

# British Phycological Society Newsletter



## Editorial

This will be my final Newsletter as Editor and I must say that I have enjoyed my three years in charge. It has brought me into contact with many pleasant and obliging people who have freely given up their valuable time to help keep this publication going. To all those contributors over this period we are extremely grateful. The new Editor is to be Robert Edyvean whose address is on the back page. He will be pleased to hear from you about any phycological subject great or small so do not postpone or prevaricate; write to him at once.

1987 was the year of the Berlin Botanical Congress, a big event in every sense, and it was good to see how many BPS members from UK, continental Europe and further afield were present. However, if any phycologists felt overwhelmed by the massed ranks of other botanists, then 1988 will provide solace. To the organisers of the Melbourne Congress we send best

wishes for an outstandingly successful meeting; There is no prize for identifying this year's masthead!

Those members who continue to miss our summer field meetings, and who would like to see them reinstated, may have their wishes gratified. The British Ecological Society is to hold a summer meeting on the Isles of Scilly in July 1989 and the Meetings Secretary has kindly agreed to open up this to BPS members. Some of our older members may recall a very successful BPS visit to the Isles of Scilly in 1968 - it really is an excellent place for phycology. Any would-be participants should contact the BES Meetings Secretary (See FORTHCOMING EVENTS).

Finally we wish all members a happy Christmas and good health in the coming year.

Editor

## Immobilized micro-algae and cyanobacteria

### 1. Introduction

Cell immobilization is a major growth area in research, development and practice in biotechnology. It can be defined as "the attachment, or entrapment, of the cells on, or in, an inert carrier, or matrix". The overall rationale for the immobilization of biocatalysts i.e. cells, isolated membranes, organelles and enzymes is a powerful one and the approach is being used for the application of isolated higher plant and animal cells, bacteria, yeasts and filamentous fungi. Although regarded as a new technology, we should remind ourselves that many microorganisms, including algae and cyanobacteria, grow on surfaces or in porous structures in their natural environments, and that several long-established industrial processes depend upon immobilized cells e.g. vinegar manufacture using *Acetobacter* attached to wood chips and waste water treatment using trickling filters containing films of bacteria, protozoa, fungi and algae. However, research on the immobilization of micro-algae and cyanobacteria for biotechnological purposes is at an early stage, although several potential uses for immobilized photosynthetic microbes are already apparent.

Cells may be used in immobilized form for the following purposes:

- a) Production of useful substances or energy by de novo biosynthesis or biotransformation.
- b) Removal of harmful or waste substances from potable waters and effluents.
- c) Recovery of useful/valuable materials from primary sources and effluents.
- d) As measuring devices (biosensors)
- e) Model systems for research

This article will not attempt to provide comprehensive citations to the very large literature of cell immobilization. A large number of reviews exists, largely on the immobilization of heterotrophic cells. For reference to these and a survey of the primary literature for 1983-1985 the useful review of Scott (1987) is recommended. For reviews of the relatively small literature on immobilized algae and cyanobacteria, see Rao and Hall (1984) and Robinson, Mak and Trevan (1986a).

### 2. The rationale for cell immobilization

Immobilization enables cells to be conveniently handled and retained in a bioreactor, while the gaseous and liquid phases, containing e.g. substrates for bioconversion, or materials for recovery, are passed through the reactor. The rationale for cell immobilization and advantages of

the use of immobilized versus free-living cells extends to plants, animal and microbial cells in general, and applies in all aspects to micro-algae and cyanobacteria:

- a. Retention of biomass. Immobilized cells can be used in fed-batch and continuous flow bioreactors at flow rates far greater than the maximum growth rate of the organism without the loss of biomass (wash-out), in contrast to cells in free suspension.
- b. Recovery of extracellular products. Biomass is retained in the reactor, extracellular products are recovered from the medium leaving the reactor and the need for post-harvest cell separation is avoided.
- c. Reactor biomass concentration. In contrast to continuous flow processes containing cells in suspension, immobilized cell biomass concentration in a reactor can be varied independently of dilution rate, enabling higher volumetric productivity to be achieved.
- d. Limitation or prevention of cell growth. Growth of immobilized cells can be permitted or prevented, to favour the formation of primary or secondary metabolites respectively.
- e. Multienzyme reactions. The immobilization of whole cells rather than isolated enzymes, may avoid the problems of enzyme extraction and purification, loss of enzyme activity *in vitro*, cofactor regeneration and permits the operation of biosynthetic processes involving multi-enzyme reactions.
- f. Greater protection against environmental stress. Immobilized cells are often less susceptible to environmental stress (e.g. extremes of temperature and pH) than free-living cells and entrapment in particular may protect fragile organisms from the shear forces and mechanical abrasion often associated with growth of free-living cells in reactors.
- g. Genetic advantages. The likelihood that unwanted mutations or revertants may outgrow the desired mutant or strain in use in a bioreactor is lessened by immobilizing the organism. In addition to the option of preventing cell growth and division, the containment of dividing cells in/on discrete particles ensures that a mutant arising is confined to its place of origin and that, unless cell escape is a problem, it does not take over the whole reactor.

### 3. Methods of cell immobilization

A wide variety of immobilization methods has been devised, initially for use with bacteria, yeasts and fungi (Venkatasubramanian, 1979; Woodward, 1985). Most are readily transferrable to algae and cyanobacteria. The constraints of mass transfer in and out of the support matrices available, matrix (in) stability and toxicity of some materials used (e.g. polyacrylamides) may affect phototrophic and heterotrophic cells. The additional requirement in the choice of immobilization method for the phototrophs is that of adequate light transmission. Cell immobilization may be achieved by prior culture using standard methods e.g. in liquid suspension,

then cell harvest and attachment or entrapment. Alternatively, immobilization may be obtained passively by allowing cells to invade and colonise a suitable support and subsequently become immobilized.

The natural tendency of many microbes to adhere together (aggregate) or attach to surfaces can be exploited as an immobilization method. (Whilst this particularly applies to several yeasts and fungi (e.g. *Saccharomyces cerevisiae*, *Penicillium chrysogenum*) and some floc-forming bacteria (*Zymomonas mobilis* strains), the tendency of many filamentous cyanobacteria to aggregate (e.g. many *Nostoc*, *Phormidium* spp.) has not been exploited. Attachment to surfaces may be achieved by covalent bonding, ionic attraction, cross-linking with glutaraldehyde and the use of photocrosslinkable resins (Woodward, 1985). Attachment methods are not widely used since covalent bonding often causes cell inactivation and ionic attachment is sensitive to changes in the pH and ionic strength of the liquid phase.

Cell entrapment has been more widely adopted with all groups of cells and with algae and cyanobacteria in particular. The materials used for entrapment include natural polysaccharides e.g. alginates, carrageenans and agars, proteins e.g. gelatin, collagen and egg white or synthetic polymers (acrylamide, photocrosslinkable resins and polyurethanes). Alginates have been the most widely adopted and cell entrapment using these materials is straightforward. Soluble alginic acid is first mixed as an aqueous solution with a concentrated cell suspension and entrapment performed by stabilization with multivalent cations e.g.  $\text{Ca}^{2+}$ ,  $\text{Ba}^{2+}$  or  $\text{Al}^{3+}$ .

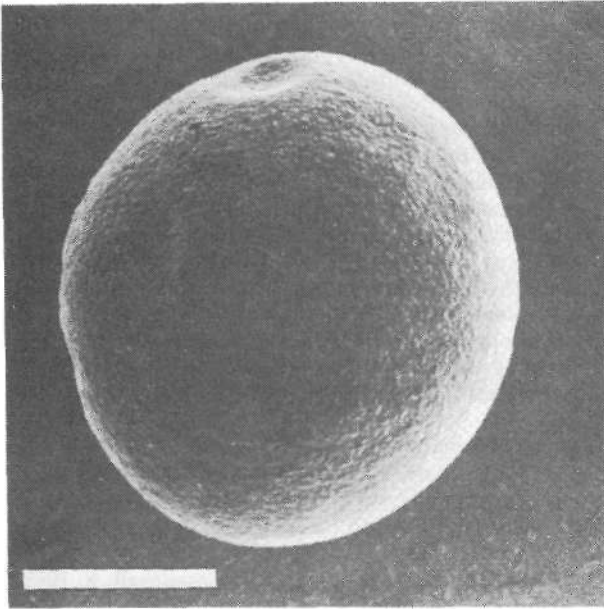
For example alginate beads containing algae can be formed by pumping the alginic acid/cell mixtures through a fine nozzle and allowing droplets to fall into a bath of 0.1M  $\text{CaCl}_2$  solution (e.g. Musgrave, Kerby, Codd and Stewart, 1982). Entrapment of cyanobacteria and microalgae has also been performed in thin alginate films (e.g. Musgrave, Kerby, Codd, Rowell and Stewart 1983b; Adnan and Codd, 1987). Much of the work on the selection of matrix material has been empirical since gel stability, permeability and toxicity problems vary with the type of reactor and organism used and there is considerable scope for further development in this area.

### 4. Examples of the use of immobilized micro-algae and cyanobacteria

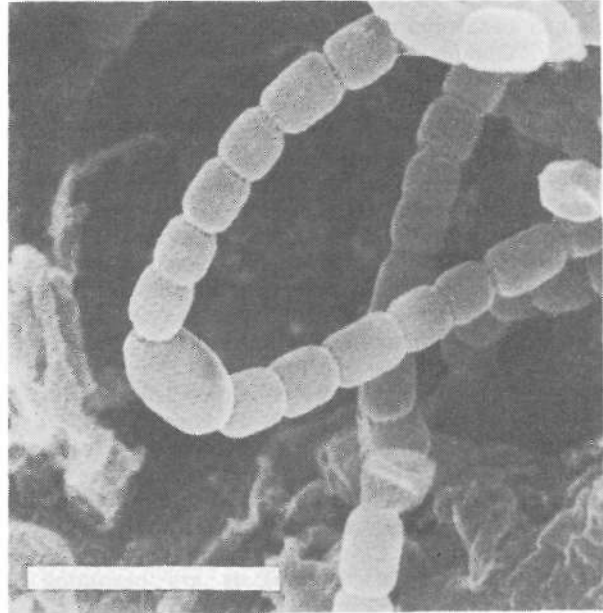
Algae and cyanobacteria have begun to be immobilized for the purposes of energy conversion, biosynthesis, product transformation, waste removal and as biosensors. All of these objectives have been coupled to the photosynthetic activity of the cells, rather than any heterotrophic potential. For example electric current has been generated using immobilized *Anabaena* (Ochiai, Shibata, Sawa and Katoh, 1980) and hydrogen photoproduction has been obtained by several species of *Anabaena* and *Anacystis*, *Mastigocladus laminosus* and *Nostoc muscorum* using cells attached to glass beads (Lambert, Daday and Smith 1979) and entrapped in alginates, agar, agarose and polyurethane foam (Weetall and Krampitz, 1980; Kayano, Karube, Matsunaga, Suzuki and Nakayama, 1981; Muallem, Bruce and Hall, 1983; Brouers and Hall, 1986).

Nitrogen-fixing *Anabaena* spp. have been immobilized in calcium alginate beads and films, polyvinyl foam and polyurethane foam for the photoproduction of ammonia (Musgrave *et al.*,

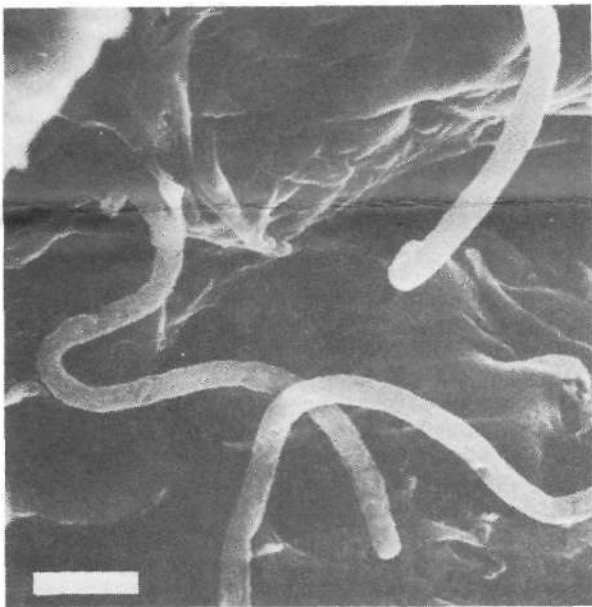
Scanning electron micrographs of immobilised microalgae and cyanobacteria.



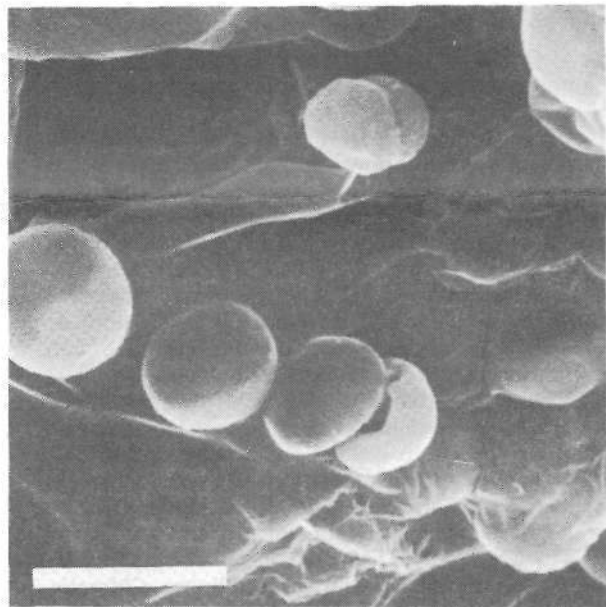
Intact calcium alginate bead containing cells. Bar = 1.0mm



Filaments of *Anabaena cylindrica* in a 6-month old calcium alginate bead. Bar = 10µm.



Filaments of *Oscillatoria agardhii* in a 28-day old calcium alginate bead. Bar = 10µm.



*Chlorella emersonii* in polyacrilamide gel. Bar = 10µm.

1983a, b; Brouers and Hall 1986; Jeanfils and Loudeche 1986; Kerby, Musgrave, Rowell, Shestakov and Stewart, 1986). The strategy employed has been to first grow cultures under  $N_2$ -fixing conditions to maximize  $N_2$ -fixing capacity, then to immobilize and maintain the biocatalyst under  $N_2$ -fixing conditions and to prevent the assimilation of the fixed  $N_2$ . This has been achieved by the incorporation of the chemical inhibitor of the main  $NH_4$ -assimilating enzyme glutamine synthase, methionine sulphoximine, in the medium (Musgrave *et al.* 1982, 1983) and the use of mutants deficient in glutamine synthase (Kerby *et al.* 1986). Extracellular amino acid production by immobilized  $N_2$ -fixing *Anabaena*  $N_2$ -fixing *Anabaena* mutants has also been obtained (Kerby, Niven, Rowell and Stewart, 1987).

Immobilized phototrophs can be used to convert  $CO_2$  into extracellular organic carbon and

extensive studies on sulphated polysaccharide excretion by immobilized *Porphyridium cruentum* have been made by Gudin and colleagues. Entrapment in polyurethane foams has enabled extracellular polysaccharide release to be obtained from a red-batch fluidized bed for 3 years (Gudin and Thepenier, 1986). Glycerol excretion and glycollate excretion have been obtained with immobilized *Dunaliella parva* and *D. tertiolecta* (Grizeau and Navarro, 1986) and *Chlorella emersonii* (Day and Codd, 1985, 1986), respectively. Hydrocarbon production and transformation has also been obtained with immobilized *Botryococcus braunii* (Bailliez, Largeau and Casadevall, 1985).

Immobilized micro-algae and cyanobacteria have so far received little attention as possible systems for waste removal and detoxification. However, increasing concern over unacceptable

levels of nitrate and nitrite in potable waters has created an interest in the use of immobilized microbes for their removal. Jeanfils and Thomas (1986) have immobilized *Scenedesmus obliquus* in alginate beads and used these to remove nitrite from water. Optimization of this laboratory-scale process appears to be well justified.

Oxygen-evolving photosynthetic cells may find application as suppliers of O<sub>2</sub> to aerobic heterotrophs in processes containing immobilized biocatalysts. Several systems involving immobilized aerobic bacteria and moulds are limited by O<sub>2</sub> supply to the entrapped cells and co-immobilization of the heterotrophs with photosynthetically-active micro-algae or cyanobacteria may help to alleviate this limitation. Increased yields of hydroxyacetone and of keto acids by immobilized cultures of the aerobic bacteria *Gluconobacter* and *Providencia* respectively have each been obtained by co-immobilization with *Chlorella* (Adlerkreutz, Holst and Mattiasson, 1982; Wikstrom, Swajcer, Brodelius, Nilsson and Mosbach, 1982). We have obtained increased yields of extracellular amylase produced by immobilized *Bacillus mycoides* by co-immobilizing with photosynthesising *Chlorella emersonii* (Adnan and Codd, 1987). Microbiologists are becoming increasingly interested in the metabolic relationships between organisms in mixed fermentations and co-immobilization offers considerable potential as a model in this research.

##### 5. Constraints and further prospects for the use of immobilized micro-algae and cyanobacteria in biotechnology

As emphasised by Robinson *et al.*, (1986a) an increased understanding of the effects of immobilization on the physiology and biochemistry of algae and cyanobacteria is essential to enable greater practical application of these organisms in immobilized systems. These workers with *C. emersonii* (Robinson, Dainty, Goulding, Simpkins and Trevan, 1985) and Bailliez *et al.* (1985) with *B. braunii* have found that the growth rate and respiration rate of the immobilized algae were lower than with free-living cells. We have examined several key enzymes of photosynthesis and photorespiration in *Chlorella* (Day and Codd, 1985, 1986) and of nitrogen fixation and metabolism in *Anabaena* (Musgrave *et al.* 1982) and found these to be similarly active in immobilized and free-living cells. Chlorophyll content per cell is significantly higher in immobilized than free-living *Chlorella* (Robinson *et al.* 1985) and the heavy peripheral growth of this alga in spherical alginate beads (Day and Codd, 1985; Robinson *et al.* 1985) suggests that the immobilized cells may be light-limited. However, rates of photosynthetic O<sub>2</sub> evolution by intact beads containing *Chlorella* versus incident irradiance are similar to those of free-living cells (Day and Codd, 1985) and more recent studies have indicated CO<sub>2</sub> supply to be limiting in these systems (Robinson, Goulding, Mak and Trevan, 1986b).

The acknowledged need for increased basic knowledge of cell physiology, biochemistry and genetics to underpin biotechnology applies to immobilized cells, as to microbes, animal and plant cells in free liquid culture, tissue culture etc. The identification of additional potential applications for immobilized micro-algae and cyanobacteria may help to justify the scientific need for, and finance for, further fundamental studies on the effects of immobilization. For example, the ability of micro-algae to accumulate heavy metals in wastewater treatment systems (Gale, 1986) and the renowned

ability of *Chlorella* to accumulate gold from dilute aqueous solutions (Greene, Hosea, McPherson, Henzl, Alexander and Darnall, 1986) offer further prospects for using immobilized algae in processes of environmental and commercial value.

Algae and cyanobacteria are receiving increasing attention as sources of fine biochemicals and biologically-active compounds (e.g. Borowitzka, 1986; Metting and Pyne, 1986). Compounds produced by these organisms of potential scientific and commercial value include antibiotics, lipids, pigments, plant and animal cell growth regulators and other pharmaceuticals. Screening programmes are being established in several countries to identify additional low volume- high value products of these organisms and it is anticipated that cell immobilization will further develop as part of the enabling technology in the economic applications of micro-algae and cyanobacteria.

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G.A. Codd, Department of Biological Sciences, University of Dundee, Dundee DD1 4HN, U.K.

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## XIV International Botanical Congress Berlin 1987



The programme confidently announced that the Congress would open on July 24 at 15.00h, and at that time exactly it did so, with a fanfare by the excellent Westfälisches Sinfonieorchester. The Congress was held in the International Congress Centre (ICC), an architectural colossus whose grim exterior concealed a host of technological marvels. Its enormous ground floor contained banks, post office, restaurants and an unfailingly polite and helpful secretariat. From this level arose a series of escalators which smoothly and silently conveyed botanists to and from their sessions in the various lecture rooms and halls. These ranged in size from small seminar-room type of accommodation to Hall 1, the cavernous but acoustically perfect auditorium in which the opening ceremony and concert took place.

At registration, we received a volume of abstracts and a guide book to the sessions. The latter was a model of good organisation and a delight to use. It contained a fold-out time-table of all lecture and poster sessions plus a map of the ICC showing their various locations. It was easy, therefore, to plan one's day and, if the chosen session did not altogether fulfil

expectations, there were always plenty others in reserve.

The organisation was flawless and the only problems encountered by the writer were caused by the participants themselves, who sometimes turned up in droves to sessions for which questionnaire returns had suggested small audiences. Other sessions which seemed likely to be popular were inexplicably thinly attended. At lunch one day, a participant reported that a cladistics session had not been very well attended, tidings which were received with satisfaction by the non-cladists present.

Approximately 3,700 persons registered and, especially heartening, 20% of these were students. The Congress President (K. Esser), Congress Secretary General (W. Greuter) and the President of the German Botanical Society (W. Nultsch) are to be congratulated. They and their team of energetic and enthusiastic organisers have demonstrated that Botanical Congresses are very much alive and, in doing so have justly earned every bit of the official and unofficial praise which they received.

It would require an entire newsletter to detail all the algal papers and posters, and invidious to be selective. Some, it is true, were somewhat isolated in otherwise non-algal sessions, but many were not. In any case, there is a good argument for sometimes combining papers on a variety of taxa but with a common scientific methodology rather than vice versa.

Phycologists did eventually meet together socially at a party kindly provided by Professor Geissler and her colleagues at their new laboratory in the Institute for Systematic Botany and Plant Geography at the Free University. It was a very enjoyable conclusion to a memorable Congress.

Editor

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## International Symposium: Progress in Algal Taxonomy

Smolenice, Czechoslovakia, June 15-19, 1987

The picturesque castle at Smolenice in the foothills of the Carpathian mountains was the somewhat idyllic venue for this symposium. It was organised under the auspices of the Slovak Academy of Sciences with Dr Frantisek Hindak the chairman of the organising committee and Drs Hanus Ettle, Jiri Komarek; and Petr Marvan the convenors of the scientific programme. Four days were spent in formal sessions at the Castle followed by a post-symposial excursion (organiser Dr. Oldrich Lhotsky) to the South Bohemian fishpond region of Trebon.

After the formal opening ceremony on Monday afternoon there followed invited papers by Drs Jorgen Kristiansen, Patricia L. Walne, Dieter Mollenhauer, and Ljudmila Rundina. The theme of the Tuesday morning sessions was the 'Taxonomy of Individual Groups' with the six presented papers dealing with green or blue-green algae. In the

afternoon all the participants visited nearby Driny Cave and in the evening Oldrich Lhotsky gave a slide-illustrated talk on the history of algological research in Czechoslovakia. The next day was given over to a workshop on the 'Taxonomy of Green Algae' organised by Hanus Ettl (assisted by Dr Hans J. Sluiman). The first part covered taxonomic concepts at lower levels and included lectures on the pyrenoid in *Monoraphidium* (Krientz, L.), the culture-based definition of *Pseudendoclonium* spp. (John, D.M. & Johnson, L.R.), cell wall autolysis in asexual reproduction of *Uronema* (Schlosser, U.G.), and the coenocytic line within coccal green algae (Komarek, J.). The second part dealt with the classification of higher taxa with Dr Michael Melkonian talking on the importance of motile cell ultrastructure and Dr Sluiman presenting new information on cell division in *Trebouxia* aggregate. On the final day Dr Marvan gave an introductory lecture on modern methods of taxonomic evaluation and there followed four dealing with the taxonomy of diatoms (principally *Stephanodiscus* spp.) and one on the dinoflagellate *Ceratium* by Dr Barbara Hickel. About 20 posters were presented covering algal taxonomy, ecology, and

distribution. Following the poster presentation on the final day Dr Imre Friedman gave an interesting talk on endolithic algae in the Arctic. Gifts were presented at the closing ceremony to some of the more senior phycologists attending the Symposium.

The Symposium was attended by over 70 participants from 17 countries with English the working language. Much emphasis was given to the poster presentations which numbered more than the lectures. One of symposium's most important achievements was to provide a forum for phycologists from east and west to discuss and to exchange ideas on algal taxonomy. Like many small meetings there was a general air of informality and this along with the friendly atmosphere created by our Czech hosts led in no small measure to its success. The finale was a barbeque in the forest where we were treated to meat roasted over ashes, excellent Carpathian wines, and music provided by a folk group.

Dr David M. John, Department of Botany, British Museum (Natural History), Cromwell Road, London SW7 5BD.

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## Taxonomic Data

Are you writing a Flora, handbook or monograph, or revising a classification, or using numerical taxonomy? If you are prepared to use one, a computer can help in many aspects of a taxonomist's work. Whether you are a botanist or a zoologist, cladist or pheneticist, conservative or radical, you are likely to be:

- 1) compiling data describing species (taxa) i.e. a database, and
- 2) processing it: for keys, classifications and descriptions; computers can do all these things very well, not to mention making bibliographies and catalogues.

Underlying all this is the DATA, and if it's well organised in computer-readable form, it's a DATABASE, and if everyone were to use the same FORMAT, then it could be exchanged and processed internationally. For these reasons, you might do well to choose the DELTA format (Ref.1), since it's the most comprehensive and flexible available.

### DELTA format

Allows all kinds of characters, whether they be qualitative (binary or multi-state, ordered or unordered) or quantitative (integer or real, with units if needed). Comments are allowed anywhere, and character dependency can be described. Directives are included to control computer processing. The designer of DELTA has prepared his own processing package (CONFOR, Ref.1), and several impressive databases have already been distributed e.g. genera of grasses, plant pathological viruses.

### My program package

1. Key construction in either style, with optional indentation, auxiliary characters are included, and there is a choice of the number of characters to search for when constructing each lead. There is also

weighting of characters and taxa, and partial keys (where not all the taxa are distinct) can be produced.

2. On-line identification In two parts: part I checks and compresses the data, Part II is interactive and works in a question and answer mode, and can suggest good characters for general use or for diagnosing a particular taxon. The user can vary the accuracy wanted (mistakes can be tolerated), and taxa can be compared.

3. Interactive key construction The best possible way to write a diagnostic key. The program looks after all the details while helping you to make an expert choice at every stage.

4. Description printing The numerical database is converted to printed descriptions with paragraphs, sentences and punctuation, and sectional summaries. Characters can optionally be numbered for proof-reading.

5. Diagnostic descriptions A program to find all the sets of characters which will distinguish each taxon from all the others. There are options to find larger sets also, and to set the minimum number of characters differences.

6. Identification by matching A program which identifies by making a comparison using similarity coefficients.

7. Conversion into similarity coefficients for further processing by clustering programs for (phenetic) classifications.

8. Conversion into PAUP format for data input into PAUP, a popular program for cladistic classification.

Further programs are under preparation: one for interactive key construction and another for editing DELTA data.

### Publications

A good many of the techniques used above are described in the book (Ref.2). Research papers have been published which describe most of the programs. Each program is supplied with complete

documentation, and there is a test data set provided which is used as basis for worked examples throughout.

#### Language and distribution

All programs are written in a very standard FORTRAN 77. They can be implemented on all kinds of computers, mainframes to minis or micros. They run on MSDOS micros (IBM and compatibles, Apricot), and under UNIX. CP/M micros with only 64K RAM are too small in general, but the interactive program Part II runs well under CP/M, and there is a special version for the BBC-B. Various botanical datasets are also available, particularly for identifying difficult groups of British plants, and for identifying Angiosperm families. Programs are made available on magnetic tape for mainframes or minis, or on floppy discs for micros. For IBM PC compatibles, please state whether you have 256K RAM (minimum) or 512K, and whether you want versions which use the 8087 maths coprocessor.

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Richard Pankhurst, Department of Botany, British Museum (Natural History), Cromwell Road, London SW7 5BD

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## Developments at the culture collection of algae and protozoa

It is just over a year since the relocation of the CCAP to the Freshwater Biological Association and the Scottish Marine Biological Association took place as reported in the BPS Newsletter of December 1986. It has been a very busy year with the main objectives being to establish the cultures in their new laboratories and incorporate the already existing culture collections at FBA and SMBA, merge the CCAP library and bibliographic information with the FBA library and prepare a new catalogue.

The new catalogue which is now in press contains a major revision of the strain holdings. Over 2000 strains of algae and protozoa are listed with information on source, synonymy of strain designations in other collections, media for maintenance etc. There is a large section on media preparation including many media not previously listed. Among details of other CCAP services offered are the procedures for both requesting and depositing cultures together with further information on patent deposits. We realise that the high cost of the cultures is a deterrent to many on tight budgets and we are looking at ways to make at least some of the cultures much more affordable - keep watching the Newsletter!

CCAP is not just a collection of cultures. It is now situated within the research and facilities of the two Associations and being developed within their research programmes. These include studies of eco-physiology, biochemistry and life histories of algae and protozoa. There are also interlinkages with studies of zooplankton and microbial algal grazing. The particular strengths of CCAP at Cambridge of electron microscopy and cryobiology have been further enhanced on relocation by new equipment purchase. A Hexland cryo-transfer has been fitted to the JEOL 100CX TEMSCAN electron microscope enabling examination of fully hydrated (frozen) cells to be carried out by scanning electron microscopy. A planar Kryo 10 controlled rate freezer has been installed in the cryo/cell biology laboratory enabling cells to be frozen at set rates of cooling. These new facilities are already contributing to CCAP research. The inter-relationships between CCAP and the Associations gives the added benefits of the finest library of its kind, at the FBA and the invaluable Fritsch Collection of Algal Illustrations under the ever-attentive curation of John Lund.

So far, CCAP has welcomed a steady flow of visitors. It provides limited facilities for collaborative work with visiting scientists. CCAP has been and will continue to be an important international scientific resource. We hope you will take advantage of it and use it.

Ivan Heaney, Freshwater Biological Association, The Ferry House, Ambleside, Cumbria LA22 0LP.

## Letters to the Editor

Dear Sir

I don't know what the "masthead vignette" for July 1987 is - unless it is the Editor's dental record in case, in a fit of despair at the tardiness, puerility, or sheer lack of Newsletter contributions, he decides to "uncoil this mortal shuffle"?

An Anonymous Reader

Dear Anon,

Thank you for your interesting letter. I have come across your publications from time to time and, I see that according to Dixon, Irvine & Price, you have been producing these with unflagging energy since 1820. So it is an honour as well as a pleasure to hear from you.

Anyhow the objects you refer to were not my dental record. Actually, they are an imprint of my worry beads which fell from my hands at the thought of having no copy whatsoever.

Editor

P.S. Are you sure you are not confusing this with another society's Newsletter?

P.P.S. The objects could be the morphs of *Spondylosium planum* described by West (1912).

# Forthcoming Events

## Conservation Association of Botanical Societies/Flora and Fauna Preservation Society

A symposium with the title IS NATURE CONSERVATION WORKING FOR PLANTS? will be held on Saturday March 5th 1988 in the Meeting House of the Zoological Society of London, Regent's Park, London. Further details and booking forms are available from FFPS, 8-12 Camden High Street, London, NW1 4RY.

## British Ecological Society.

The B.E.S. have several meetings in 1988 that may be of interest to BPS members.

12-14 April: BES Jubilee Symposium I - Ecological concepts. The contribution of ecology to an understanding of the natural world. University College, London.

6-9 July: Techniques in the teaching of ecology. University of Keele.

13-15 September: BES Jubilee Symposium II - Towards a more exact ecology. University of Oxford.

July 1989: Summer field meeting, Isles of Scilly.

For details of these, please contact Dr P.J. Edwards, Hon. Meetings Secretary B.E.S., Department of Biology, The University, Southampton, SO9 5NH.

## The Chromophyte algae: Problems and perspectives

Plymouth, England, 5 - 9 April, 1988

This international Symposium will draw together workers from a wide range of disciplines to discuss the latest thoughts on the status and relationships of this diverse assemblage of algae. Aspects of their biochemistry, physiology, fine structure and phylogeny will be explored and their possible affinities with certain fungi and protozoan groups examined.

## Scope

The chromophyte algae will be regarded in the broadest context for the purposes of the symposium including, therefore, the following groups:

Cryptophytes	Dinoflagellates	Prymnesiophytes
Raphidophytes	Xanthophytes	Eustigmatophytes
Chrysophytes	Diatoms	Brown Algae

In addition, contributions on relevant aspects of Flagellated Protozoa and Fungi will be welcomed.

## Organisation of the Symposium

The Symposium will include 'keynote' addresses from invited speakers together with contributed papers from participants. Poster sessions and informal workshops will be organised outside the main sessions. Invited contributions will be published in the Special Volume Series of the Systematics Association.

Keynote speakers include:

G. Beakes (Newcastle)  
T. Christensen (Copenhagen)  
J. Dodge (London)  
J.C. Green (Plymouth)  
S. Jeffrey (Tasmania)  
B.S.C. Leadbeater (Birmingham)  
O. Moestrup (Copenhagen)  
D.J. Patterson (Bristol)  
F.Round, R.Crawford (Bristol) & D.Mann (Edinburgh)  
T. Cavalier-Smith (London)  
M. Clayton (Monash University)  
S.P. Gibbs (McGill)  
P. Heywood (Rhode Island)  
K. Kowallik (Dusseldorf)  
S. Liaaen-Jensen & T. Bjørnland (Trondheim)  
C. O'Kelly (Massey University)  
J. Raven & A. Johnston (Dundee)  
J. Whatley (Oxford)

For further information, please contact either:

Dr J.C. Green  
Chromophyte Symposium  
Marine Biological Assoc. of the UK  
Citadel Hill  
Plymouth PL1 2PB

Tel: 0752 221761

or

Dr B. S.C. Leadbeater  
Chromophyte Symposium  
Dept. of Plant Biology  
The University  
PO Box 363  
Birmingham B15 2TT

Tel: 021 472 1301 ex. 2573

*Editorial address* R.G.J. Edyvean, Department of Metallurgy, University of Sheffield, Mappin Street, Sheffield S1 3JD.

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