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PROTIST NEWS

Meeting Report: 7th International Phycological Congress, Thessaloniki, Greece, August 18–25, 2001

Enjoying warm and sunny days, approximately 450 phycologists from around the world reported their latest scientific discoveries and discussed algal current problems at the Aristotle University at Thessaloniki. The local organisers included I. Teskos, S. Delivopoulos, S. Haritonidis, and G. Nikolaidis. The Congress was organised around four themes: (a) systematics: changing concepts and total evidence, (b) cells and molecules: changing concepts and total evidence, (c) physiological and ecological interactions, and (d) algae and human affairs. In this report, we summarise some of the over 400 oral and poster presentations, and we name the speaker or first poster author, their institution, and the country of the institution. Unfortunately, we cannot mention all presentations or all authors of selected presentations. The full list of authors and the abstracts have been published in a special issue of *Phycologia* (2001, Vol. 40 (4) (suppl.): 1–132).

Greece is often considered the birthplace of western civilisation, and Aristotle as the father of biology. Not surprisingly, therefore, the first plenary lecture, presented by Mark Ragan (Brisbane, Australia), was titled "Phycology from Aristotle to Aristotle University". Ragan reminded us that the Greek word "phykos" appears in Homer's Illiad, and that Virgil referred to "worthless seaweeds". He also pointed out that Aristotle found it difficult to draw distinctions in his "chain of life" and that he recognised a "vegetative soul" for plants. Ragan reminded us that Theophrastis contributed significantly to Aristotle's knowledge of plants. Ragan's lecture proceeded chronologically, highlighting such famous scientists and works as Pliny (recognised 9 seaweeds), the Herbals (do not mention seaweeds), John Ray (views on classification), Linneaus (recognised several genera of algae, didn't consider life a continuum), Leeuwenhoek (microscopic algae), Lamaroux and Harvey (recognised the significance of pigmentation in algal classification), as well as contributions by Lyngbye, Agardh, Kützing, Nägeli, and Bütschli.

The systematic sessions were organised around major groups of algae (stramenopiles, alveolates, red and green algae) and algal biogeography. Speakers typically reviewed older literature, providing a foundation for discussing more recent discoveries. Although most speakers addressed many forms of evidence, it was surprising that most speakers did not conduct phylogenetic analyses incorporating all types of data, i.e., the usual meaning of "total evidence" analysis. Guillou (Barcelona, Spain) stressed the importance of picoplankton (e.g., contribute ~80% of primary productivity in oligotrophic waters), the recent discoveries of new algal classes dominated by picoplankton, and the widespread occurrence of small heterotrophic stramenopiles. Mann (Edinburgh, Scotland) discussed diatom morphology and phylogenetic analyses using (primarily) the *rbc*L gene. These results corroborate earlier 18S rRNA analyses that show the centric diatoms are a paraphyletic group, and they suggest that the *rbc*L gene is better suited for generic or family level analyses. Diatom genera that have been redefined in the past decade using plastid structure, critical analysis of the frustule by SEM and sexual compatibility are monophyletic in *rbc*L analyses, whereas certain traditionally circumscribed genera (e.g., *Amphora* and *Achnanthes*) are polyphyletic. Lundholm (Copenhagen, Denmark) provided a detailed morphological and molecular examination of the toxic diatom *Pseudo-nitzschia*, showing there were several clades that correspond to toxic and non-toxic forms. Burger (Montreal, Canada) presented phylogenetic analyses based upon complete mitochondrial genomes, showing that the stramenopiles form a monophyletic clade. The genomes are 35–50 kb in size, and most are circular (*Ochromonas*, as previously published, is linear). Dinoflagellates and apicomplexans were emphasised in the alveolates sessions, with additional remarks on the Perkinozoa and cilates. Taylor (Vancouver, Canada) provided a review of dinoflagellate morphological characters, fos-

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sils and evolutionary schemes. Saldarriaga (Vancouver, Canada) focused on phylogenetic analyses, corroborating earlier studies showing the dinoflagellates, apicomplexans and ciliates are related. In these analyses, the syndinians (and *Perkinsus*) were basal to other dinoflagellates, and the dinoflagellates were sister to the apicomplexans. The alveolates, stramenopiles and cryptophytes share a common plastid-containing ancestor in GapC gene analysis, implying that ciliates, oomycetes and other nonplastid taxa in this clade are secondarily heterotrophic. Moestrup (Copenhagen, Denmark) showed that the Perkinsozoa, including *Parvilucifera*, was an intermediate group between the dinoflagellates and apicomplexans based upon LSU rRNA sequence analyses. Light and electron microscopical features, as well as molecular phylogenies, for several recently published generic revisions/descriptions were also presented. Lewis (London, England) addressed the dual naming of flagellates and cysts that result when scientists independently study living and fossil forms. She suggested that the thecal plates of flagellates are more stable than the spines used for naming cysts. Montresor (Naples, Italy) described the intraspecific variability in *Scrippsiella trochoidea*, concluding that there may be cryptic species within this complex. Mc Fadden's group (Melbourne, Australia) summarised evidence showing the apicoplast of *Plasmodium* and *Toxoplasma*, while highly reduced, is essential. Enzymes for fatty acid synthesis, heme synthesis, isoprenoid biosynthesis, etc., are nuclear-encoded and targeted to this highly reduced plastid. They reported that investigations are underway to develop antibiotics acting specifically against these apicoplast pathways in an effort to cure malaria. Marin (Cologne, Germany) presented a review of classical green algal classification (e.g., schemes based upon an evolution of ever-increasing complexity from a single cell flagellate) through to modern schemes based upon ultrastructure and molecular phylogenies. Marin also discussed *Chlamydomonas*, showing that this large genus (>600 spp.) is polyphyletic. A review of Ehrenberg's type description (*C. pulvisculus*) showed that it included forms that belong to several species in different lineages. In a revision that will please many, Marin suggested that *C. reinhardtii* should be designated the new type species. Other changes include the recognition (again) of *Chloromonas* and *Chlorogonium*, along with two new genera. Nozaki (Tokyo, Japan) conducted phylogenetic analyses based upon 6021 bp of chloroplast genes, showing that the common *Volvox*, *Pleodorina* and *Eudorina* are polyphyletic. He proposed dividing *Volvox* by recognising the old generic names *Besseyosphaera* and *Campbellosphaera*. Molecular phylogenetic investigations of *Ulva* and *Enteromorpha* (Shimada, Sapporo, Japan) and *Codium* (Pedroche, Mexico City, Mexico) contradict the gross morphology used to traditionally classify these algae. Several papers addressed problems in non-flagellate green microalgae. For example, the small coccoid *Picocystis*, was discussed by Lewin (La Jolla, USA) and Hepperle (Stechlin-Neuglobsow, Germany), while Shubert (London, England) discussed the cell wall ultrastructure of *Scenedesmus* and *Desmodesmus*. Krienitz (Neuglobsow, Germany) examined the broader concept of families and genera of coccoid algae. Two brown algal hypotheses (Ectocarpales are basal taxon, Fucales are basal taxon) were discussed by de Reviers (Paris, France), and current results suggest both hypotheses are incorrect. Rather, it appears that *Choristocarpus* (Dictyocales) is the basal taxon based upon LSU rRNA and *rbc*L genes. Kawai (Kobe, Japan) described a recently discovered branched uniserate filamentous alga containing alginates in the cell wall. Based upon 18S rRNA sequence analysis, this new organism falls at the base of the Phaeophyceae, but it lacks certain brown algal features, and it was proposed that this alga belongs to a new class (Schizocladiophyceae). Lane (Fredericton, Canada) examined representatives of the Laminariales in a combined analysis using the LSU and ITS rRNA plus the *rbc*L gene. Three clades were recovered in the analysis, however, they did not correspond to the existing kelp classification based upon morphological data. Two red and green algal papers emphasised species concepts, speciation, and population diversity (Kooistra, Naples, Italy; Zuccarello, Sydney, Australia). Saunders (Fredericton, Canada) examined the supraordinal taxonomy of red algae, suggesting that red algae are more diverse than other algal groups that are divided into many classes. He reported that the traditional Bangiophyceae (paraphyletic group) and Floridiophyceae (four assemblages) are no longer adequate for an evolutionarily based classification that incorporates the large amount of recent morphological and molecular data.

The biogeographical papers focused on red, green and brown seaweeds. For example, postglacial colonisation was investigated by Stam (Groningen, The Netherlands) using molecular data to study North Atlantic brown seaweeds and by Schneider (Hartford, USA) using traditional floristic studies to examine post Pleistocene algae in Bermuda.

The cell and molecular biology began with Brown's (Austin, USA) review of algal contributions to advances in cellulose biology, especially cellulose-synthesising terminal complexes (TCs). Okuda (Kochi, Japan) described the role of membranes in cellulose biosynthesis, including a new and distinct TC found in *Scrippsiella*. Kück (Bochum, Germany) described the mitochondrial DNA size of algae to approximately range between that of *Chlamydomonas reinhardtii* (15.7 kb) to *Prototheca wickerhamii* (55.3 kb). He pointed out that mitochondrial cytochrome *c* and other "old mitochondrial genes" are now coded in the nucleus, but that the mitochondria of algae have some new genes and new roles due to lateral gene transfer. Kowallik (Düsseldorf, Germany) presented a phylogenetic tree based upon 41 common plastid proteins, suggesting that a phylogeny of the plastids can now be accurately produced. He presented evidence that refuted earlier claims of small ring plastid DNA in dinoflagellates, and suggested that the typical dinoflagellate plastid arose from a cryptophyte, not a red alga. Gilson (Melbourne, Australia) reported that the chlorarachniophyte *Bigelowiella natans* has a nucleomorph containing three linear chromosomes, it is between 380–455 kb in size, is AT rich and has telomeres. Approximately 25% of the genes are involved in "housekeeping", and only about 5% are "end product" genes. He also reported that chlorarachniophyte nucleomorphs are intron rich, but very short (18–20 bp), implying that as the nucleomorph evolved genes were lost but introns were maintained and compacted.

A plenary lecture by Katsaros (Athens, Greece) summarised the use of algae as model systems, focusing on cytoskeletal aspects of algal cells. Luetz-Meindl (Salzburg, Austria) showed that actin-binding proteins (spectrin, alpha-actinin, profilin) are involved in the multipolar growth of desmid cells. Wilson (Melbourne, Australia) used time-lapse videomicroscopy and fluorescent stains and antibodies to examine the cytoskeleton of red algal spermatia and trichogynes of multicellular forms and the motion/movement of unicellular forms. Evidence suggests that the actin-myosin system governs sexual plasmogamy. Pickett-Heaps (Melbourne, Australia) described his continuing work on the role of the cytoskeleton during diatom morphogenesis, emphasising the formation of long siliceous spines. Van de Meene (Melbourne, Australia) presented videos showing rotation during the formation of the long (>100 µm) apical spine in the diatom *Rhizosolenia*. Using fluorescence microscopy techniques, she found a double ring of actin and tropomyosin at the base of the spine, with microtubules extending from the rings toward the cell centre. Kugrens (Fort Collins, USA) described the ultrastructure of different species of Uroglena *sensu lato*. The posterior of *Uroglena volvox* cells were tapered, with microtubules extending toward the centre of the colony. Conversely, cells of *Uroglena articulata* (probably *Uroglenopsis*) had a blunt posterior attaching to gel stalks that extended toward the colony centre. The flagellar apparatus and other features were also different, suggesting that *Uroglena* and *Uroglenopsis*, a genus ignored in recent literature, have fundamentally distinct ultrastructural features.

New facets to the large body of previous work on chemical interactions involving algae were presented at the meeting. Pohnert (Jena, Germany) presented new data concerning mechanisms by which grazed diatoms can actually inhibit reproduction of their copepod grazers. Many such interactions are mediated by aldehydes derived from fatty acid metabolism, but these compounds are clearly induced as part of a co-ordinated chemical defence and not simply as secondary metabolites. Another group of compounds receiving attention at the meeting were phlorotannins from macroalgae (e.g. Targett, Lewes, USA). These compounds are water-soluble compounds with antifouling properties. In many cases, mechanical damage (e.g. by grazing) appears to be a signal for production of these compounds, but the signalling pathways remain to be established (Steinberg, Sydney, Australia).

A major focus of the meeting was global change (reflected in the conference theme "ta panta rei"- everything changes) and the implications of such changes for different species of algae. Presentations relevant to the topic were included within both physiological and ecological interactions, and algae and human affairs themes. Several talks and posters focused on understanding and predicting responses of algae to increased UV radiation (especially the UV-B band) (e.g. Franklin, Canberra, Australia; Wiencke, Bremerhaven, Germany). Such responses include induction of mycosporin-like amino acids and xanthophyll cycling in order to protect cells from increased radiation and dissipate excess absorbed energy (e.g. Nixdorf, Bremerhaven, Germany; Neale, Edgewater, USA; Figueroa, Malaga, Spain; Karsten, Rostock, Germany; Korbee, Malaga, Spain). Responses of algae to increased temperature and increased CO_2 concentrations were also the subject of a number of papers and posters. A common result emerging from these studies, and highlighted by Beardall's (Clayton, Australia) keynote speech is that different components of climate change have differing and sometimes opposing effects. Moreover, the availability of nutrients such as nitrate strongly modifies the responses of algae (e.g. Gordillo, Malaga, Spain).

Complicating the prediction of the effects of climate change is a number of biogeochemical interactions between algae and their environment. For example, the links between algal sulphur metabolism and climate were discussed by Kirst (Bremen, Germany). Such interactions formed an important part of James Lovelock's Gaia hypothesis. In the theory, global warming increases algal production, which leads to increased production of the sulphur compound DMSP in algae. Subsequent cleavage and release of DMS to the atmosphere leads to oxidation products that act as cloud condensing nuclei, which leads to increased reflection of solar radiation and hence global cooling, and a regulating feedback loop is thus formed. DMSP appears to act as a compatible osmolyte involved in acclimation to changes in salinity, but many questions about the metabolism of the compound remain, and there are complicated interactions between grazing and DMS release. Interestingly, among the algal species so far examined, production of DMS seems to be largely confined to marine and not freshwater algal species (e.g. Kirst, Bremen, Germany). New information about algal sulphur metabolism brought about by analysis of mutants was presented by McDermott (Ames, USA), but few species besides green microalgae have received such attention. A second biogeochemical interaction explored at the meeting was the limitation of primary production in large regions of the oceans by iron. Two recent open-ocean iron enrichment experiments in the Southern Ocean, in both Pacific (the SOIREE experiment, presented by Boyd, Dunedin, New Zealand) and Atlantic sectors (the Eisenex I experiment, presented by Gervais, Bremerhaven, Germany), have demonstrated substantial changes in pelagic ecosystem structure brought about by iron additions, and significant effects on ocean chemistry. One possible effect of climate change is the shoaling of ocean mixed layers, which could lead to dramatic changes in patterns of primary production (Boyd, Dunedin, New Zealand). Also in the realm of biogeochemistry, the importance of biofilms (involving epi- and endolithic algae, yeasts and bacteria) as the "skin" of the planet was emphasized in a paper given by Krumbein (Oldenburg, Germany). Indeed, a case was made that the rocks of the planet could be largely considered as biological products, and that calcifying organisms in biofilms may well be driving plate tectonic processes. The impact of climate change on these groups of organisms remains largely unknown.

Some of the most visible anthropogenically-driven changes affecting algae involve species introductions, invasions and irregular blooms. These were considered in special sessions at the meeting, related to the theme of algae and human affairs. Results presented in many talks indicate that the idea that algal blooms and invasions are caused simply by nutrient enrichments (i.e. bottom-up control) or changes in predators (i.e. top-down control) is probably too simplistic. For example, evidence was presented in papers given by McCook, and by Diaz-Pulido (Townsville, Australia) that displacement of corals by macroalgae is much more complex than can be explained by increased algal growth due to nutrients. In many of the coral reef systems studied, herbivores seem to have the capacity to graze any increases in algal production brought about by nutrient enrichment. Moreover, and the results of algal-coral competitions is highly species-specific.

A large number of papers and posters were devoted to other anthropogenic effects on algae, particularly pollution. Algae are increasingly being used as bioindicators of heavy metal pollution in a number of ecosystems (e.g. Ismail, Kuala Lumpur, Malaysia; Z'bikowski, Gdynia, Poland). There is a growing understanding of how algae respond to metals in terms of induction of metallothioneins and phytochelatins (e.g. Torres, La Coruna, Spain; Pistocchi, Ozzano, Italy; Seferlis, Thessaloniki, Greece), and how the metals affect algae at the structural and biochemical levels (e.g. Pribyl, Brno, Czech Republic; de la Jara Valido, Las Palmas, Spain). However, not all anthropogenic effects are negative. Chapman (Baton Rouge, USA) described how the over 4000 oil platforms in the Gulf of Mexico have provided a "steel archipelago" that is dramatically increasing productivity (algae to fish) and diversity.

A number of new and developing methods are being applied to algal research and these ranged across the themes of the meeting. Fourier-transform infrared (FT-IR) and Raman spectroscopy were discussed in two talks given by Wood and Heraud (Clayton, Australia). These are being applied to identify chemical bonds in algal material, and quantify biochemical components of cells. Such methods work best in symmetrical and chromophoric molecules, and have some limitations; FT-IR requires removal of water from sample, for example. However, coupled with new imaging techniques, they offer the promise of single-cell quantification and localisation of materials in cells as an alternative to bulk biochemical analyses. Microsensor technology is being applied examine variables such as intracellular pH. Preliminary results indicate that some diatom species may maintain cytoplasmic pH's substantially higher than that of other cells examined (Kühn, Bremen, Germany). X-ray elemental analyses are being applied to algae to localise metals in seaweeds and colloidal gold labelling has been used to determine associations between metals and organic compounds in algae (e.g. Andrade, Rio de

Janeiro, Brazil; Salgado, Rio de Janeiro, Brazil). Simon (Roscoff, France) reported application of tyramide signal amplification of fluorescence in situ hybridization and confocal microscopy to examine bacterial groups associated with algae. Both endocytoplasmic and endonuclear bacteria have been identified in dinoflagellate species. It was shown that bacteria can attach to the dinoflagellate, augmenting the toxicity of *Alexandrium* through association, however, PSP toxin production was not induced by the attached bacteria. Medlin (Bremerhaven, Germany) described nested sets of rRNA probes that were effective in identifying algae from the class level to the population level. A hand-held electrochemical detection device has been developed using DNA chip technology so that field workers can quickly evaluate the presence or absence of toxic phytoplankton. Such advances bring automated identification of algal species one step closer to reality.

In addition to new methodologies, the research presented showed that a number of classical ecological ideas are being revisited. Papers were presented describing carefully-constructed experimental tests of Grimes concepts of disturbance and stress (Karez, Kiel, Germany), and Hutchinson's paradox of why planktonic algae exhibit such enormous diversity in environments with seemingly very few niches (Sommer, Kiel, Germany). Another fundamental ecological variable, mortality rates, has also been receiving attention. Veldhuis (Den Burg, The Netherlands) presented evidence that large proportions of phytoplankton cells are dead or dying in different ocean regions. Evidence that the underlying mechanisms of cell death in algae are apoptotic was presented by Segovia (Belfast, Northern Ireland).

Finally, some concerns were expressed about the overall profile of algal research in the biological sciences. Prud'homme van Reine (Leiden, The Netherlands) reported that amongst the thousands of algal species, only about 500 of the living species are of economic importance, while Lorenz (Göttingen, Germany) demonstrated how few strains of algae are maintained in culture collections, relative to what is available for other micro-organisms. In addition to living species, it should be remembered that petroleum deposits (crude oil, natural gas) are derived from carbon fixed by marine phytoplankton (and transformed by bacteria, heat and pressure); it is ironic that it is the burning of these reserves that created one of the focuses of algal research at this Congress.

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