# THE PHYCOLOGICAL SOCIETY OF AMERICA

*'Ipse super maria fundavit eum.' Psalms.*

Volume XI News Bulletin, November, 1958 Number 35

P. C. SILVA, Editor

## THE INDIANA UNIVERSITY MEETINGS

The thirteenth annual meeting of the Phycological Society of America was held in conjunction with the A.I.B.S. convention at Indiana University, Bloomington, August 24 to 28, 1958. Sunday, August 24, an algal foray led by Fay K. and W. A. Daily was held in Brown and Monroe counties, Indiana. During Monday afternoon, an open house was held in the phycological laboratories where the culture collection and living mounts of the volvocaceous series were demonstrated by Richard C. Starr and assistants. Individual papers were presented at sessions Tuesday morning and Wednesday morning and afternoon. All sessions were held jointly with the Phycological Section of the Botanical Society of America.

### MINUTES OF THE BUSINESS MEETING

The business meeting of the Phycological Society of America was called to order by the President, Dr. L. H. Whitford, at 4:20 p. m., August 27, in Room 135, Education Building, with 35 members present.

Minutes of the twelfth annual meeting (Stanford University) were approved as circulated to members in News Bulletin No. 32.

### OLD BUSINESS

*Secretary's Report*

The following officers were elected by mail ballot from a slate of nominees prepared by the Nominating Committee (J. Brunel, R. Patrick, and H. Humm, chairman):

P. C. Silva, University of Illinois . . . . . . . . . . President
R. C. Starr, Indiana University . . . . . . . . Vice-President
W. A. Daily, Butler University . . . . . . Secretary-Treasurer

(P. C. Silva agreed to continue to serve as Editor until Jan. 1, 1959, by which time it is hoped that the Executive Committee will be able to appoint someone for a three-year term.)

As of August 27, 1958, we have 12 Organizational Members and 265 Individual Members. During this past year we have gained 35 new members, but unfortunately we have lost 36 because of 32 "drops", one resignation, and three deaths. There were three reinstatements. There are also 79 members who have not paid their 1958 dues.

*Treasurer's Report*

| | | | |
|---|---|---|---|
| Balance on hand, Aug. 21, 1957 | | | $1070.53 |
| Income | | | |
| Dues | | | |
| Current | $381.00 | | |
| Back | 122.00 | | |
| Future | 30.60 | | |
| | | $533.60 | |
| Sale of reprints | | 193.50 | |
| Interest on savings (Jan. 9, 1957-Aug. 1958) | | 36.30 | |
| | | $763.40 | |
| Expenditures | | | |
| Printing and mailing of *News Bulletin* | | $438.07 | |
| Secretary's expenses | | 7.25 | |
| | | $445.32 | |
| Balance on hand, Aug. 22, 1958 | | | $1388.61* |
| Assets | | | |
| Checking account, Farmers Bank, Union Point, Georgia | | | $ 564.78 |
| Savings account, Farmers Bank | | | 773.83 |
| Checks to be deposited | | | 50.00 |
| | | | $1388.61 |

* The apparent gain of $318.08 will be offset by charges of about $325.00 for the printing of the August 1958 News Bulletin, the bill for which has not yet been received.

## NEW BUSINESS

*Executive Committee's Report*

The fourteenth annual meeting of the Society will be held at Montreal, Canada, at some time during the period August 19-29, 1959, which are the inclusive dates of the Ninth International Botanical Congress convening in that city. Only a business meeting will be held. Opportunities to present papers will be provided by the Phycology Section of the Congress. Professor Jules Brunel is chairman of the committee charged with organizing the Phycology Section.

The Secretary was instructed to write a letter of inquiry to Professor Brunel concerning a place to hold the business meeting and the possibility of serving refreshments.

The Secretary was instructed to write a letter of appreciation to Professor R. C. Starr, our local representative for the Bloomington meetings.

The meeting was adjourned.

Respectfully submitted,
W. A. DAILY,
*Secretary*

# PAPERS PRESENTED AT BLOOMINGTON

## Speculations Concerning the Function and Phylogenetic Significance of the Accessory Pigments of Algae

ROBERT EMERSON AND RUTH V. CHALMERS
University of Illinois

Special interest attaches to the accessory pigments of algae for two reasons. First, the natural occurrence of the pigments in certain combinations, each peculiar to a phylum or group of phyla, is accepted as evidence that the pigments are taxonomically and phylogenetically significant, but there seems to have been no serious attempt to provide a plausible and comprehensive explanation for the development and survival of the existing combinations of pigments since Tilden (J. E. Tilden, The Algae and Their Life Relations, Univ. of Minnesota Press, Minneapolis, 1935). The scheme she devised was in accord with information then available, but there have been important advances in our knowledge of the algal pigments which call for a fresh look at the problem. Second, it is now well established that light absorbed by the accessory pigments can be contributed to photosynthesis with high efficiency, and something is known of the manner in which this contribution is made, but the physiological significance of the different pigment combinations is not clearly understood.

Chlorophyll *a* is common to all autotrophic algae and higher plants. It is always accompanied by other plastid pigments, some of which have been shown to contribute the light energy they absorb to photosynthesis. These include chlorophylls *b* and *c*, the carotenoid fucoxanthol, and the phycobilins phycoerythrin and phycocyanin. We refer to these as accessory pigments. Various carotenoids other than fucoxanthol always accompany chlorophyll, $\beta$ carotene apparently being as universally distributed among photosynthetic plants as chlorophyll *a* itself. The extent to which light energy absorbed by carotenoids other than fucoxanthol can be contributed to photosynthesis is uncertain, so for the present we are not including them among the accessory pigments.

The primary role as sensitizer of photosynthesis is now usually assigned to chlorophyll *a*, both because of its universal distribution in photosynthetic plants above the bacteria and because of the evidence (from observations on fluorescence) that excitation energy acquired by the accessory pigments through absorption of light can be transferred to the chlorophyll *a*, thus leading to the same excited state of the chlorophyll *a* as that which results from direct absorption of light by the chlorophyll *a* itself. The accessory pigments are believed to act only indirectly in photosynthesis, by absorbing light in various parts of the spectrum and transferring the excitation energy thus acquired to the chlorophyll *a*.

Our measurements of the quantum yield of photosynthesis in longer wave lengths of red light have suggested that the accessory pigments may play a more direct part. Emerson and Lewis showed in 1943 (Amer. J.

Bot. **30**: 165) that longer wave lengths of red light are utilized for photosynthesis with a relatively low quantum yield. This was surprising, because these wave lengths, being within the red absorption band of chlorophyll *a*, must be expected to bring about the same excited state of chlorophyll *a* as would result from the absorption of shorter wave lengths. The yield of photosynthesis should not depend upon the wave of light which produced the excited state, if the excited state is the same in all cases.

We found (Emerson *et al.*, Proc. Nat. Acad Sc. **43**: 133. 1956) that the range of wave lengths where the yield of photosynthesis is low was different for the red alga *Porphyridium cruentum* and the green alga *Chlorella pyrenoidosa*. *Porphyridium* showed a diminished yield beginning at about 650 m$\mu$. For *Chlorella*, the yield did not begin to decline until about 685 m$\mu$. We thought it possible that the difference might be correlated with the accessory pigments characteristic of these algae.

In *Chlorella*, chlorophyll *a* is accompanied by chlorophyll *b*. Light absorption by chlorophyll *b* probably does not extend as far toward long wave lengths as absorption by the *a* component. Direct observation of the limit of the red absorption band of chlorophyll *b* in live cells is not possible, but estimates based on comparison of the absorption spectra of chlorophylls *a* and *b* in solvents suggest that the wave lengths where the yield of photosynthesis is low are probably beyond the absorption band of the *b* component, and in a region where the *a* component accounts for all the light absorption.

In *Porphyridium*, chlorophyll *a* is accompanied by phycobilins, and there is no chlorophyll *b*. The zone where absorption is attributable to chlorophyll *a* alone must begin where absorption by the phycobilins terminates. The most prominent phycobilin of *Porphyridium* is phycoerythrin. Its absorption probably does not extend beyond 600 m$\mu$. Some phycocyanins are present, but since their concentration is low, they probably do not contribute much to absorption beyond 650 m$\mu$. At wave lengths longer than this, absorption of light must be attributable almost entirely to chlorophyll *a*. This is also the beginning of the region where *Porphyridium* shows a declining yield of photosynthesis.

We speculated that the yield of photosynthesis might be low in long wave lengths because these wave lengths were exciting chlorophyll *a* alone, and that maximum yield of photosynthesis might require excitation not only of the chlorophyll *a*, but also of some accessory pigment having an absorption band on the short-wave side of the red band of chlorophyll *a*. In the case of *Chlorella*, this requirement could be met by chlorophyll *b*, and in *Porphyridium*, by either phycocyanin or phycoerythrin.

We tested this hypothesis by measuring the yield of photosynthesis in two beams of light, to which the cells could be exposed either separately or simultaneously (Emerson, Science 127: 1059. 1958). We found that as long as the wave lengths of both light beams were within the range of absorption by accessory pigments, the yield of photosynthesis for the two wave lengths together was equal to the sum of the yields for the two wave lengths taken separately. But if one of the beams was limited to long wave lengths of red light which could only be absorbed by chlorophyll *a*, and the other beam provided shorter wave lengths which could be absorbed at least partly by accessory pigments, then the photosynthesis for the two beams given simultaneously exceeded the sum of the yields of the two beams given separately.

We interpreted this to mean that the shorter wave lengths increase the yield from the beam of longer wave lengths. The alternative possibility, that the long wave lengths increase the yield from the shorter wave lengths, seems to us unlikely because in general the yields for the shorter wave lengths alone appear to be maximal, while the yield from the long wave lengths alone is lower than the maximum. By treating the increase due to combination of long and short wave lengths as an increase in the yield from the long wave lengths only, it can be shown that the yield from the long wave lengths approaches the maximum attainable with shorter wave lengths, while interpreting the increase in the opposite way, as an effect of long wave lengths upon the yield from short wave lengths, would lead to yields above the maximum, making this the less probable alternative.

We then compared the effects of different wave lengths upon the yield from a beam of long-wave red of fixed wave length and intensity. To do this, we adjusted the intensity of the beam of shorter wave lengths so that at each wave length setting, this beam by itself gave the same rate of photosynthesis. We found that the effectiveness of the shorter wave lengths in improving the yield from the beam of long-wave red corresponded approximately with the absorption spectrum of the accessory pigment or pigments of the alga being tested. More precisely, the effectiveness varied with the *fraction* of the absorption of the short-wave beam which could be attributed to the accessory pigment or pigments.

This fraction can be only roughly estimated for live cells, but the regions where it is obviously large are clearly identifiable with maxima in the effectiveness of supplementary light. With *Chlorella*, we found maximum effectiveness of supplementary light at about 480 m$\mu$, a region where absorption by chlorophyll *b* is at its maximum and absorption by chlorophyll *a* is very small. The fraction absorbed by chlorophyll *b* attains its largest value here. There is a lower peak of effectiveness of supplementary light at about 655 m$\mu$, coinciding approximately with the red maximum of chlorophyll *b*. Here absorption by chlorophyll *a* is also considerable, so that the fraction absorbed by the *b* component is much less than at 480 m$\mu$. For *Navicula*, the maximum effectiveness of supplementary light is at about 540 m$\mu$, where fucoxanthol contributes most to absorption, and there is a second smaller maximum in the neighborhood of 645 m$\mu$, probably attributable to the contribution of chlorophyll *c* to the absorption of light. *Anacystis* and *Porphyridium* each show single peaks in effectiveness of supplementary light, near where phycocyanin and phycoerythrin contribute most to light absorption (at about 600 and 546 m$\mu$, respectively).

The evidence seems clear that at least at long wave lengths of light, full efficiency of photosynthesis is not sustained by excitation of chlorophyll *a* alone, and that simultaneous excitation of some second pigment, with an absorption band or bands at shorter wave lengths, serves to restore to normal the efficiency of the long wave lengths absorbed only by chlorophyll *a*.

Inevitably, this raises a question in regard to the Chrysophyceae and Xanthophyceae. These algae contain chlorophyll *a*, but lack the common accessory pigments clearly identifiable as photochemical contributors to photosynthesis. Strain (*In* Smith, G. M., ed., Manual of Phycology, Waltham, Mass., 1951, chapter 13) lists *Tribonema bombycinum* as containing a new chlorophyll which he designates chlorophyll *e*, but it remains to be seen whether this component will prove to be generally characteristic of the Xanthophyceae and whether it occurs in amounts sufficient to account for an appreciable fraction of the light absorbed. Some of the Chrysophyceae are reported to contain small amounts of fucoxanthol, and it may be present in all members of the group, but it is not yet known whether this pigment can contribute to photosynthesis when it is not accompanied by chlorophyll *c*.

We have tested two Xanthophyceae supplied to us through the kindness of Professor Starr of the University of Indiana (*Polyedriella helvetica* and *Tribonema aequale*) and have failed to find any evidence of effects of supplementary light upon the yield of photosynthesis from longer wave lengths of red. Provisionally, we attribute this to absence of accessory pigments. In the case of *Tribonema*, the quantum yield of photosynthesis seems to be low throughout the spectrum, as if the chlorophyll *a* without accessory pigments were incapable of sustaining a high yield of photosynthesis, either in long wave red or at shorter wave lengths. Many more comparisons must be made with a wider range of algal types before we can have confidence that such a generalization is valid.

We have not yet tested any Chrysophyceae for their response to supplementary light, but we consider it significant that at least one representative of this group (*Ochromonas malhamensis*) seems to show only a limited capacity for photosynthesis (Myers and Graham, J. Cell. Comp. Physiol. **47**: 397. 1956).

On the basis of the effects of supplementary light which we have described here, we are tempted to sketch a possible sequence of evolution of the combinations of pigments to be found in algae. In agreement with Oparin's premises concerning the origin of life (A. I. Oparin, The Origin of Life, Edinburgh, 1957), we suppose that when organisms containing chlorophyll first appeared, organic substances were available in abundance, and evolution of heterotrophic forms of life must have been well advanced. Because of the universal presence of chlorophyll *a* in all photosynthetic plants except bacteria, it is likely that all are derived from a common ancestor containing the *a* component. Since none of the accessory pigments is to be found in all the phyla of photosynthetic algae and higher plants, we may suppose that chlorophyll *a* appeared first without accessory pigments. Throughout the phyla of plants, chlorophyll *a* is always accompanied by $\beta$ carotene and also by other carotenoids, so that in all probability the earliest organisms containing chlorophyll *a* also contained carotenoids, perhaps exclusive of fucoxanthol. These organisms may have been capable of limited photosynthetic activiy such as we can see in the chrysophycean *Ochromonas*. Organic nutrition may have made up for the low photosynthetic efficiency which we suppose to be characteristic of chlorophyll *a* when it is unaccompanied by other active pigments.

We may suppose that organisms containing various pigments in addition to chlorophyll *a* appeared in the course of geologic time and that some of these were capable of supplementing the activity of chlorophyll *a* in such a way that efficient photosynthesis, with production of organic material and oxygen from carbon dioxide and water, could sustain a fully autotrophic mode of life. The various combinations of pigments may have initiated parallel lines of evolution, the end results of which we see today in the different classes of algae.

Our suggestion, that the accessory pigments may endow the photosynthetic system with an effectiveness which it could not have if chlorophyll *a* were the only photosynthetic pigment, seems to offer a plausible explanation for the success of the combination of chlorophylls *a* and *b*. We see that light absorbed by the accessory pigments can extend efficient photosynthesis to longer wave lengths. Possibly, all the light absorbed by chlorophyll *a*—at long and also at short wave lengths—must be supplemented by light absorbed by some accessory pigment in order to sustain maximum yield of photosynthesis. If this is the function served by the accessory pigments, then the farther the absorption of light by the accessory pigment extends towards the red absorption band of chlorophyll *a*, the greater will be the range of wave lengths which can sustain maximum efficiency for the light absorbed by chlorophyll *a*. From this standpoint, chlorophyll *b* should be superior to the other accessory pigments, because the red absorption band of the *b* component is about as close as it can be on the short-wave side of the corresponding band of the *a* component. (We assume that any pigment, such as chlorophyll *d*, with its absorption band on the long-wave side of the *a* component, would be ineffective, because its excited state would be lower than that of chlorophyll *a*). Phycoerythrin, on the other hand, with its absorption extending only to about 600 m$\mu$, makes available the smallest range of wave lengths for sustaining efficient use of red light absorbed by chlorophyll *a*, and phycocyanin is in an intermediate position. Of all the algal groups, the Rhodophyceae are abundant over the smallest part of the earth, while the widespread occurrence of the Myxophyceae, particularly in highly specialized environments, is probably due to broad physiological tolerances not related to pigmentation. The fucoxanthol might offer no greater spectral range than the phycoerythrin were it not for the fact that chlorophyll *c* usually accompanies fucoxanthol, making a combination with chlorophyll *a* which may be as good as, or perhaps better than, the combination of chlorophylls *a* and *b*. Certainly these are the two combinations which are most outstandingly successful—fucoxanthol-chlorophyll *c*-chlorophyll *a* in the oceans, and chlorophyll *a*-chlorophyll *b* on land and in fresh water.

If the carotenoid peridinin of dinoflagellates serves the same function as the fucoxanthol of brown algae and diatoms, then the combination of chlorophylls *a* and *c* with peridinin may be as effective as the combination of fucoxanthol with these two chlorophylls and may contribute to the competitive success of the dinoflagellates.

In contrast, the classical outlook that the value of accessory pigments lies in their capacity to increase absorption of light in parts of the spectrum poorly covered by the absorption bands of chlorophyll *a* does not seem to account for the outstanding success of the combination of chlorophylls *a* and *b*. The *b* component, with its absorption bands closely overlapping those of chlorophyll *a*, hardly increases the range of absorption at all. The combination of chlorophyll *a* with the phycobilins looks most promising from the standpoint of maximum coverage of the visible spectrum with pigment absorption bands, but the more specialized distribution of the organisms for which this pigment combination is characteristic leaves room for doubt whether coverage of the spectrum has been the primary factor in determining the survival value of the accessory pigments.

We have omitted the photosynthetic bacteria from our discussion because the biochemical changes brought about by their photosynthesis seem to be fundamentally different from the biochemistry of photosynthesis as we encounter it in the algae and high plants. The bacteria produce no free oxygen and require hydrogen donors from which hydrogen can be separated at much smaller energy cost than from water—the hydrogen donor for algae and higher plants. The evolutionary position of the photosynthetic bacteria seems to have no direct bearing on the problem of the evolution and function of the accessory pigments of algae and higher plants.

Grateful acknowledgment is made to the National Science Foundation for support of this research (Grants G-1398 and G-4969).

## ABSTRACTS

### A Quantitative and Qualitative Study of the Phytoplankton of the Danube River at Vienna

GEORGE CLAUS AND CHARLES W. REIMER
Academy of Natural Sciences of Philadelphia

Quantitative and qualitative samples were taken during 16 months from 11 stations covering an area from just above Vienna to approximately 20 miles below the city. From these collections four stations were selected and material from each for four seasons was analyzed. One of the striking features is that the influence of raw sewage of the city seems to stimulate, rather than depress, the individual numbers per liter. Although the Danube above Vienna is considered as oligotrophic, it is apparently changed to meso-eutrophic as a result of the organic and inorganic enrichment entering at Vienna.

The phytoplankton blooms found are characterized by at least three factors: 1) they are localized, frequently found at one station only and never observed extending across the entire river; 2) they persist for several days at the same locality (the current of the water is about 2m/sec.); 3) they consist of only one to ten species.

The term "bloom" is applied under one of the two following conditions: 1) if the individuals of a species are found to number 100,000/liter and in

previous samples have not exceeded 30,000/liter; 2) if the individuals of a species rise to over 1,000,000/liter and in previous samples have not exceeded 200,000/liter.

In October 1957, seven species made up a bloom at Sta. 2 and none of these was found in the blooms present at the same time in Sta. 3 and Sta. 4. Although these blooms at Sta. 3 and Sta. 4 consisted of diatoms alone, two species of diatoms were peculiar to Sta. 2 only, the other three species being common to both blooms.

The largest number of organisms in any one bloom occurred in October at Sta. 3. At that time there was recorded a total of 4,600,000/liter comprising seven dominant species of diatoms. The cause of these blooms and of their ability to maintain themselves at the same place against the current is not yet clear.

During the entire study 659 species were identified. This is in contrast to the opinions of Brunthaler, Schallgruber, Stundl and Tamas that the plankton of the Danube is very poor in species as well as in individuals. From this investigation it is clear that the Danube compares very favorably in species number to the plankton of other rivers studied in Europe. The most important elements of the phytoplankton are the diatoms, which represent an average of 69 per cent of the total population.

## The Algae of the Salt River Valley, Phoenix, Arizona

JANET D. WIEN
Arizona State College

The growth of algae and aquatic weeds in canals in the Salt River Valley constitutes a major impediment to the operation of the irrigation system. Local companies spend $250,000 annually for mechanical control. The approach of the present investigation, a two-year study, has been to determine the factors which favor abundant growth in the hope of using this information to establish an ecological control. That such a control is possible is suggested by the observation that only in certain sections of the canals does the growth get out of balance. Other sections maintain a natural ecological system which apparently is unfavorable to extensive development of plant material. A weekly ecological study at three stations in the canals is in progress.

Important initial work, now completed, is an inventory of species. Those of particular importance are *Oscillatoria princeps, Cladophora glomerata, Rhizoclonium hieroglyphicum, Hydrodictyon reticulatum, Enteromorpha intestinalis, Oedogonium sp., Compsopogon coeruleus,* and *Thorea ramosissima.* Identification of species, and sometimes even of genera, was made difficult by lack of fertile material. In the period of almost two years only *Chara* was found in fruit. A *Vaucheria*-like alga which also has several morphological characters of *Dichotomosiphon* could not be placed clearly in either genus on the basis of vegetative growth.

## A Phycological Study of an Acid Mine Pond

CAROLE A. MORGAN
Robert A. Taft Sanitary Engineering Center, Cincinnati

Acid mine stream drainage ponds in the Athens County, Ohio, area constitute an unusual habitat for numerous aquatic micro- and macro-organisms, including algae, the sulfur bacterium *Thioploca*, purple photosynthetic bacteria, and *Chironomus* larvae. One such pond, carrying dissolved minerals such as iron, magnesium, manganese, and sulfates and with a pH of 2.3 to 3.0 and a D.O. of 0.08 p.p.m., was chosen for a time study to determine its phycological population. Algae identified include species of *Gloeocystis, Oocystis, Cylindrocystis, Hormidium, Pithophora, Euglena, Eunotia,* and *Navicula*. Other tiny desmids inhabit the waters at various seasons.

## Community Relationships in Soil Algae

HERMAN S. FOREST
University of Oklahoma

I. Colonization of sterile soil. The algal flora colonizing ground-level pots of sterilized soil was compared with that of the undisturbed surrounding area. Twenty plots were utilized, the algae being grown in their original soil in moist plate culture for identification. Plate presence was the parameter for quantitative comparison. Of the 45 taxa encountered, those attaining 50% frequency in control plots were considered predominants, constituting the characteristic flora. After one, three, or five-and-a-half months' colonization the experimental plots resembled the control area in algal flora, especially in predominants, and both predominants and other species waxed and waned in luxuriance together. Hence, succession and strong competition were not found to be marked phenomena in this study. Examination of algal crusts showed them to be different in proportion of species from the uncrusted soil.

II. Interaction of three species in a limited laboratory community. *Ulothrix flaccida* Kuetz., *Nostoc muscorum* Kuetz., and *Scytonema hoffmanni* C. Ag. were inoculated in standardized portions into sterile moist plate cultures of their native soil. In three series they were grown singly, in pairs, and all three together. Ten 5 mm square subquadrats from each plate were examined and frequency by subquadrat used for quantitative comparison of growth. *Ulothrix* and *Nostoc*, both predominants in the field, grew rapidly alone or in combination. *Scytonema*, occasionally found in the soil, grew slowly, but attained the same frequency as the others in eight weeks. At the end of seven months the colonies containing the three together had declined, all three being reduced about equally. The relationship among the three species could be described as co-existence, and the higher frequency of two of them in the field is probably due to their rapid growth during short favorable periods.

## A Quantitative Comparison of the Soil Algae of Central Oklahoma Prairie and Woodland

ROBERT B. ENGLAND
Miami Junior College, Miami, Oklahoma

The surface algal flora of a central Oklahoma tall-grass prairie was compared with that of a blackjack-post oak woodland. Twenty plots were sampled in each area during each of the four seasons. The buried slide method proved inadequate, so that direct sampling of undisturbed soil and moist plate cultures were used to enable identification. Ten randomly chosen 5 mm square subquadrats were examined from each plate. Immediate examination and weekly re-examination of one series of plates indicated that the flora was not altered in composition by culture. Fifty-one taxa were encountered. Little difference in the total flora was found between the two habitats, especially as regards predominants, and 29 species were common to both areas among the totals of 45 from the woodland and 35 from the prairie. Six species could be reported as characteristic of the woodland and three of the prairie, but of these only two of the woodland species were restricted to that area.

## Source of the Fast-Death Factor Produced by Unialgal *Microcystis aeruginosa* NRC-1

BEULAH SIMPSON AND PAUL R. GORHAM
National Research Laboratories, Ottawa, Canada

Of nine strains of *Microcystis aeruginosa* isolated from different waterblooms, only two (NRC-1 and NRC-3) produced fast deaths when injected intraperitoneally into white mice. From one waterbloom producing fast deaths, two strains were isolated, one of which produced fast deaths (NRC-3) and the other slow deaths. The endotoxin, causing fast deaths, was active orally at a dosage that was 20 times greater than intraperitoneally.

Five bacterial contaminants, isolated from strain NRC-1, were non-toxic orally and produced only slow deaths when injected intraperitoneally. The symptoms were quite different from those observed with the alga. The bacterial populations isolated from lysed or actively growing cultures of strain NRC-1 failed to produce typical fast deaths. A non-toxic strain of *M. aeruginosa* (Gerloff, No. 1036) grown in the presence of the bacterial contaminants from strain NRC-1 still remained non-toxic.

Thirty-five isolations of single algal cells were made from strain NRC-1.

Two of these isolates grew and, although neither was pure, only one produced fast deaths.

It is concluded that the fast-death factor is produced by the alga and that production is genetically controlled.

## Observations on the Purple Vacuolar Pigments in the Zygnemataceae

RALPH E. ALSTON
University of Texas

Certain algae, notably within the family Zygnemataceae, produce blue or purple vacuolar pigments. Most species reported to form such pigments are swamp or bog inhabitants. The pigments have been described as "anthocyanin-like" or as "phycoporphyrins."

A collection of *Zygogonium ericetorum* with purple cell sap was made from a bog in south-central Texas. Tests of the pigment indicated that it was not an anthocyanin but rather an iron-tannin complex. It was possible to show that the properties of the algal pigment matched those of a synthetic tannin, that the bog water and the cell sap were high in iron content, and by use of the dipyridyl reagent, that the iron was attached to a tannin-like substance within the algal cells. This type of pigment does not appear to have been reported previously in nature.

Upon comparing these results with results of earlier studies, it appears probable that those algal pigments called anthocyanins or phycoporphyrins were in fact iron-tannins such as occur in *Zygogonium ericetorum*.

Work by Dr. Ann Allen indicates that *Spirogyra pratensis* growing in the Waris medium (containing an iron chelating agent) also produces a purple pigment. The pigment appears in dead or dying cells, however.

## Control of Sexuality in *Chlamydomonas chlamydogama*

FRANCIS R. TRAINOR
University of Connecticut

As with other species of *Chlamydomonas*, nitrogen starvation stimulates zygospore production in *C. chlamydogama*. However, this is only true when mixed mating types are in a harvesting solution with a low level of ammonium nitrate. When mating types are held separately under nitrogen starvation, either on agar slants or in liquid, zygospore yield upon mixing of gametes decreases rapidly with time. There is evidence that vitamin $B_{12}$ is necessary only for growth of the mating types, with no effect on mating.

Light is necessary for a sexual reaction. Twelve-hour diurnal illumination is far more effective than continuous illumination in producing high zygospore yield. Inhibition of mating, possibly in pair formation, under some conditions of illumination might explain the higher zygospore yields obtained under diurnal illumination.

## Investigations on the Genus *Gonium*

JANET R. STEIN
University of California, Berkeley

The volvocacean genus *Gonium* comprises those colonial members in which the cells form a flat or slightly curved plate. Of the 25 species that have been described since O. F. Müller erected the genus in 1773, only seven are recognized today. These include *G. sociale* (Duj.) Warming and *G. sacculiferum* Scherffel, the 4-celled species; *G. octonarium* Pocock with 8 cells; *G. pectorale* O.F.M. and *G. formosum* Pascher with 16 cells; *G. discoideum* Prescott with 32 cells; and *G. multicoccum* Pocock, which may have 8, 16, or 32 cells.

All species except *G. formosum* and *G. discoideum* are now in clonal culture. Sexual clones all are isogamous. The only species in which homothallic strains are known is *G. sociale* (cf. Starr, J. Tenn. Acad. Sc. 30:90. 1955), although not all isolations are homothallic. The 4-celled species produce zygotes with reticulate cell walls, whereas the other three species have smooth-walled zygospores.

## Sexual Isolation in *Pandorina morum*

ANNETTE D. WILBOIS
Indiana University

In *Pandorina morum* Bory, a species of colonial green flagellate common in fresh-water ponds, fertilization is accomplished by the fusion of two isogametes of complementary mating type. Since collections from widespread areas of the United States were found to be morphologically indistinguishable, a number of them were analyzed for sexual compatibility.

Fifty-six strains were used, each derived from a single, originally isolated colony. The 56 strains represented 34 collections: a pair of compatible mating types was isolated from 22 collections and a single strain from each of the remaining 12. To test the compatibility of the strains, they were paired in all possible combinations under optimal conditions for mating. Results were scored in terms of presence or absence of zygotes.

It was found, on the basis of intercrossing results, that the 22 pairs of mating types could be classified into 15 sets of complementary mating types, each set sexually isolated from all others (minimum of 15 syngens, *sensu* Sonneborn, 1957). Of the 12 single strains, three were found to mate with one of the 15 sets of mating types while the remaining nine failed to mate with any strain available. An examination of the sources of the mating types failed to reveal any clear pattern in their geographical distribution. The cause of the extreme sexual isolation found among the morphologically similar strains of this species remains to be investigated.

## Effects of X-Radiation on Reproduction in *Haematococcus*

R. L. HULBARY
State University of Iowa

Cells of *Haematococcus pluvialis* Flotow in both cystous and motile stages were treated with X-rays in doses ranging from 200r. to 100,000r. Morphological effects were produced at doses of 9000r. or more in motile cells. Doses of 18,000r. or more were lethal for some individuals irradiated in motile cell cultures. Dried cysts were more resistent to X-rays. No morphological or lethal effects were observed in cysts unless 70,000r. or more were applied. The threshold for immediate death is approximately 18,000r. in motile cells. Cell counts and cytological study of cultures exposed to irradiation indicated that many cells died in the process of cell division. Reproduction by zoospores, prevalent in this species, was, in this manner, sharply diminished over a period of seven days following exposure. Morphological effects of irradiation included: cells with 2, 3 and 4 pairs of flagella; irregularities in shape of the protoplast; elongated or cylindrical cells; and formation of aplanospores instead of zoospores. Irradiated cultures are being purified and maintained for further study.

## Conjugation in Saccoderm Desmids

PAUL BIEBEL
Indiana University

Sexual strains representing most genera of saccoderm desmids (Mesotaeniaceae) have been isolated. The strains include: *Gonatozygon monotaenium* DeBary, *Spirotaenia condensata* Bréb., *Cylindrocystis crassa* DeBary, C. *brebissonii* Menegh., *Netrium digitus* var. *digitus* Itz. & Rothe, and *N. digitus* var. *lamellosum* (Bréb.) Grönblad. All isolates grow well in Pringsheim's soil-water medium. The *Cylindrocystis* and *Netrium* strains can also be grown in bacteria-free culture on agar media.

All strains proved to be homothallic with the exception of *Netrium digitus* var. *lamellosum*, which is heterothallic. Zygospores are produced spontaneously, but erratically, in old cultures of the homothallic strains. Conjugation can be reliably and precisely induced in both homothallic and heterothallic bacteria-free cultures through the use of media from which the nitrate salt has been omitted.

The complete sexual cycle of the two *Netrium* varieties has been obtained in culture. Zygospores of the homothallic var. *digitus* germinate to produce a vesicle which emerges successively from two different walls, the inner of which is double and colored, the outer of which is colorless and apparently single. In a great majority of cases, two products are cut out from each vesicle, although one or three products have been found. In the heterothallic var. *lamellosum*, practically all of the zygospores give rise to two products.

## Some Effects of Ultra-Violet Light on *Cosmarium turpinii*

ROBERT KORN
Indiana University

Ultra-violet light was employed to determine what effects a mutagenic agent would have on the growth and differentiation of the desmid *Cosmarium turpinii* Bréb. The survival curve indicates that death occurs at the typical exponential rate. Delay of the first division due to irradiation is directly proportional to the dosage up to 200 seconds, after which a plateau is established. The slopes of the survival curves and delay of first division curves increase with an increase in age of culture, indicating that sensitivity to UV increases with age. This sensitivity strikingly increases after three weeks, the time when the growth curve tapers off. It is suggested that sensitivity to UV is a function of the physiological age of the cell.

The frequencies of tri-, quadri-, uni-, and nullradiate forms decidedly increase with UV treatment. A morphological "mutant" was obtained which is sensibly different from the characteristic shape of *C. turpinii,* yet maintaining the bilateral symmetry.

## Meiosis in *Closterium*

J. EUGENE FOX
Indiana University

Zygospore germination has been regularly obtained in several species of the desmid genus *Closterium.* The gametic nuclei remain unfused in the zygospore until shortly before germination. The zygospore can thus be properly termed a dikaryon. Upon germination a vesicle, undifferentiated except for two plastids and the diploid fusion nucleus, is released from the zygospore.

In the most thoroughly investigated species, *Closterium acerosum,* most of the chromosomes are small and dot-like, the haploid number being about 220. At the first anaphase, however, two long chromosomes with satellites can be seen; these are probably nucleolar organizers. At the end of the first division one nucleus is associated with each plastid. The plane of the second division occurs at right angles to that of the first with the result that now each plastid has two nuclei associated with it. One nucleus of each pair, however, becomes pycnotic and disintegrates. It is important for purposes of genetic analysis to note that the surviving functional nuclei contain non-sister chromatids which have segregated at the first division. A single cytokinesis occurs so that two cells are produced from each germinal vesicle.

## Third International Seaweed Symposium

The Third International Seaweed Symposium was held at University College, Galway, Ireland from August 13-20th, and was attended by more than three hundred delegates of many different nationalities. Evening receptions were given in their honor by both civic and government dignitaries.

The conference was opened by Mr. Seán Lemass, Tánaiste (Vice-President) and Minister for Industry and Commerce of Eire, who emphasised the importance and potentialities of the seaweed industry to his country's economy. There were several general lectures, one evening Public Lecture on "The Sea as a Potential Source of Food," given by Dr. L. A. Walford of Washington, and an interesting and instructive Trade Exhibition. In addition films were shown daily on both the commercial exploitation of seaweeds and the scenic beauties of Ireland. For the rest of the time members met in parallel sessions on Chemical, Industrial and Biological aspects of seaweed studies.

The Symposium was favored by generally good weather, in what was for the British Isles as a whole a very poor summer, thus enabling everyone to enjoy the excursions to the full. There were collecting expeditions to a variety of localities ranging from Clew Bay (the area of Cotton's "Clare Island Survey") to Miltown Malbay (one of Harvey's famous collecting grounds). Some members paid a visit to seaweed processing factories, and there was also an opportunity to visit the remote, desolate Aran Islands.

The success of the Symposium was in a great part due to the unsparing efforts and warm friendliness of our Irish hosts, and for the phycologists in particular of Dr. Máirín de Valera. - - - D.E.G. & L.M. Irvine.

## Studies on the Nutrition of *Kirchneriella subsolitaria*

MILTON POTASH
University of Vermont

A basic culture medium was established for the maintenance of populations of *Kirchneriella subsolitaria* G. S. West under sterile conditions. The medium contained per liter 0.01 g $K_2HPO_4$, 0.025 g $MgSO_4 \cdot 7H_2O$, 0.04 g $Ca(NO_3)_2$, 0.01 g $Na_2CO_3$, 0.003 g $Fe(SO_4)_3$, 0.003 g Na citrate, and 0.003 g $Na_2$-EDTA, plus a trace element solution.

An attempt was made to determine the concentrations needed to produce maximum numbers of cells under the experimental conditions used. By varying nitrate content, it was found that a concentration of 0.08 g $Ca(NO_3)_2$ per liter, or 13.6 p.p.m. of nitrogen, produced maximum populations of the alga. A series of cultures with varying concentrations of phosphate indicated that maximum production was gained from a concentration of 0.006 g $K_2HPO_4$ per liter, or 1.1 p.p.m. of phosphorus. Greater concentrations produced no further growth. It is indicated that in both series population density was limited by complete removal of the nitrogen source.

Variation of concentrations of all other nutrients above or below that of the basic medium resulted in no significant increase or decrease in cell number. Maximum densities were of the magnitude of 10,000 cells/mm$^3$. An N/P ratio of approximately 12.5/1 is indicated.