three occasions, I have seen tiny mobile green bodies inside apparently liquefied root cortex cell contents. These green bodies were sub-ellipsoid or ovoid, 1-2µm long, not bubbles nor host chloroplast remnants nor bacteria, and their movements did not seen to be brownian. The roots (2 *Lemna* species, 1 *Spirodela*) were healthy with no evidence of fungal or bacterial softening or damage: just green "fish" in tiny rectangular aquaria!

Conclusions

Algae can invade root caps and the living root cortex tissues of vascular aquatic plants. However the most obviously pictured colonizations by filamentous or plaque algae such as *Entocladia* may not be the commonest or most important. Algae may influence the notoriously unpredictable reappearances and collapses of some vascular aquatic populations (e.g. *Lemnaceae genera*), especially when overwintering turions become enmeshed.

See also:
www.miniaturegreenworlds.co.uk
(includes references).

Appreciation is given to present and past help from Joan & Brian Davies (Marlborough), Chris Carter (Northampton), Dr D.M. John & Dr Hans Sluiman (Edinburgh).

Table. Greenness & Algal Invaders within living tissues of Underwater Aquatic Vascular Plants.

Features	Azo. Root	L. mn root	Root ca	L. mt root	Root cap	L. tri root	Root cap	Spi root	Root cap	E. nut stem	E. nut root	Cal root	Cer stem	Ror root	Str root	Comments
1. Green tissues in rapid growth (meristematic) regions near root tip. Presumed Phytochrome		√√	-	√√	-	√√	-	√√	-	-	√√	√	-		√√√	Not observable in old, large or opaque roots, or underwater stems.
2. Organized intracellular host plant chloroplasts, mostly 2-6µ.		√√√	-	√√√	-	√√√	-	√√	-	√√√√		√	√√√			Root chloroplasts often smaller than those in stem, leaf or frond.
3. Green bodies 0.5-8µ in host plant tissues, mostly extracellular.	(2)	√√	√√	√√	√√	√√	√√	√√	√√		(2)	√	√		(3)	Probably includes many damaged & extruded host chloroplasts & grana.
4. Algal blobs, wedges, plaques, pairs or quartets in host plant tissues (seldom deep).	(2)	(3+)	√	(3+)	√	(3+)	√	√	√	√*?	(1)	(2)	(2)	(1)	(2)	Inside root caps & less often in root cortex tissues. Invasions more likely in old or damaged tissues, with epiphytic algal infestations
5. Algal ovoids & spheroids in host plant tissues, 8-25µ. (Seldom deep).	(2)	(3+)	√	(3+)	√	(2+)	√	(3+)	(1+)	√*?	(1)	(1)		(2)		
6. Slender filamentous algae, (width 2.5-8µ) infiltrations. (Seldom deep).		(1)	(1+)	(1)	(1+)		(1+)	(2+)	(1+)		(1)			(2)		Different appearances from common epiphytic filamentous algae.
7. *Entocladia* (probably 2 species). Infiltrations of root & stem tissues.		√	√	√	√	√	√	√	(1+)	(1)	(1)					*Entocladia endophytica*, and probably *E. cladophlorae*.
8. *Entocladia*. Deep peristelar meshes (Lemnaceae roots) & central canal plaques (*Ceratophyllum* stems).		√	-	√	-	√	-	√	-	-			(2)			Probably mainly or wholly *E. cladophorae*. Older host plants.

Key: Azo = *Azolla filiculoides*; L.mn, L.mt, L.tri = *Lemna minor*, *minuta* & *trisulca*; Spi = *Spirodela polyrhiza*; Root cap = inside root cap of each preceding species; E.nut = *Elodea nuttallii*; Cal = *Callitriche* (*C. obtusangula*, *C. platycarpa* & *C. stagnalis*); Cer = *Ceratophyllum demersum*; Ror = *Rorippa amphibia*; Str = *Stratiotes aloides*. (1), (2), (3), √, √√, √√√, √√√√ = Features observed once, twice, thrice, occasionally, commonly, usually, invariably. A dash signifies inapplilcable. *Numerous, but doubtfully subepidermal.

Gerald T. Kraft. Algae of Australia: Marine Benthic Algae of Lord Howe Island and the Southern Great Barrier Reef, 1. Green Algae. ABRAS, Canberra, CSIRO Publishing, Melbourne, Australia, 2007: vi + 347 pp. ISBN 9780643094321 (hbk). Price AU$125.

This volume represents the fourth in the Algae of Australia series and targets the green algae from the tropical-subtropical coral reef settings of Australia. The previous volumes comprise the marine red algal order Nemaliales by J. M. Huisman (164 pages) published in October 2006, Introduction by 35 authors and edited by P. M. McCarthy and A. E. Orchard (744 pages) published in March 2007, and the macroscopic freshwater algal orders Batrachospermales, Thoreales, Oedogoniales and family Zygnemaceae by T. J. Entwisle, S. Skinner, S. H. Lewis and H. J. Foard (191 pages) published in April 2007.

The uniqueness of the endemic marine flora is showcased from the world's southernmost consolidated coral reefs of Lord Howe Island, an oceanic volcanic outcrop located between Australia and New Zealand, and the Capricorn Group of the southern Great Barrier Reef consisting of patch reefs and coral cays. Many of the marine green algal species described in this attractive green hard-cover book are also found in other coral reef areas in the western and central Pacific. A two-page Content with the listing of orders, families and genera simplifies the finding of a specific genus.

The book begins with an Introduction which details the history of phycological research and descriptions of Lord Howe Island and the Capricorn Group, supported by maps and 18 colour photographs (see pp. 134 and 135). The Systematic Arrangement of orders, families and genera is then summarized in outline form with explanations of the particular taxa used in the book. Habitats of selected green algae and affinities of the green algae from the subject area are briefly discussed. A dichotomous Key to Genera, consisting of 41 couplets, is provided to all 41 genera of green algae. The text page to the particular genus and citing of the preceding couplet makes the key easier to use. Most importantly, the key really works based on my progressing through the key targeting different morphological shaped genera.

The systematic sections comprise 83 percent of the book and include workable identification keys to the species within each genus, and descriptions of 41 genera and 135 species and infraspecific taxa of marine benthic green algae. Species are discussed in the order of their position in the species key. Reference citations are provided for each species and synonyms in the text which makes it easy for the reader to immediately identify the applicable reference. The collection site of the type specimen is also provided.

The black and white photographs and microphotographs, two to 13 photos per species, of the habit, morphology and anatomy of the species are clear and complement the detailed descriptions of the genera and species. There is, however, one glaring editorial error in my copy, where the identical plate of 11 photos (Figure 72, p. 200) of *Halimeda micronesica* Yamada and *H. discoidea* Decaisne is replicated and labeled Figure 73 (p. 207) with the caption *Halimeda gracilis* Harvey ex J. Agardh. Where's the plate for *H. gracilis*? Such an error is surprising when one considers the rarity of typographical errors in the text.

The 33-page section on the genus *Halimeda* covers 16 species, with one newly described species, and is co-authored by Joanne M. Noble and Gerald T. Kraft who update its taxonomy based on past molecular findings conducted over the past six years. This co-authorship is fitting since J. M. Noble did her M.Sc. Thesis in 1987 in the Heron Island region of the Capricorn Group, and described the new species *H. magnidisca* J. M. Noble in 1986 from the Capricorn Group and participated in the description of *H. howensis* Kraft & J. M. Noble in 2000 from Lord Howe Island. The *Halimeda* section contains a few line drawings of surface patterns and shapes of utricles, and medullary siphons which are most appropriate.

My favourite section is the discussion after the listing of examined specimens where the author provides his taxonomic insights of the species under discussion. I was elated to read that I was not alone in believing that *Pseudochlorodesmis furcellata* (Zanardini) Børgesen may still be a distinct species and not a life stage of *Halimeda tuna* (J. Ellis & Solander) Lamouroux. A bonus section of this book is the additional 57 colour photos of the green algae in their natural habitats. An extensive Bibliography of 412 references is provided which represents the past and current nomenclatural, molecular and taxonomic treatments on Pacific tropical and subtropical green algae, and other references applicable to the geographic sites.

The Bibliography is followed by an Appendix which compiles and reintroduces the descriptions of one new genus *Botryodesmis*, 11 new species (*Boergesenia magna*, *Botryodesmis exocarpa*, *Bryopsis profunda* Kraft & K.R. Dixon, *Cladophoropsis herpa*, *Cladophoropsis planiuscula*, *Codium gongylocephalum*, *Codium reversum*, *Halimeda cereidesmis*, *Pseudochlorodesmis monopodialis*, *Ulva polyclada*, *Ulvella perfurcata*), one new form (*Halimeda gracilis* Harvey ex J. Agardh f. triloba J.M. Noble & Kraft), three new combinations (*Ulva flexuosa* Wulfen subsp. *paradoxa* (C. Agardh) Kraft, *Ulva howensis* (A.H.S. Lucas) Kraft, *Valonia nutrix* (Kraft & A. Millar) Kraft), and one new name (*Chaetomorpha ochlophobians*). A Glossary of 338 words and an insightful section on explanations of Abbreviations and Contractions follow the Appendix. I, especially, like the Index which displays the accepted taxa in roman letters, and the synonyms and doubtful names in italics. The Index also includes the authors of all genera and species mentioned in the text.

I found this book helpful during my floristic study of the septate green algae, e.g., Cladophorales and Siphonocladales, from the central Pacific islands just north of the equator. Aside from the usefulness of this book to Pacific tropical-subtropical phycologists, this volume will be an important reference to coral reef scientists working in the Great Barrier Reef area as well as on Lord Howe Island. Gerald Kraft should be proud of this book and I, personally, look forward to seeing the companion volumes on the browns and reds in book form but at a user-friendlier price.

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Posa A. Skelton and G. Robin South. The Benthic Marine Algae of the Samoan Archipelago, South Pacific, with Emphasis on the Apia District. Nova Hedwigia, Beihefte132: iii + 350 pp., 2007. ISBN 978-3-443-51054-1. Price EUR109.

This soft-cover supplemental issue of Nova Hedwigia represents a slightly revised version of P. A. Skelton's Ph.D. dissertation to the University of the South Pacific originally entitled A survey of the benthic marine algae of the Apia District, Samoa, South Pacific and treats123 genera and 205 species of red, brown and green benthic marine algae from this district on the north coast of Upolu in Samoa. The issue also consolidates under one cover many of the taxonomic and nomenclatural findings made in previous studies on Samoan algae, as well as algae from other south Pacific islands, by P. S. Skelton and his advisor G. Robin South. This issue covers 57 percent of the 360 species of red, brown and green benthic marine algae now documented from the entire Samoan Archipelago which encompasses the independent nation of Samoa (formerly British Samoa and later Western Samoa) and the United States unincorporated territory of American Samoa.

An informative Abstract precedes the Introduction where the past phycological history and description, with maps, of the Apia District are discussed. The Materials and Methods section summarizes the field collection and laboratory methods, and describes the eight sites within the Apia District where collections were made. The red algae is organized in accordance with a revised classification of the supraordinal level proposed by Saunders & Hommersand (2004) which is briefly discussed in the section Taxonomic Treatment of the Rhodophyta.

The Catalogue of species comprises 289 of this 350-page issue and provides information on 83 genera and 134 species of red algae, 15 genera and 23 species of brown algae, and 25 genera and 48 species of green algae. Descriptions and reference citations are provided for each order, family and genus. Type reference, locality, depository and other reference citations are included for each species. A workable dichotomous key to the species within each genus aids in the identification of the appropriate species or will indicate quickly that your specimen is another species. Descriptions are complemented by an iconography of 757 black and white digital images. Most photos are clear and show the intended morphological and anatomical characteristics.

The subheading "Representative specimens" is reserved for those specimens collected from the Apia District, while the subheading "Other specimens examined" covers specimens from American Samoa and other geographic sites, e.g., Hawaii and various Pacific island groups, Australia, Canary Islands, South Africa. I did see a few spelling errors in Hawaiian place names, but should assume some responsibility since I served as an outside reader for the dissertation version; otherwise, I encountered few typographical errors in the text. The final two sections cover "Habitat and remarks" and geographic "Distribution" of the species around Pacific and Indian Ocean islands. The taxonomic views of phycologists who have spent long periods observing specimens in the field of a particular island group are extremely informative.

I was pleasantly surprised to see the brown algal genus *Sargassum* represented in the Apia District of Upolu by the same three species, i.e., *S. crassifolium* J. Agardh, *S. cristaefolium* C. Agardh and *S. polycystum* C. Agardh, found on western Pacific reefs of Palau and Yap in Micronesia. The finding of only four species of *Caulerpa* in the Apia District of Upolu was, likewise, surprising when one considers the species diversity of this genus around other south Pacific island groups. The use of the binomial *Halimeda incrassata* (Ellis) Lamouroux for Samoan specimens is the authors' prerogative; however, a remark should be included as to why the name of an Atlantic species based on molecular evidence is retained for a Pacific alga.

The Discussion covers several topics relative to the marine flora in the Apia District, i.e., taxonomic appraisal of the Apia flora, description of mangrove algal flora and two species of seagrasses, invasive species, failure of deliberate introduction of *Kappaphycus alverezii* (Doty) Doty ex P. Silva and *Eucheuma denticulatum* (Burman) Collins & Hervey for mariculture, species richness of the Apia flora as compared to the rest of the Samoan Archipelago and other Pacific island groups, and affinities of the Samoan flora with its extremely low endemism of 1.3 percent. A section on future taxonomic studies targets the ecological important blue-green algae (cyanophytes or cyanobacteria) and crustose corallines which represent a void in our overall floristic knowledge of benthic marine algae throughout the Pacific islands.

The Reference section contains 888 literature citations, including current nomenclatural and taxonomic treatments of tropical and subtropical algae. The 36 excellent colour images of benthic marine algae in their habitat settings include photos of six red algae, 15 brown algae, 13 green algae and two seagrasses. The alphabetized Index to Genera and Species is in large boldface print and easily read.

The descriptions and figures in this supplemental issue were extremely helpful during my examination of approximately 1,000 slides of benthic marine algae collected from the Manu'a Islands of American Samoa in 2002, 2004 and 2006 by United States National Oceanographic and Atmospheric Administration research vessels. This reference source on Samoan algae will be useful to phycologists and coral reef scientists, not only working in the south Pacific, but to those working in the western and central Pacific, since 95 percent of the benthic marine algae described here will be encountered in these areas. Posa Skelton, a local Samoan, and Robin South are to be commended for their extensive studies on the benthic marine algae in the south Pacific and the publishing of this excellent reference which expands our knowledge of the biodiversity and biogeography of Pacific benthic marine algae. Perhaps, we may see a future supplement which will cover the remaining 155 species now known from the Samoan Archipelago. Libraries will, no doubt, purchase this reference for their shelves; however, the price may deter individuals from purchasing this reference for their personal library.

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McCarthy, P.M. & Orchard, A.E. [Eds], 2007. Algae of Australia: Introduction. ABRS, Canberra; CSIRO Publishing, Melbourne, Australia, 744 pp. AU$180.00. ISBN: 9780643093775.

This introduction to the Algae of Australia is a weighty tome. Weighing in at over 2 kg it contains a vast amount of information about the algae, covering the history of phycology in Australia, phylogeny and classification, fossil record, guide to identification, bibliography, ecology, global biogeography and economic importance of all major groups of algae. After 28 beautiful colour illustrations from John Huisman's (2000) Marine Plants of Australia, the book launches into the history of systematic phycology in Australia. There is no preface or introduction to the book prior to this chapter which left me wondering about the book's purpose and who it is aimed at, and given its title, what would come after the introduction. This slight unease was confirmed as I worked my way through the chapters. While the subject of the book is the algae of Australia, the material is a hybrid of Australian algae and a general text book on phycology. But it is easy to dwell on the negatives of a compendium that contains much valuable and frequently fascinating information and which almost anyone working in phycology might find of interest. The book has been put together by 35 authors from Australia, Belgium, Canada, New Zealand, Tasmania and the USA, and who are (or were) acknowledged specialists in their areas of expertise.

Returning to the history of systematic phycology in Australia, written by Roberta Cowan and the late Sophie Ducker (1909-2004), I found this one of the most fascinating chapters, perhaps because it brings together a wealth of information on the expeditions and exploration of the algae of Australia. Starting with the European collections made in 1699 by the English adventurer and privateer William Dampier, through William Henry Harvey, an Irishman who collected some 20,000 specimens during his time in Australia between 1854 and 1855 and who Sophie Ducker considered to be the single most important contributor to phycology in colonial Australia, this section takes us right up to the 21st century and includes the names of many familiar phycologists. The history covers both mainland Australia and the Oceanic islands and gives an insight into marine, non-marine macroalgae and microalgae and includes sections on fossil algae, symbiotic algae, introduced algae, conservation, the history of the Australian Society for Phycology and Aquatic Botany which was founded in 1980, and popular accounts of Australian algae. There is no question that Australian phycology has played a vital role in the development of the subject over the last three centuries.

The book continues with a general chapter on the phylogeny and classification of the algae. I get the impression from reading this section that the book has been a long time in the publishing process because the most recent references cited in this chapter are from 2004 and this probably reflects the huge effort that must have gone into putting this volume together. We are told in this chapter that the classification for the present series (although what this series is can only be surmised from the end of the book where a volume on the Nemaliales in the series (Huisman, 2006) is mentioned) follows van den Hoek et al. (1995) which seems a pragmatic, if cautious, approach given the upheavals that are taking place in phylogeny and classification.

The next chapter on the fossil records of algae covers the subject from an Australian perspective but in the context of the rest of the world. I do not profess to be an expert on fossil algae and while I found this another good chapter to read, my impression was that some of this was a bit patchy. For example, in the section on Rhodophyta, there is no mention of *Bangiomorpha pubescens* Butterfield (Butterfield 2000) which is considered to be the oldest taxonomically resolved eukaryote, or of the red algal fossils from neoproterozoic deposits in China (Xiao et al. 1998) but fossil Corallinaceae are mentioned, including material described from France.

I was impressed by the efforts that had gone into the following chapter by John Huisman and Tim Entwisle who bravely provide keys to divisions, classes and orders plus tables of what the authors describe as superficial characters, which they define as those that might be obvious without detailed study, but are not always fully diagnostic. It all looks a bit impenetrable at first site when faced with keys which, for example, distinguish Euglenophyta from Chlorarachniophyta, but there is no doubt that this is an approach that could enable people to build up an understanding of the higher level classification and should provide a useful reference point. This section is followed by 38 pages of what the authors describe as 'mainly recent' literature on the taxonomy and morphology of algae. Next comes a major part on the major groups of algae with contributions from a large number of different authors. I do not intend to dwell on this section, suffice to say that it is valuable in the coverage given to the different groups of algae but somewhat variable in its attention to Australia.

Much of the rest of the book, which is on the ecology, biogeography and economic importance of algae, appears to be a general compilation of material but I was taken with a few paragraphs at the end of the ecology chapter which drew attention to how little is really known in any detail about the terrestrial algae in Australia and the potential for significant discovery. This is exciting stuff and a bit more if this sort of thing in the book would have gone down well. I also very much liked the sections on biogeography by Max Hommersand, John Huisman, Julie Phillips, Alan Millar and Gustaaf Hallegraeff, which left me with a much greater feeling of Australia and its algae. The economic importance of algae makes an interesting read and is a useful resource of information before the book comes to an end with a substantial glossary, interspersed with some more lovely colour photographs, including another 27 seaweeds by John Huisman.

In conclusion, while I have enjoyed many aspects of this book and found it a 'good read', I felt at times that the title was misleading and that it was a text book about algae with some emphasis on Australia. Part of me feels that more focus on Australia and its algae and less general material would have made it more distinctive. For me, that would have given it a different and more ready appeal, particularly as it is not as up to date as perhaps it could be. Finally, I apologise to all the authors whose names I have not mentioned but who have contributed so much to a book which is no doubt a tremendous contribution to phycological literature.

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Juliet Brodie
Natural History Museum
London
March 2008

Obituary

Antony Edward Bailey-Watts

Tony Bailey-Watts died peacefully on 15 July 2007. He is survived by his wife Sheila, two sons (Gerard and Sam) and two granddaughters (Rebecca and Freya).

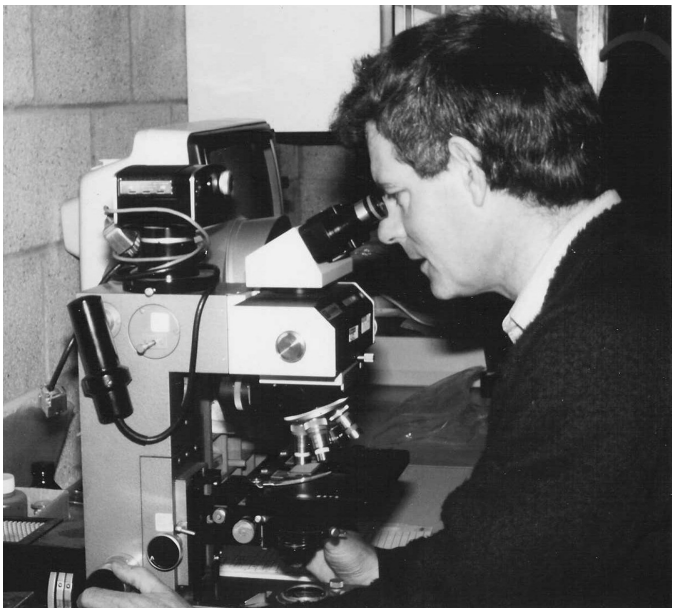
Tony was born in Surrey, England, in 1942. He studied Zoology and graduated from Sir John Cass College, now part of London Metropolitan University, in 1964. During this period, his interest in limnology was inspired by one of his teachers, Julian Rzóska, who helped him and a group of students organise a trip to the Sudan. Memories of the Crater Lakes of Jebel Mara had a lasting impact on the young Tony.

After graduating, Tony worked as a chemist/biologist for the River Dove Water Board, Leicestershire, England, for a short period. As part of his training, he was sent to the Freshwater Biological Association (FBA) in Windermere to learn algal identification. Here, he met the algologists Erica Swale and Hilary Belcher who brought to his attention the opportunity to join an interdisciplinary study of Loch Leven, in Scotland. This was being initiated as part of the International Biological Programme (IBP), a worldwide project that aimed to understand and quantify the productivity of the world's habitats.

Tony began a lifetime of work on the phytoplankton of Loch Leven in April 1967, obtaining a Ph D from the University of London in 1973. During these early years, he was helped and influenced by many staff from the FBA, notably John Lund. By 1968 he had already published a paper in Nature on 'a blue-green alga of bacterial size' (Bailey-Watts et al. 1968), bringing the importance of these very small algae in freshwater lakes to the attention of the world.

During his research career, Tony published 70 scientific papers and completed almost 100 customer funded reports covering a wide range of topics. Most of these focused on his key area of interest, the causes and effects of nutrient enrichment (eutrophication) in lakes. In relation to this, Tony was one of the first to highlight the impact of catchment based activities on lake water quality and the importance of lake sensitivity factors in determining the response of the algal community.

Tony became fascinated by the variable nature of algal communities. He became involved with the International Association of Phytoplankton Ecology and Taxonomy (IAP) and became an active member of the British Diatomists, where he encouraged and published with the legendary amateur John Carter on the diatoms of Shetland (Carter & Bailey-Watts 1981). He also a contributed to the first volume of Diatom Research (Bailey-Watts, 1986).



Tony enjoyed passing on his experience to other freshwater ecologists. He became an Honorary Lecturer at the University of Edinburgh and was awarded a Doctor of Science degree by the University of London in 1995. In the latter part of his career, he also became involved with the Lake Tanganyika Biodiversity Project. This was funded by the United Nations Development Programme and aimed to help young Africans to set up their own projects. Many scientists in the UK, Europe, Asia and Africa have benefited from the help and support that Tony gave them over the years. Tony will be remembered not only for his work on Loch Leven but also for his also contribution to freshwater science across the world.

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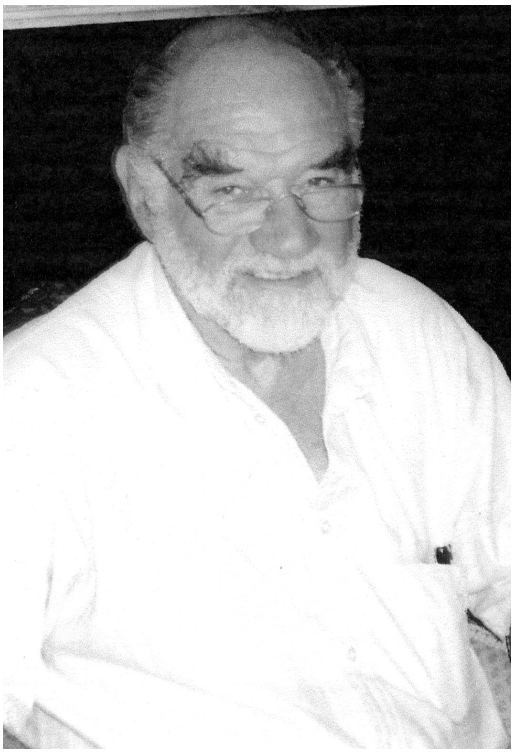
Linda May, CEH

James Henry 'Jim' Price (1932 - 2007)



Jim Price was born on the 6th of February 1932 in London but moved to Brinsley near Nottingham in 1938 following the early death of his father. After completing grammar school education he was employed as a clerk with an insurance company before being conscripted for national service in the Royal Air Force. On leaving the RAF Jim went on to study at Loughborough Teachers Training College and qualified to teach geology and biology. At this time he met his first wife Barbara by whom he had two daughters.

Jim Price enrolled at Liverpool University as a mature student in 1959. While there he studied phycology under Dr Elsie Burrows and Prof. Peter Dixon; he developed an interest in marine ecology, and under Peter Dixon's guidance, a particular interest in the Rhodophyta. After leaving university he went to Portsmouth Polytechnic for a short period as a lecturer in botany and marine science. Jim joined the Natural History Museum in July 1963 as a Senior Scientific Officer and head of the marine algal section of the Botany Department and remained in the department until retirement in 1992.

In addition to his professional interest in phycology and natural history, he developed interests in classical music and in particular opera, philately, and rare books. Jim met his second wife Susana M. Cabrera at the British Phycological Society winter meeting of 1970 at the then Polytechnic of North London (Susana had come to England from Argentina to meet European phycologists to pursue her interest in the mass-culture of algae). They were married in Argentina in May 1970 and had two daughters.

Jim developed a deep knowledge of the history of phycology, phycologists and historical aspects of the literature on marine algae. He prepared several detailed catalogues on collectors and collections that are available for consultation in the algal herbarium at BM. He was also a long-term contributor to the Oxford Biographic Dictionary. With Peter Dixon and David Irvine he collated literature information for a 'Distributional Bibliography of the Marine Algae of the British Isles'. Jim was actively involved (with David John and George Lawson) over many years in the collation and reviewing of literature for 'Seaweeds of the western coast of tropical Africa and adjacent islands'. Jim also edited several conference proceedings, not least the highly successful 'Shore Environment' volumes.

With members of the marine algal section at BM he undertook floristic and ecological field studies in Kent and Cornwall, and was active in the Botany Department's 'Flora of Mull' project. Abroad, Jim undertook fieldwork in the South Orkneys, Patagonia, Aldabra, Angola, Ascension Island, and the Faroes. Taxonomically his interest lay in the Ceramiaceae and the genus *Callithamnion*. He published on aspects of the typification of its species, its ecology, and more recently the application of isozyme techniques to its systematics. Jim will be remembered by the species *Aglaothamnion priceanum* Maggs, Guiry & Rueness named in his honour. Jim Price was also a visiting lecturer at the Universities of Buenos Aires and La Plata in Argentina and at Santiago de Compostela in Spain.

Most recently he was actively editing "A monograph on some British Desmids" by A.J. Brook and D.B. Williamson for the Ray Society, a volume that will soon see publication.

Jim's health, mentally and physically, began to decline in 2006; following a routine hip-replacement operation he died unexpectedly of heart failure three weeks later on 25th October 2007. A celebration of his life took place in Truro, Cornwall, on the 8th of November 2007.

Some key publications

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A full list of publications can be found on the BPS web site.

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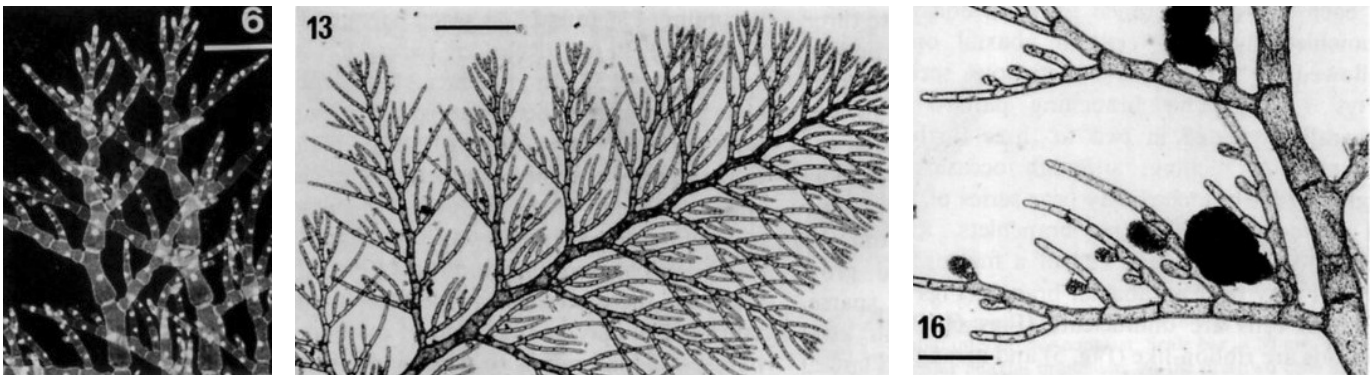

Aglaothamnion priceanum, from left to right: Apices of cultured thalli, stained with DAPI to show uninucleate cells; apex, showing brancing pattern (scale bar = 500 µm; parasporangial clusters at different stages of development (scale bar = 150 µm).

From Maggs, C.A., Guiry, M.D. & Rueness, J. (1991). *Aglaothamnion priceanum* sp. nov. (Ceramiaceae, Rhodophyta) from the north-eastern Atlantic: morphology and life history of parasporangial plants. *British Phycological Journal* **26**: 343-352.

Professor N.G. Carr

Researcher into blue-green algae

The biochemist N.G. Carr founded a research school that made seminal contributions on the metabolism, physiology, molecular biology and ecology of cyanobacteria - or blue-green algae - perhaps the most numerous organisms on Earth.

Cyanobacteria are involved in today's most urgent scientific issue: the rise in atmospheric CO_2, causing global warming. The present composition of the atmosphere, discussed at a recent meeting of the Royal Society, results from the "Great Oxidation Event" over two billion years ago, when oxygen gas first accumulated in the air and CO_2 levels plummeted.

These changes were brought about by cyanobacteria using the energy in sunlight to split water into oxygen, released as a gas, and hydrogen, which transformed CO_2 into organic matter. In the current era this 'oxygenic photosynthesis' also occurs in chloroplasts of plants; and chloroplasts evolved from cyanobacteria. Cyanobacteria, then, changed the conditions for life on Earth and are ultimately responsible for creating the food we eat and the air we breath.

Noel Gordon Carr was born in South Shields in 1935. The family moved to Leeds where his father, a pharmacist, established a small chain of chemist shops. Noel attended Roundhay Grammar School. At the age of 14 he was crippled in both legs by polio. For much of his life he discounted the handicap; walking with two sticks he moved at a dizzying pace and negotiated stairs with particular daring. In 1954 he won a State Scholarship to Leeds University where he read biochemistry. On graduating he moved to Trinity College, Oxford, researching the metabolism of purple bacteria for his DPhil with June Lascelles.

Carr's first postdoctoral position was at the University of California, San Francisco. He worked on lipid metabolism but his career-changing experience was attending C.B. van Niel's course in microbial ecology at the Hopkins Marine Station, Stanford University. When Carr returned to the UK in 1962, to take up an ICI Fellowship in the Biochemistry Department at Liverpool, he turned his attention to certain blue-green algae, convinced of their pivotal position in biology.

Carr and his students demonstrated that these algae produced a substance (poly-hydroxybutyrate) known only in bacteria and they showed that the ribosomes of blue-greens were of the bacterial type. These and other features supported the reclassification of blue-green algae as cyanobacteria, formally proposed in 1970 by Roger Stanier of the Institut Pasteur, Paris.

In the mid-1960s an old idea, that plant chloroplasts evolved from cyanobacteria engulfed by plant ancestors, was revived, separately, by the biologists Patrick Echlin and Lynn Sagan. Carr's group provided compelling evidence for this by DNA-RNA hybridization: chloroplast genes in a green flagellate showed a closer affinity to those in free-living cyanobacteria than to the corresponding genes in the flagellate nucleus. Carr's lab produced the first extensive genetic maps of the cyanobacterial chromosome by observing the frequency of specific mutations obtained by applying mutagens at different stages of the cell replication cycle. All of these studies anticipated the findings that later depended on DNA sequencing techniques.

In the 1970s and 1980s Carr's group investigated the biochemical pathways of cyanobacteria, discovering new enzymes and explaining modifications of metabolic cycles that made these organisms dependent on photosynthesis for growth. They also determined the conditions required for differentiation of heterocysts, cells specialised for nitrogen fixation.

Appointed to a Chair of Biology at Warwick University in 1984, Carr, with his colleagues Nick Mann and Dave Scanlan, developed molecular methods of investigating nutrient uptake by cyanobacteria. They identified a gene involved in phosphate uptake, which becomes active only when phosphate is limiting; measurement of the gene's activity provided an assay for phosphate limitation in the ocean. A similar system was developed for iron. These assays were used to investigate the productivity of the minute picoplanktonic cyanobacteria, which account for much of the photosynthesis and CO_2 uptake in the oceans. Recently there have been trial fertilisations of the oceans with iron to increase CO_2 absorption from the atmosphere.

Noel Carr enjoyed collaborating with people. He became founding editor of Blackwell's Studies in Microbiology

series. He and the botanist Brian Whitton edited two important works on their speciality: The Biology of the Blue-green Algae (1973), setting the classical studies in the context of the modern biochemistry and electron microscopy; and The Biology of the Cyanobacteria (1982). Carr generated numerous ideas and exploited a number of them commercially with companies including Schweppes Research Ltd, and the Helicon Foundation, California. He was coinventor of a patent to use cyanobacteria for the biosynthesis of fine radiochemicals, which, as he told it, considerably enriched The Radiochemical Centre, Amersham.

At conferences Carr would remark that scientists were such nice people. He saw them at their best, uplifted by his own generous spirit. But he deflated pomposity. At a meeting in which the first DNA sequences from cyanobacteria allowed the tentative construction of phylogenetic trees, an august plenary speaker cautioned "Only God can make trees." Noel responded by sketching a New Yorker cartoon of two lumberjacks leaning on their axes, surrounded by felled timber, saying "We may not be able to put 'em up but we sure-as-hell can knock 'em down."

Visiting Carr, especially in the Liverpool days, I saw him much involved with his research students. After a long day at the lab he would take everyone to the pub. From there we would move on to Noel's house where his children came and went while his wife Di produced bacon and eggs for everyone. Di was always supportive to Noel, which became increasingly important as he struggled with the legacy of his polio and, finally, his inability to fight off bacterial infections.

Noel was a keen theatre-goer and a connoisseur of wine and art; he became Chair of the Friends of the Mead Gallery at Warwick University. With characteristic enthusiasm he promoted the visual arts and raised funds for the Gallery's notable collection. In retirement he played bridge most afternoons at the historic Leamington Tennis Court Club.

Anthony Walsby

Noel Gordon Carr, biochemist: born South Shields,Co Durham 3 December 1935; Research Fellow, University of California, San Francisco 1961-62; ICI Fellow, Biochemistry Department, Liverpool University 1962-64; Lecturer, Senior Lecturer and Reader in Biochemistry 1964-84; Professor of Biological Sciences, Warwick University 1984-96 (Emeritus); married 1960 Diana Clavering (one daughter, two sons); died Warwick, 30 October 2007.

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Anabaena

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Copy which is submitted for publication in *The Phycologist* should be concise and informative. Articles should be scientifically sound, as jargon free as possible and written in a readable scientific magazine style. Unless absolutely essential, references should not be included. All types of relevant material will be considered, these include job advertisements, scientific reports, book reviews, news items of topical interest, meeting announcements, grant awards, promotions, appointments, profiles of eminent phycologists and obituaries. If you are interested in submitting material that does not fall within any of these broad categories, or you are unsure of the appropriateness of a potential article, then contact the editor. Suggestions for future articles or a series of articles are welcomed.

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