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Editor:
Bruce Osborne

Contents

Editorial

We hope that you like the new format of 'The Phycologist' and that this encourages you to submit articles and correspondence relating to phycological issues. The current issues features articles on two Manton prizewinners, **Gareth Edwards** and **Karin Rengefors**, who obtained their awards at the last Winter Meeting and, in a new 'Historical Corner' **John Raven** details the discovery of the unusual phenomenon of aquatic CAM. There is also a report, funded by a BPS summer studentship, on arsenate tolerance in *Fucus*. Also on the scientific front is an important date for your diaries, The BPS Winter Meeting, held this year in Dundee between the 4-7 January and a report on a new five-year European Science Foundation Scientific Programme on Cyanobacterial Nitrogen Fixation. The European Science Foundation has also published its priority areas for funding the Life and Environmental Sciences over the next four years and these are detailed on page eight. I am sure there are many more interesting phycological items out there, so keep sending them in! Details for submission of articles are given on the last page of the current issue. Clearly the success of this new venture, as well as the success of the British Phycological Society, depends on the active participation of its members. Remember also that any comments of suggestions are welcome, so keep those coming in too.

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HISTORICAL CORNER

Crassulacean Acid Metabolism in Algae

Bioassays using human taste buds showed that some terrestrial plants had a higher acid content at the end of the night than at the end of the day. This phenomenon has been known for at least two centuries. By the mid twentieth century the changes in acidity were known to be largely due to changes in the concentration of malic acid. Synthesis of malic acid at night involved the fixation of one molecule of carbon dioxide for each molecule of malic acid produced and almost all of the carbon dioxide released during deacidification during the daytime was refitted and converted mainly into carbohydrates. Refixation of carbon dioxide is favoured during the day because of stomatal closure, whilst net fixation of atmospheric carbon dioxide is facilitated by stomatal opening. The phenomenon was termed Crassulacean Acid Metabolism (CAM), because it was first charcterised in members of the family Crassulaceae.

Having considered the outlines of 'how' CAM operates. We can ask 'why' in terms of the ecology and evolution of plants with this pathway, such a mechanism might be advantageous. The most reasonable explanation seems to be that of water economy. Terrestrial CAM plants only loose one-tenth to one-fifth as much water in transpiration per unit gain in dry matter than is the case with plants that only show net carbon dioxide fixation in the light. The economy of water use can be explained by the reduced evaporative losses of water at night and the elimination of transpiration during the day due to stomatal closure. Commonly the CAM syndrome in terrestrial plants is associated with species from arid or semi-arid regions (many cacti, Crassulaceae and Euphorbiaceae), although it also occurs in many tropical epiphytes (orchids, bromeliads, some ferns). One of the most puzzling aspects of this syndrome, however, is why it is not a more common feature of plants found in the hottest and driest terrestrial habitats.

Finally, coming to the link with algae, CAM-like physiology also occurs in some aquatic vascular plants. A diel fluctuation in the acidity of tissues of aquatic species of *Isoetes* was found by Jon Keeley in the USA in the 1970's. He soon realised that this was CAM, rather than the build-up at night of fermentation products and their metabolism during the daytime that he was originally looking for. This serendipitous finding led Keeley and then others, to look at other aquatic vascular plants. Aquatic CAM was found in all aquatic species of Isoetes and in several flowering plant genera, including Littorella and Crassula (which, interestingly, also has terrestrial CAM species). The 'how' of aquatic CAM is more uncertain than is the case for terrestrial CAM, especially in terms of restricting carbon dioxide leakage during refixation in the light. The 'why' of aquatic CAM clearly does not involve economy of water use. Perhaps another way of looking at this is to consider carbon, rather than water, limitation. Terrestrial CAM, for instance, could be regarded as a response to limited carbon availability, since a reduction in water vapour loss will always involve a reduction in carbon uptake. Accordingly, aquatic CAM can also be regarded as a response to a limited carbon supply, with some aquatic CAM plants actually maintaining net fixation of carbon

dioxide over the complete diel cycle. Jon Keeley plausibly maintains that, in some instances, aquatic CAM could have evolved in situ in response to carbon limitation, although in the case of Crassula species the aquatic forms presumably took CAM with them when the predominantly terrestrial ancestral forms became aquatic.

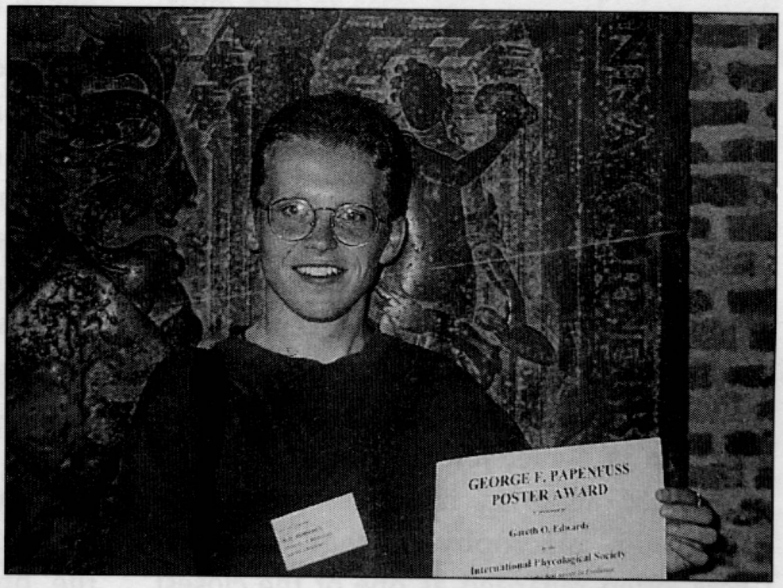
The question then arises, what about the algae as CAM organisms? Their embryonic descendants, at least in the sporophyte phase, can exhibit CAM, but is this trait also observed in algae? Jon Keeley did not find any CAM algae in his investigations of freshwater macrophytes that included *Chara*, often regarded as one of the closest living relatives of ancestral embryophytes. Since the algae were late comers to investigations of CAM, there was already a substantial amount of literature on the magnitude of dark carbon dioxide fixation rates, as determined by the ^{14}C technique. The brown macroalgae had the highest rates of dark carbon dioxide fixation, so that it seemed sensible to initially examine these algae for the presence of CAM. Andrew Johnston found CAM-like diel variations in both titratable acidity and malate levels in *Ascophyllum nodosum*. Subsequent work on the occurrence of CAM-like variations in titratable acidity followed in collaboration with Bruce Osborne, who was 'moonlighting' from a Science and Engineering Research Council postdoctoral position, appropriately on algal growth at very low irradiance, which were actually little more than moonlight! The investigation of CAM only involved 'dawn' and 'dusk' measurements so they could be conveniently fitted in before and after the 'normal' working day. This work showed that other members of the Fucaceae sensu lato also showed diel fluctuations of titratable acidity, although similar variations were not found in other local fucoids, such as *Halidrys*, or in other brown algae, or in red or green algae. More detailed investigations on these organisms by Misni bin Surif produced similar results, as did other work on *Fucus vesiculosis* from the Baltic and western North Atlantic. Studies on Southern Hemisphere brown macroalgae showed that, again, it was only organisms that are closely related to the Fucaceae showed variations in titratable acidity.

Despite the variations in malic acid found in *Ascophyllum nodosum* it is not certain if the brown algal phenomena should be called CAM. The recent work of Jon Keeley on *A. nodosum* shows that labelling of malate with radioactive carbon dioxide supplied in the dark is followed by labelling of other soluble organic compounds in the dark, either in the presence of labelled carbon dioxide, or in a chase with unlabelled carbon dioxide. This is despite the fact that earlier measurements demonstrated diel variations in malic acid concentration. Furthermore, based on the measured variations in malic acid, CAM-like processes could only contribute a few percent, at most, to the net daily carbon gain, even if all of the carbon fixed into this compound during the night was converted into reduced organic carbon in the daytime.

John Raven

THE 1998 MANTON PRIZEWINNERS

Gareth Edwards was awarded his prize for a paper on 'Interspecific fertilisation in *Fucus: sex on the seashore'*. Gareth studied for a BSc in Biological Sciences at the University of Birmingham, graduating in 1995. He is currently in the final year of his PhD studies, working on a NERC CASE-funded project, which is supervised by Professor Jim Callow of the University Birmingham and Dr Colin Brownlee of the Marine Biological Association, Plymouth.



His research project has examined a number of aspects of fertilisation in *Fucus*. *In vitro* fertilisation events have been studied and shore-based populations, containing putative hybrid swarms have been surveyed. Morphometric analysis and molecular markers (RAPDs) have been used to answer the question. 'Does *Fucus* form interspecific hybrids?' The results of this study were presented at the Sixth International Phycological Congress in Leiden in August 1997, as well as at the recent British Phycological Winter Meeting at Royal Holloway College, London. Gareth also came back with a prize from the Leiden meeting and was a joint recipient of the George F. Papenfuss award for the best poster display.

Aside from phycology, Gareth's interests include reading (Steinbeck's 'Doc' is a literary hero), playing the guitar in a rock band called 'Ashtray' and (or as well as?) listening to 'music' (anything from Mahler to Megadeth). Gareth also enjoys cooking vegetarian food almost as much as he enjoys eating it!

The other recipient of the Manton Prize is **Karin Rengefors.** Karin studied for her PhD thesis in the Department of Limnology, Uppsala University, Sweden and was supervised by Professors Kurt Pettersson and Peter Blomqvist. Immediately following the Royal Holloway College meeting she successfully defended her PhD thesis entitled 'The role of resting cysts in the survival and succession of freshwater dinoflagellates'. Karin's research involved studying the seasonal dynamics of motile cells and cysts of dinoflagellates in Lake Erken, Sweden. Karen was particularly interested in the possible mechanisms controlling cyst germination.

Laboratory studies showed that germination was controlled by temperature after a mandatory dormancy period that involved an endogenous clock. The second part of Karen's thesis included studies on the possible uptake of phosphorus by cysts resting in nutrient-rich sediments. Whilst her studies indicated that some uptake may take place, further work is required to confirm these findings.

During Karin's PhD studies she spent three months as a guest researcher at Dr Donald Anderson's laboratory at Wood's Hole Oceanographic Institution, USA. She also spent five weeks carrying out quantitative X-ray microanalysis with Dr Ivan Heaney, of the Aquatic Systems Group, at the Department of Agriculture for Northern Ireland in Belfast.

In 1995 Karin won first prize in the Student Oral Contribution Category at the XXVI Congress of the International Association of Theoretical and Applied Limnology in Sao Paulo, Brazil. Currently, Karin has a part-time postdoctoral fellowship from the Swedish Foundation for Strategic Environmental Research, in which she will be studying the role of the littoral zone as the site of inocula for phytoplankton populations. In the meantime she is looking for postdoctoral fellowships abroad.

BPS SUMMER STUDENTSHIP

Arsenate Tolerance in *Fucus vesiculosus*: Is the Phosphate Uptake System Altered?

B.S. Chesman (supervised by M.T. Brown), Department of Biological Sciences, University of Plymouth

The history of metal mining in the south west of England dates as far back as the Bronze age when alluvial tin was mined. Over the centuries, a combination of natural weathering processes, waste water from mines and leaching from spoil heaps has resulted in high arsenic concentrations associated with the sediments and waters of several estuaries in Cornwall. Although output declined sharply in the 20th century and the last tin mine in the Carnon valley closed in 1991, it has recently been established that Restronguet Creek, which receives drainage from this area, contains the highest concentrations arsenic, of any estuary in the UK. Despite these elevated concentrations, several seaweed species, such as *Enteromorpha intestinalis* and *Fucus vesiculosus*, continue to thrive in these waters. To grow in such arsenic contaminated conditions seaweeds must either reduce the amount of arsenic taken up, alleviate its toxic effects internally, or use a combination of the two.

The predominant form of inorganic arsenic in seawater, and the most toxic to algae, is arsenate. Algae readily take up dissolved arsenate, in part due to its chemical similarity with the essential nutrient phosphate. This similarity results in competition for the phosphate uptake system in many species of angiosperms, bacteria and fungi. The aim of the present study was to establish whether the ability of *F. vesiculosus* to grow in an estuary heavily contaminated with arsenate is due, at least in part, to modification of the phosphate uptake mechanism thus reducing arsenate accumulation. The hypothesis was tested by comparing the phosphate uptake rates and kinetic parameters of *F. vesiculosus* collected from the highly contaminated Restronguet Creek with that of material from the relatively unpolluted Helford estuary (Fig. 1).

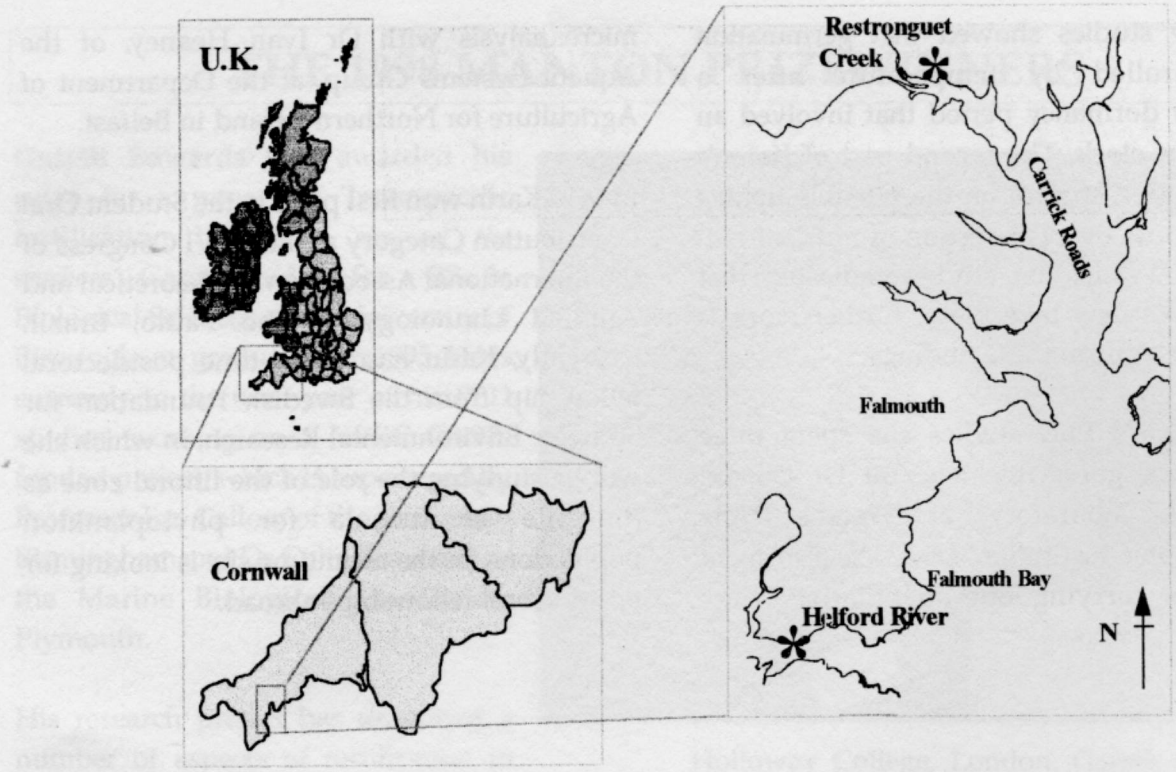


Figure 1. Location of Restronguet Creek and the Helford estuary showing collection points (*).

Phosphate uptake was measured in a series of experiments using a combination of perturbation and multi-flask methods. Material was preconditioned in nutrient depleted seawater at 15°C for 36 h prior to experimentation. Kinetic parameters V_{max} and K_s, generally used to describe transport capabilities of macrophytes, were computed. Substitution of these parameters into the Michaelis - Menton hyperbolic equation allowed curves to be fitted to the data for the calculation of V_1.

The results suggest an alteration in the phosphate uptake system in *F. vesiculosus* from the arsenic contaminated site. Plants from Restronguet Creek took up less phosphate, depleting the initial concentration by 82% overall, as opposed to 92% depletion by the Helford plants (Fig. 2.). The rate of phosphate uptake

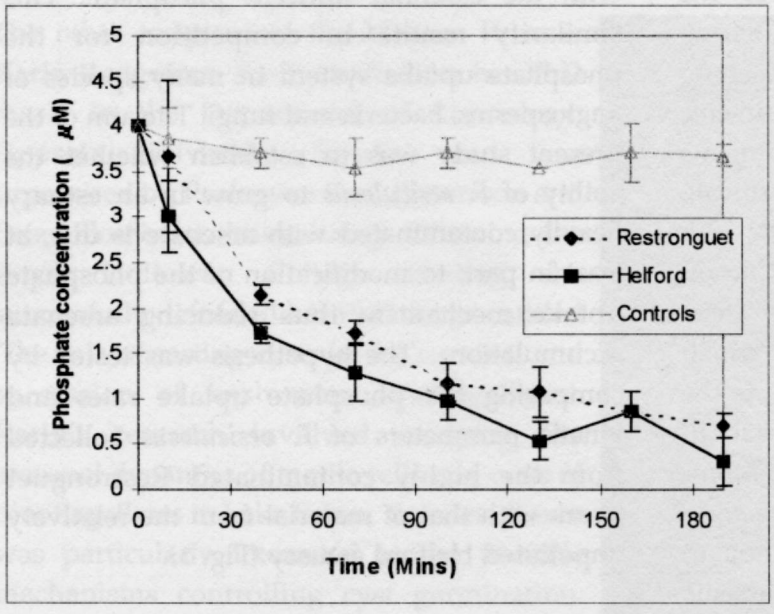


Figure 2. Decrease in phosphate concentration in the medium with time for *Fucus vesiculosus* from Restronguet Creek and the Helford estuary. Each point represents the mean of three replicates. Error bars represent the standard error of the mean (n=3).

Table 1. Kinetic parameters K_s , V_{max} and V_1 for phosphate uptake (95% confidence limits) in *F. vesiculosus* from Restronguet Creek and Helford estuary.

Kinetic parameters				
Origin of *Fucus*	V_{max} (10^{-4} µmol g^{-1} s^{-1})	K_s (µmol)	V_{max}:K_s	V_1 (10^{-4} µmol g^{-1} s^{-1})
Restronguet	12.074 ± 0.71	10.864 ± 1.40	1.11	1.017
Helford	11.041 ± 0.83	6.487 ± 1.28	1.70	1.475

Figures represent kinetic parameters + standard error of the mean

was found to be consistently lower for the Restronguet material, particularly in the initial stages of the experiments (Fig.3.), although the maximum uptake rate, V_{max}, is similar for material from both sites (Table 1.). This apparent anomaly indicates that there are differences between the phosphate uptake mechanisms of the two ecotypes.

V_1 reflects the ability of the alga to take up phosphate at an external concentration of 1M, and is 31% lower for the Restronguet material. The lower affinity of Restronguet *F. vesiculosus* for phosphate is confirmed by the K_s values. K_s is the half saturation constant (the substrate concentration where uptake is half its maximum) and the higher the value of K_s, the lower the affinity of the carrier site for the ion. *F. vesiculosus* from Restronguet Creek was found to have a significantly higher K_s value ($p<0.05$) than *F. vesiculosus* from the Helford estuary (60% higher). As K_s is not independent of V_{max}, the ratio V_{max} to K_s was also calculated (the theoretical initial slope of the Michaelis-Menten curve) and found to be greater for Helford material, further illustrating the lower initial uptake rate for Restronguet *F. vesiculosus*.

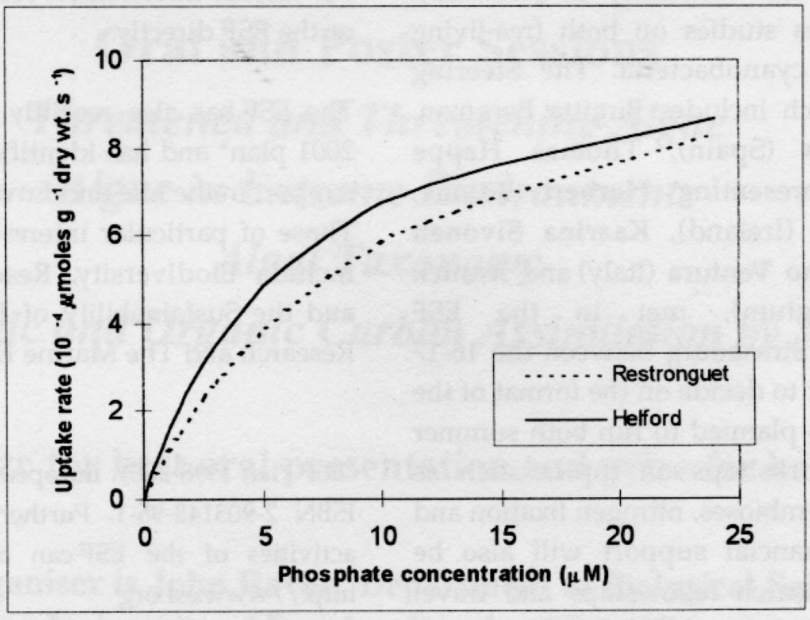


Figure 3. Variation of phosphate uptake rate with initial phosphate concentration for *F. vesiculosus*. Depletion was followed over a one-hour period using the multi-flask method.

Suppression of the 'high affinity' phosphate uptake system has been demonstrated as a method of arsenate tolerance in terrestrial grasses. No biphasic uptake has been demonstrated for marine macroalgae but the generally low nutrient conditions of the marine environment suggest that uptake of nutrient ions will naturally take place *via* high affinity, typified by low K_s values. There has been the suggestion that arsenate may be taken up by marine phytoplankton when concentrations are equal to or greater than those of phosphate. Findings of this study show that at low phosphate concentration (0.75µM) little or no uptake occurred in the tolerant *F. vesiculosus* whilst uptake took place in the non-tolerant plants. As both ions are taken up by the same carrier this apparent modification to the uptake system will effectively reduce the amount of arsenate taken up and act as a method of tolerance to high inorganic arsenic concentrations. When phosphate uptake was followed in the presence of arsenate, an efflux of phosphate from both ecotypes was observed. The cause of these phenomena has yet to be established.

I would like to thank the BPS for the studentship which enabled me to conduct the greater part of this research over a five-week period during summer 1996. I was also given the opportunity to present a poster outlining my work at the BPS Annual Winter Meeting in Sheffield, where I was able to discuss my findings. Altogether it was an enjoyable and rewarding experience, which has inspired me to seek further research in the field of phycology. I hope the BPS continues to offer this encouragement to undergraduates.

ESF ANNOUNCES NEW PROGRAMME ON CYANOBACTERIA

The European Science Foundation (ESF) has recently announced a new 5 year Scientific Programme on cyanobacterial nitrogen fixation, with funding of approximately half a million pounds. The programme is chaired by **Birgitta Bergman**, from the University of Stockholm and encompasses studies on both free-living and symbiotic cyanobacteria. The Steering Committee, which includes Birgitta Bergman, **Enrique Flores** (Spain), **Thomas Happe** (Germany), representing **Herbert Böhme**, **Bruce Osborne** (Ireland), **Kaarina Sivonen** (Sweden), **Stefano Ventura** (Italy) and **Annick Wilmotte** (Belgium), met in the ESF headquarters in Strasbourg between the 16-17 October this year to decide on the format of the programme. It is planned to run both summer schools and workshops on topics such as cyanobacterial symbioses, nitrogen fixation and biodiversity. Financial support will also be available for research fellowships and travel grants and a major international symposium is planned for the final year of the programme.

For those of you who are not familiar with the workings of the ESF, the programmes are essentially supported by member organisations on an *à la carte* basis and financial support is normally restricted to participating countries. For further information contact Bruce Osborne, or the ESF directly.

The ESF has also recently published its 1998-2001 plan* and has identified priority areas for support in the Life and Environmental Sciences. Those of particular interest to the phycologist include Biodiversity, Resource Management and the Sustainability of Ecosystems, Climate Research and The Marine Environment.

*ESF Plan 1998-2001. European Science Foundation. ISBN 2-903148-96-1. Further information on the activities of the ESF can also be obtained on http://www.esf.org

British Phycological Society Winter Meeting and 47th Annual General Meeting

4-7 January 1999

University of Dundee, Scotland

Presidential Address

'From Algal Culture to Ecosystem; From Information to Culture'

to be given by

Professor Brian Moss

University of Liverpool

oOo

Oral and Poster Sessions

Threatened and Threatening Algae

Algae in Extreme Environments

Algal Taxonomy

Inorganic and Organic Carbon Assimilation by Algae

Manton prize for best oral presentation and prize for best poster

Local Organiser is John Raven, Department of Biological Sciences, University of Dundee, Dundee DD1 4HN.

International Meeting
Primary Productivity of Planet Earth

Biological Determinants and Physical Constraints in Terrestrial and Aquatic Habitats

Plymouth, UK, 6-11 September 1999

Topics Include

Plant form and function; carbon metabolism and primary productivity; ecological constraints; regional and global assessments; photosynthesis and plant productivity in transition

Confirmed Speakers

Paul Falkowski (US), John Grace (UK), Philip Grime (UK), Todd Kana (US), Steve Long (US), Trevor Platt FRS (Can), John Raven FRS (UK), Shubha Sathyendranath (Can), Victor Smetacek (Germany), Thomas Voglemann (US), Ian Woodward (UK)

Contributions

As well as invited presentations there will be the opportunity for a limited number of oral and poster contributions

For Further Details and a Registration Form

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Note that numbers will be restricted to 100 participants

Organised by Richard Geider, Bruce Osborne, Steve Long and Murray Brown

Sponsored by The Marine Biological Association of the UK, The British Phycological Society, The British Ecological Society, The Challenger Society, The Society for Experimental Biology

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Instructions for Contributors

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.

Copy should be submitted, preferably, on disc (ms word for windows) and the editor reserves the right to edit the material before final publication.

Submission of Copy and Deadlines

Copy should be submitted to: Dr Bruce Osborne, The Phycologist, Botany Department, University College Dublin, Belfield, Dublin 4, Ireland, Tel. +35317062249, Fax. +35317061153, E-mail: BOsborne@Macollamh.ucd.ie.

Deadlines are January 31 for the April Issue, May 31 for the August issue and September 30 for the November issue

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