THE BLUE-GREEN ALGAE OF KASETSART UNIVERSITY CAMPUS AND VICINITY

by

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ABSTRACT

Forty species and 1 variety under families Chroococcaceae, Oscillatoriaceae, Nostocaceae, Scytonemataceae and Rivulariaceae are studied, out of which 35 species including the variety, are additions to the blue-green algae of Thailand. A simplified chart of the Kasetsart University campus is shown left to indicate the collecting areas of part of the algal specimens. The other areas of collection are located within a kilometer radius around the campus. In addition, 2 tables and 5 plates with 40 figures are represented.

Discussion of results and recommendation are emphasized. It is significant to note that many species which cause much of the natural pollution belong to the genera *Oscillatoria* and *Spirulina*, an observation which should need more material for study and verification. This justifies the recommendation.

Introduction

The appointment of the writer from the SEATO for a year, April, 1974 to March, 1975 gave him the opportunity to study the blue-green algae of the campus of Kasetsart University at Bangkok, Thailand. To give the study a wider area for the sources of algal materials in the field, the collecting ground was extended to about a kilometer radius from the circumferential boundary of the University. This should include additional species which are otherwise not available in the campus. Besides, a more ecological distribution of specimens can be recorded in the work in order to help the determination of some rare species which would need more material.

The results obtained during a limited time of six months from April to September of 1974 is the first comprehensive report of the blue-green algae in Kasetsart University campus and its vicinity. It is also a contribution to knowledge of the blue-green algae for Thailand.

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Studies of the blue-green algae

Very little information in published form is available for the blue-green algae of Thailand especially of its fresh-water species. In 1933, Smith reported an edible blue-green alga, *Nostochopsis lobatus* Wood collected from a mountain stream in Chiengmai of Northern Thailand. But the earlier record algal collection and study dates back in 1866 when the "Die Preussische Expedition nach Ost-Asien" reported 13 species of marine algae collected in Simaharadscha, Siam. There was no blue-green alga in the report. In the "Flora of Koh Chang" 1900-1916 were included 27 species of the filamentous Myxophyceae and 2 *Calothrix* species insufficiently developed to warrant complete identification. And in the Danish Siboga Expedition, 1913 was reported 6 filamentous blue-green algae all collected from Koh Chang, Golfe de Siam.

In the present report composed of 40 species and 1 variety, 35 species and the variety are additional records of the blue-green algae of Thailand. It is only a matter of time and development when the blue-green algae of the country could be put together in a Cryptogamic Herbarium through extensive and intensive collections and study. Thailand is a big country with an area of 518,000 square kilometers. Including the seacoasts which line in long stretch of the Gulf of Thailand to the south and the Indian Ocean in the southwest, the number of species could be easily increased and very much completed.

Opportunity for work

The tropical country of Thailand possesses extensive inland waters in the form of permanent canals and various sizes of standing water. The areas occupied by squatters remain usually moist, if not submerged partly during the year. The surroundings of small markets in the provinces and workshops frequented by people generally develop into veritable collecting places of the blue-green algae. Quite many species of the algae are also abundant in higher altitudes whenever sufficient sunlight is available. They thrive also equally well along the seacoasts including the littoral zones. They live in practically all habitats and are considered to be ubiquitous in distribution. Indeed, they are the lowest photosynthetic organisms in the development of the Plant Kingdom.

Mr. Teera Leckcholaryut, instructor of the Department of Fishery Biology helped in the collection of the algae in the University campus while Mr. Taweesak Songsirikul, also instructor of the same Department extended very kindly similar assistance to collect the specimens outside the University.

Area of investigation and laboratory

The campus of Kasetsart University with an area of 14,000 rai (560 acres) and its vicinity of about a kilometer radius outward from the circumferential boundary furnish many characteristic collecting grounds from where the blue-green algae can grow luxuriantly (see Chart). The permanent canals inside and outside the university

campus, the green-houses of the Faculty of Agriculture, Forestry and the Biological Sciences are good sources of collection. The squatters surroundings within the vicinity, private homes and ordinary places added many specimens in the total collection during six months.

More than 200 packets of algal materials were examined under the light microscope from where 40 species and 1 variety were easily classified into 5 families, namely: Chrococcaceae, Oscillatoriaceae, Nostocaceae, Scytonemataceae and Rivulariaceae. It is significant to note the relative amount of species reviewed in each genus of the 18 genera which may be shown in Table 1.

The fresh specimens of each collection were allowed to dry slowly in the laboratory to avoid any possible shrinkage. The cells of the blue-green algae usually retain the normal form and structure ever after long keeping in dried condition. With the use of any detergent solutions, the cells appear as normal as in the fresh specimens. They are kept in 3 x 5″ envelops, and with spray of enough amount of naphthalene powder to protect from insects, they keep indefinitely long in the container. One half of the duplicate materials are deposited in the Cryptogamic Herbarium of the Department of Fishery Biology, Faculty of Fisheries, Kasetsart University, and the other half in the Cryptogamic Herbarium of the Department of Botany, College of Arts and Sciences, University of the Philippines, where the writer has his permanent office and laboratory. All illustrations are drawn from the portable Camera Lucida under the microscope. The number which follows each specimen in the collection belongs to the writer exclusively for Thailand.

TABLE 1. Relative abundance of species as studied in the laboratory

Order	Families	Genera	Species	Remarks
Chroococcales	Chroococcaceae	Synechocystis	1 species	The genus *Oscillatoria* with 13 species and 1 variety dominate the number and abundance of species so far observed in the laboratory. Those of *Phormidium* easily come next with 5 species. Similar studies in the other parts of Thailand are needed in order to collect more materials to verify the present result.
		Aphanocapsa	1 species	
		Aphanothece	1 species	
		Microcystis	1 species	
Nostocales	Oscillatoriaceae	Spirulina	2 species	
		Oscillatoria	13 species	
		Phormidium	5 species	
		Lyngbya	3 species	
		Symploca	2 species	
		Porphyrosiphon	1 species	
		Microcoleus	2 species	
	Nostocaceae	Anabaenopsis	1 sepcies	
		Nostoc	1 species	
		Cylindrospermum	1 species	
	Scytonemataceae	Desmonema	1 species	
		Tolypothrix	1 species	
		Scytonema	2 species	
	Rivulariaceae	Calothrix	1 species	

TABLE 2. Representative species of the collection to show the nature of the habitat from where each specimen is generally available

Species	Permanent Water		Usually wet		Usually dry	Remark
	Much Pollution	Little Pollution	Mostly wet	Dry/wet Seasonally		
1. Microcystis aeruginosa	XX					*Spirulina subsalsa*, *S. major*, *Oscillatoria prolifica*, *O. tenuis*, *O. princeps* and *O. chalybea* were collected dominant in permanent canals with much pollution. They do not have sheaths apparently. *Lyngbya martensiana* is an exception. Usually dry habitat did not yield much specimens except partly the *Scytonema* species.
2. Spirulina subsalsa	XX					
3. Spirulina major	XX		X			
4. Oscillatoria prolifica	XX					
5. Oscillatoria tenuis	XX	X	X			
6. Oscillatoria princeps	XX	X	X			
7. Oscillatoria chalybea	XX	X				
8. Phormidium inundatum		X	XX			
9. Phormidium retzii		X	X			
10. Symploca muscorum			XX			
11. Lyngbya major		XX	XX			
12. Lyngbya martensiana	XX					
13. Porphyrosiphon fuscus				X		
14. Microcoleus vaginatus		X	XX			
15. Nostoc comminutum		X	X			
16. Desmonema wrangelii			X			
17. Tolypothrix tenuis		XX				
18. Scytonema hoffmanni				XX	X	
19. Scytonema guyanense				XX	X	
20. Calothrix braunii				X		

Results and discussion

In Table 2, there are selected 20 representative species which can give more or less sufficient information of the habitat from where each may be collected. One may be interested to collect some of them for laboratory research and or teaching materials. The condition of the habitats observed in the areas visited for study is generally present in all the tropical countries of the Southeast Asia.

The species of the genera *Oscillatoria* and *Spirulina* have apparantly no sheaths which may obstruct or slow down the metabolism of the species. There is free passage of the raw materials needed in the synthesis of the food compound and the wastes released in the use of this food. As a result, the cells of the trichomes multiply fast and therefore increase in great number much more than the other species in the same habitat. The reserved food of the blue-green algae being proteinaceous, when they die, produces a different toxicity which usually inhibit the growth or kill other organisms in the immediate surrounding. This must be the main source of natural pollution which is very commonly observed in many permanent canals and long standing water. On the other hand, the species with prominent sheaths fail to grow as fast and therefore produce very much less pollution.

There may be additional characteristics in the blue-green algae which are better developed than those of the lower species with hardly the presence of prominent sheaths, like permeability nature of the cell wall and others subsequently inherent in the growth of the organisms. However, they are not within the scope of the investigation which should need another study and discussion.

Recommendation

It is necessary that more study be made in other parts of Thailand. More results should be available in order to verify definitely the observation from the limited material. Meanwhile, casual collections of the algae under the supervision of Professor Khanjanapaj Lewmanomont of the Department of Fishery Biology, Faculty of Fisheries may continue. She is also a Phycologist. The duplicates of the collected material sent and studied in the Department of Botany, University of the Philippines, then their scientific names are sent back to Thailand for the other duplicates preserved in the Department of Fishery Biology, Kasetsart University.

There are many objectives of scientific thinking and planning but very few can be realized without the orderly logical steps of implementation.

General taxonomic treatment

MYXOPHYTA

Class MYXOPHYCEAE Sachs

Unicellular or multicellular algae with no true nucleus and chromatophore. Protoplast peripherally with photosynthetic pigment and a central generative incipient nucleus. Main pigments are phycocyanin and chlorophyll a, others are B-carotene, xanthophyll, myxoxanthophyll and phycoerythrin. Cell wall thin to thick, the later invested oftentimes with striated sheaths. Reproduction is mostly by vegetative cell division and hormogonia; endospores and exospores in several species. Motility unknown, sexual reproduction absent.

Order 1. CHROOCOCCALES Wettstein

Family 1. CHROOCOCCACEAE Nägeli

The plants are unicellular of various shapes associated in simple or complex colonies united by mucilaginous material. Reproduction is by fission of one cell into two daughter cells, endospores and exospores in some species.

Key to the Genera

1. Cells unicellular, if colonial, apparently without sheaths.....*Synechocystis*
1. Cells unicellular forming colonies with usually visible sheaths.....2
   2. Colonies globose of definite forms.....*Aphanocapsa*
   2. Colonies irregular of indefinite forms..... 3
3. Generally terrestrial and moist habitats.....*Aphanothece*
3. Generally aquatic habitats forming water bloom.....*Microcystis*

Genus SYNECHOCYSTIS Nägeli

Synechocystis aquatilis Sauvageau Pl.I, fig. 1

S. aquatilis Sauvageau. Desikachary, Cyanophyta, pl. 25, fig. 9, 1959.

Cells single, spherical, or rarely few cells in a colony after division; in mostly moist habitat; sometimes planktonic.

Specimen : Inside campus : Light blue-green patches in a moist pot of the greenhouse at Rice Experiment Station, 9, May 27.

Genus APHANOCAPSA Nägeli

Aphanocapsa virescens (Hassall) Rabenhorst Pl.I, fig. 2

A. virescens (Hassall) Rabenhorst. Tilden, Minnesota Algae, pl. II, fig. 11, 1910.

With other algae, expanded and gelatinous; globose when young, irregular growth in maturity; sheaths faintly visible; cells mostly solitary, seldom in pairs after division.

Specimen : Outside campus : In a shallow standing water along the road, 148, July 22.

Genus MICROCYSTIS Kützing

Microcystis aeruginosa Kützing Pl. I, fig. 3

M. aeruginosa Kützing. Desikachary, Cyanophyta, pl. 17, fig. 10, 1959.

Solid, becoming clathrate colonies when matured; cells spherical with gas vacuoles; mostly planktonic.

Specimen : Inside campus : As water bloom in small pond back of the Museum and Library of the Faculty of Fisheries, 204, September 28.

Genus APHANOTHECE (Sprengel) A.Br.

Aphanothece stagnina (Sprengel) A. Br. Pl. I, fig. 4

C. stagnina Sprengel. Velasquez, Blue-Green Algae of the Philippines, pl. 1, fig. 2, 1962.

Irregular colonies in especially moist habitat; cells spherical, oval or pear-shaped forms; sheaths thin and diffluent in many specimens.

Specimens : Inside campus : Floating in a shallow pond, 21, April 18; peeled on moist soil infront of the administration, 62, May 13; growing with other algae in moist soil, 94, May 27. Outside campus : On moist surface of narrow road, 161, August 19; soil of road near dirty water, 153, August 5; as patches with an *Oscillatoria sp.*, 175, August 26; moist soil below a Buddha Temple building in diffused sunlight, 188, September 2.

Order 2. NOSTOCALES Geitler

Key to the Families

1. Trichomes generally without false branches.....*Oscillatoriaceae*
1. Trichomes generally with false branches..... 2
   2. Trichomes with heterocysts and akinetes not much differentiated.....*Nostocaceae*
   2. Trichomes with heterocysts and akinetes much differentiated..... 3
3. Heterocysts and akinetes usually intercalary.....*Scytonemataceae*
3. Heterocysts and akinetes usually basal.....*Rivulariaceae*

Family OSCILLATORIACEAE Kirchner

Filaments seldom branched, mostly solitary, some with many trichomes in a sheath; sheaths apparently absent, very thin to thick in many species; thick sheaths distinct and lamellated in other specimens; trichomes of uniform row of cells, except apical cells; no heterocysts; reproduction by cell division and hormogonia.

Key to the Genera

1. Sheaths not visible 2
1. Sheaths visible 3
   2. Trichomes closely spiral ..... *Spirulina*
   2. Trichomes straight ..... *Oscillatoria*
3. Sheaths thin not striated 4
3. Sheaths thick, generally striated 5
3. Sheaths enclosing many crowded trichomes ..... *Microcoleus*
   4. Trichomes oftentimes agglutinated ..... *Phromidium*
   4. Trichomes free, usually forming erect fascicles ..... *Symploca*
5. Generally subaerial, forming tough woody stratum..... *Porphyrosiphon*
5. Generally free-floating, oftentimes netted growth.....*Lyngbya*

Genus SPIRULINA Turpin em. Gardner

Key to the Species

1. Trichomes forming close spirals ..... *S. subsalsa*
1. Trichomes forming loose spirals ..... *S. major*

Spirulina subsalsa Oersted ex Gomont Pl. I, fig. 5

S. subsalsa Oersted ex Gomont. Desikachary, Cyanophyta, pl. 36, fig. 9, 1959.

Trichomes dark blue-green, 1-2 μ wide; spirals mostly densely coiled and very close to each other; observed among other algae in planktonic forms.

Specimens : Inside campus : Floating on a dirty canal at the Teachers' Training Centre, 5, April 11; in a dirty canal, 34, April 19. Outside campus : In a canal with other algae infront of the administration, 117, July 1; standing water at the lawn of the Atomic Energy for Peace, AEP, 189, September 16; good growth in an aquarium of the Department of Fishery Biology, 203, September 28.

Spirulina major Kützing. Pl. I, fig. 6

S. major Kützing. Tilden, Minnesota Algae, pl. IV, fig. 46, 1910.

Trichomes bright blue-green, generally 1.7 μ wide; spirals much looser and far apart to each other; observed in planktonic forms.

Specimens : Inside campus : Floating in a canal left side of the Teachers' Training Centre, 5, April 11; in a dirty pond, 34, April 19. Outside campus : In a shallow standing water along the road, 186, September 2; floating in a dirty canal near Forestry and Agriculture compound, 195, September 23.

Genus OSCILIATORIA Vaucher

Key to the Species

1. Trichome cells generally quadrate 2
1. Trichome cells generally variable 3
   2. Trichomes 2.2-5 μ wide, end cell capitate ..... *O. prolifica*
   2. Trichomes 4-6 μ wide, end cell conical ..... *O. agardhii*
      or pointed, rarely capitate
3. Trichomes constricted at cross-walls 4
3. Trichomes not constricted at cross-walls 8
   4. Trichomes broad up to 20 μ wide 5
   4. Trichomes much narrower, up to 5 μ wide 7
5. Trichomes 10-20 u wide, end cell concave ..... *O. sancta*
   with somewhat thickened membrane
5. Trichomes generally narrower 6
   6. Trichomes 4-10 μ wide, end cell ..... *O. tenuis*
      rounded somewhat thickened
   6. Trichomes 9-11 μ wide, end cell ..... *O. ornata*
      rounded
   6. Trichomes 8-13 μ wide, end cell ..... *O. chalybea*
      obtuse, somewhat bent
7. Trichomes 3-5 μ wide, transverse walls granulated..... *O. laetevirens*
7. Trichomes 2-3 μ wide, transverse walls not granulated..... *O. amphibia*
   8. Trichomes wide 9
   8. Trichomes much narrower 11
9. Trichomes exceptionally wide up to 60 μ ..... *O. princeps*
9. Trichomes not as wide up to 20 μ 10
   10. Trichomes 11-12 μ wide, cells ..... *O. limosa*
       towards tip slightly tepering, not capitate
   10. Trichomes 12-15 μ wide, cells towards ..... *O. proboscidea*
       tip distincly tapering
11. Trichomes 3.5-4 μ wide, cells towards ..... *O. chlorina*
    apex not tapering, end cell rotund
11. Trichomes 3-4 μ wide, cells towards ..... *O. animalis*
    apex tapering into a sharp point

Oscillatoria prolifica (Greville) Gomont. PI.I, fig. 7

C. prolifica (Greville) Gomont. Tilden, Minnesota Algae, pl. IV, fig. 1, 1910.

Trichomes straight, not constricted at cross-walls, attenuated, 2.2-5 μ wide; cells usually quadrate, gas vacuoles present; end cells capitate.

Specimens : Outside campus : Floating in much polluted water along the road, 154, August 5; in a polluted canal near Forestry and Agriculture compound, 195, September 23.

Oscillatoria agardhii Gomont Pl. I, fig. 8

O. agardhii Gomont. Tilden, Minnesota Algae, pl. IV, fig. 2, 1910.

Trichomes straight, not constricted at cross-walls, 4-6 μ wide, free floating, gradually tapering towards apex; gas vacuoles present; end cells not distinctly capitate.

Specimen : Inside campus : As plankton in a small pond back of Museum and Library with *Microcystis aeruginosa*, 204, September 28.

Oscillatoria sancta Kützing Pl. I, fig. 9

O. sancta Kützing. Velasquez, Blue-Green Algae of the Philippines, pl. 2, fig. 21, 1962.

Trichomes dark blue-green, straight, 10-20 μ wide; cross-walls constricted; end cells hemispherical, somewhat flattened with thickened membrane.

Specimens : Inside campus : On surface of moist polluted soil near an old building, 12 April 11. Outside campus : As dark-colored growth with other algae, 182, August 26.

Oscillatoria tenuis Agardh. Pl. I, figs. 10-10 a

O. tenuis Agardh. Tilden, Minnesota Algae, pl. XIV, figs. 17-18, 1910.

Thallus thin, light blue-green; trichomes 4-10 μ wide, straight, fragile; cross-walls slightly constricted; apex generally straight, not attenuated, not capitate; apical cells convex with slightly thickened outer wall. Var. *tergestina* (Kutzing) Rabenhorst. Trichomes 4-6 μ wide.

Specimens : Inside campus : Floating in a canal left side of the Teachers' Training Centre, 5, April 11; in luxuriant growth in an aquarium at the Faculty of Fisheries, 16, April 18; floating in a dirty water near a fish culture pond, 24, April 18. Outside campus : In a polluted canal, 117 a, July 11; in polluted water along the road, 154, August 5.

Oscillatoria ornata Kützing. Pl. I, fig. 11

O. ornata Kützing. Desikachary, Cyanophyta, pl. 37, fig. 12, 1959.

Trichomes dark blue-green, 9-11 μ wide, slightly coiled towards end, constricted at cross-walls; end cells rounded, not capitate.

Specimens : Inside campus : Standing water near the Quarantine Station, 1, April 11; polluted canal with other algae infront of administration, 106, May 27. Outside campus : In another polluted canal, 117 a, July 1; from a canal west side of the campus, 127, July 8; floating with *O. princeps* on a dirty canal, 135, July 22.

Oscillatoria chalybea (Mertens) Gomont Pl. I, fig. 12

O. chalybea (Mertens) Gomont. Desikachary, Cyanophyta, pl. 38, fig. 3, 1959.

Thallus dark blue-green; trichomes 8-13 μ wide, straight, slightly constricted at cross-walls, gradually tapering towards end; apex hooked or curved, end cells not capitate.

Specimens : Inside campus : In the greenhouse of the Rice Experiment Station, 95, May 27. Outside campus : From a permanent polluted canal, 106, May 27; in a small dirty canal at the Faculty of Veterinary Science, 195, September 28.

Oscillatoria laetevirens (Crouan) Gomont Pl. I, fig. 13

O. laetevirens (Crouan) Gomont. Tilden, Minnesota Algae, pl. IV. fig. 28, 1910.

Thallus thin, bright blue-green; trichomes 3-5 μ wide, straight; cross-walls slightly constricted, granulated; apex briefly tapering, somewhat hooked, not capitate.

Specimens : Outside campus : In a muddy path along the ricefield, 196, September 23; in a polluted pond at the squatters' compound, 197, September 23.

Oscillatoria amphibia Agardh Pl. I, fig. 14

O. amphibia Agardh. Velasquez, Blue-Green Algae of the Philippines, pl. 2, fig. 39, 1962.

Thallus thin, generally straight, blue-green; trichomes 2-3 μ wide, not constricted at cross-walls; apex of trichomes straight, not tapering nor capitate.

Specimens : Outside campus : On surface of moist soil along the road, 169, August 19; on very moist surfce and shallow water, 171, August 19.

Oscillatoria princeps Vaucher Pl. II, fig. 15-15 a

O. princeps Vaucher. Velasquez, Blue-Green Algae of the Philippines, pl. 1, fig. 14, 1962.

Trichomes black, dark blue-green, straight, exceptionally widest of all species of *Oscillatoria*, up to 60 μ broad, distinctly visible to naked eye; brittle when dry; cells very narrow, not constricted at cross-walls; end cells flatly rounded, slightly capitate.

Specimens : Inside campus : Floating in a standing water at the Rice Experiment Station, 3 April 11; on a moist wall of Forestry nursery, 90, May 15; on moist sidewalk usually inundated by irrigation water, 93, May 27. Outside campus : In a polluted canal along the street, 119, July 1; on the surface of a permanent canal, 119, July 1; surface of shallow canal along the road., 186, September 2.

Oscillatoria limosa Agardh Pl. II, fig. 16

O. limosa Agardh. Tilden, Minnesota Algae, pl. IV. fig. 6, 1910.

Trichomes dark blue-green, 11-20 μ wide, straight, cross-wall not constricted, generally granulated; apical cells rounded, not capitate.

Specimens : Inside campus behind the Department of Biology building, 19, April 18; pollution in a canal along the street, 31, April 18; from the Rice Experiment Station, 97, May 27. Outside campus : Luxuriant growth on moist soil of Dr. Sarot's orchid greenhouse, 194, September 19.

Oscillatoria proboscidea Gomont Pl. II, fig. 17

O. proboscidea Gomont. Desikachary, Cyanophyta, pl. 38, fig. 9, 1959.

Thallus blue-green; trichomes straight, cross-walls not constricted, 12-15 μ wide; distinctly attenuated, slightly curved; end cells flatly round or truncate, capitate.

Specimens : Inside campus : On moist soil near the Chemistry building, 79, May 15. Outside campus : Growing with *Aphanothece stagnina* along the road, 175, August 26.

Oscillatoria chlorina Kützing ex Gomont Pl. II, fig. 18

O. chlorina Kützing ex Gomont. Desikachary, Cyanophyta, pl. 40, fig. 4, 1959.

Thallus thin, light green; trichomes straight, cross-walls not constricted nor granulated, 3.5-4 μ wide; cells almost square, no calyptra.

Specimens : Inside campus : As excellent growth in a pond, 15, April 16; on moist surface growing with grasses near a fishpond culture, 17, April 18.

Oscillatoria animalis Agardh ex Gomont Pl. II, fig. 19

O. animalis Agardh ex Gomont. Desikachary, Cyanophyta, pl. 40, fig. 14, 1959.

Thallus dark blue-green; trichomes straight; cross-walls not constricted nor granulated, 3-4 μ wide, attenuated and sharply pointed towards end, not capitate.

Specimens : Inside campus : On moist soil at the Institute of Home Economics, 38, April 22. Outside campus : In a dirty standing water, 157, August 5.

Genus PHORMIDIUM Kützing

Key to the Species

1. Trichomes very narrow, 1.75-2 μ wide, slightly constricted ..... *P. luridum*
1. Trichomes much wider, not constricted 2
2. Trichomes generally 6-9 μ wide ..... *P. uncinatum*
2. Trichomes generally not as wide 3
3. Trichomes 3-5 μ wide, protoplasm not much granulated ..... *P. inundatum*
3. Trichomes wider, protoplasm regularly granulated 4
4. Trichomes 4-7 μ wide, apical cell rounded with calyptra ..... *P. autumnale*
4. Trichomes usually wider, 4.5-10 μ wide ..... *P. retzii*
apical cell somewhat truncate, no calyptra

Phormidium luridum (Kützing) Gomont P.l. II, fig. 20

P. luridum (Kützing) Gomont. Tilden, Minnesota Algae, pl. IV, figs. 56-57, 1910.

Thallus thin, purplish blue-green; filaments straight; sheaths hardly visible; trichomes 1.7-2 μ wide, slightly constricted at cross-walls; apical cells rotund, no calyptra.

Specimen : Outside campus : Near a private residence along a narrow path, 198, September 23.

Phormidium uncinatum (Agardh) Gomont Pl. II, fig. 21

P. uncinatum (Agardh) Gomont. Desikachary, Cyanophyta, pl. 45. figs. 9-10, 1959.

Thallus expanded, bluish-green; filaments usually straight with very thin sheaths; trichomes not constricted at cross-walls, 6-9 μ wide, briefly attenuated; cells longer than width, seldom quadrate; end cells rounded with a depressed conical catyptra.

Specimen : Inside campus : On moist old wood near an aquarium, 11, April 11.

Phormidium inundatum Kützing Pl. II, fig. 22

P. inundatum Kützing. Velasquez, Blue-Green Algae of the Philippines, pl. 3, fig. 56, 1910.

Thallus dark blue-green; filaments with very thin sheath; trichomes 3-5 μ wide, straight, not constricted at cross-walls; cells generally quadrate; end cells obtuse conical, no calyptra.

Specimen : Outside campus : On moist side of road splashed by dirty water, 155, August 5.

Phormidium autumnale (Agardh) Gomont Pl. II, fig. 23

P. autumnale (Agardh) Gomont. Velasquez, Blue-Green Algae of the Philippines, pl. 3, fig. 53, 1962.

Thallus thin, dark blue-green; filaments straight, very thin sheaths; trichomes 4-7 μ wide, briefly attenuated, not constricted at cross-walls; cells quadrate, apical cells rotund or truncate, somewhat thickened outer wall.

Specimen : Inside campus : Drying on an old cemented surface of the Institute of Food Research and Product Development Laboratory, 45, April 22.

Phormidium retzii (Agardh) Gomont Pl. II, fig. 24

P. retzii Gomont. Tilden, Minnesota Algae, pl. V, figs. 1-4, 1910.

Thallus dark blue-green; filaments straight, entangled; trichomes usually 4.5-10 μ wide, cross-walls lightly constricted; cell contents granular; apical cell hardly tapering, not capitate.

Specimen : Inside campus : Floating in a fishpond culture, 24, April 18.

Genus LYNGBYA C. Agardh

Key to the Species

1. Filaments aquatic, trichomes 6-10 μ wide ..... *L. martensiana*
1. Filaments in moist soil 2
   2. Trichomes 11-16 μ wide ..... *L. major*
   2. Trichomes much narrower, 1.2-3 μ wide ..... *L. lagerheimii*

Lyngbya martensiana Meneghini ex Gomont Pl. III, figs. 25-25 a-b

L. martensiana ex Gomont. Desikachary, Cyanophyta, pl. 52, fig. 6, 1959.

Thallus caespitose, blue-green, yellow violet when dry; filaments very long, flexible, sheaths thick, generally roughened with age; trichomes 6-10 μ wide, cross-walls not constricted, apex not attenuated; end cells rotund.

Specimen : Outside campus : Floating luxuriantly in a private fishpond, 180, August 26.

Lyngbya major Meneghini Pl. III, fig. 26

L. major Meneghini. Desikachary, Cyanophyta, pl. 52, fig. 11, 1959.

Filaments dark blue-green, expanded; sheaths thick, lamellated; trichomes 11-16 μ wide, cross-walls slightly constricted, granulated; end cells rounded with slightly thickened membrane.

Specimens : Inside campus : peelings at the Institute of Food Research and Product Laboratory, 46, April 22; from moist surface infront of the administration, 62, May 13. Outside campus : Along the roadside, 141, July 21; in a shallow water, 163, August 19; along one side of a narrow road, 176, August 27; good growth on surface of most soil, 187, September 2.

Lyngbya lagerheimii (Möbius) Gomont Pl. III, fig. 27

L. lagerheimii (Möbius) Gomont. Desikachary, Cyanophyta, pl. 53, fig. 2, 1959.

Filaments sometimes entangled; sheaths thin, colorless; trichomes generally 2 μ wide, not constricted at cross-walls, not attenuated; end cells rounded.

Specimens : Inside campus : Floating in polluted standing water, 47, April 22; under a dripping facet at the Faculty of Forestry, 81, May 15.

Genus SYMPLOCA Kützing

Key to the Species

1. Trichomes 5-8 μ wide ..... *S. muscorum*
2. Trichomes much narrower, 3.4-4 μ wide ..... *S. muralis*

Symploca muscorum (Agardh) Gomont Pl. III, fig. 28

S. muscorum (Agardh) Gomont. Desikachary, Cyanophyta, pl. 59, figs. 3-4, 1959.

Thallus thin, usually prostrate; filaments firm with thin sheaths ; trichomes 5-8 μ wide, not constricted at cross-walls; cells quadrate not granulated ; end cell rounded with somewhat thickened outre membrane.

Specimens : Inside campus : light green-brownish growth on the surface of a small tank at the Forestry nursery, 91, May 15. Outside campus : peeled on moist surface of soil, 174, August 26.

Symploca muralis Kützing Pl. III, fig. 29

S. muralis Kützing. Tilden, Minnesota Algae, pl. V. fig. 53, 1910.

Thallus expanded, dark color; filaments elongate, irregularly entangled; sheaths generally thin; trichomes 3.4-4 μ wide, not constricted at cross-walls, apex somewhat very slightly tapering ; apical cells obtuse conical, calyptra none.

Specimen : Inside campus : Under a dripping pipe at the Faculty of Forestry laboratory 81, May 15.

Genus PORPHYROSIPHON Kützing

Porphyrosiphon fuscus Gomont Pl. III, fig. 30

P. fuscus Gomont. Velasquez, Blue-Green Algae of the Philippines, pl. 4, fig. 72, 1962.

Thallus purplish-brown, dark to light green ; filaments flexuous, entangled; trichomes narrow within firm colorless sheaths, empty in several specimens; cross-walls not constricted; end cells rotund, slightly thickened.

Specimen : Outside campus : On a dry surface of soil with grasses along the road, 166, August 19.

Genus MICROCOLEUS Desmazieres

Key to the Species

1. Cells of trichomes 3.5-7 μ wide, ... *M. vaginatus*
   end cells capitate
1. Cells of trichomes 5-7 μ wide, ... *M. paludosus*
   end cells conical, not capitate

Microcoleus vaginatus (Vaucher) Gomont Pl. IV, figs. 31-31 a-b

M. vaginatus (Vaucher) Gomont. Desikachary, Cyanophyta, pl. 56, fig. 3, 1959.

Thallus dark blue-green, growth creeping composed of many long trichomes in a sheath; sheaths colorless, uneven, generally roughened with age; trichomes 3.5-7 μ wide, cross-walls not constricted; cells generally quadrate; end cells capitate.

Specimens : Inside campus : Growing at the Rice Experiment Station, 28, April 18; in the lawn of the Chemistry building, 29, May 15; inside a greenhouse of the Rice Experiment Station, 97, May 27. Outside campus : Peeled along the sidewalk, west side of the campus, 125, July 8, on a moist surface along the road, 141, July 22; cemented fence near Bangkhen railway station, 179, August 26; very luxuriant growth in the orchid greenhouse of Dr. Sarot, 148, July 29.

Microcoleus paludosus (Kützing) Gomont Pl. IV, figs. 32-32 a

M. paludosus (Kützing) Gomont. Tilden, Minnesota Algae, pl. VI, fig. 30, 1910.

Thallus growth of creeping filaments each enclosing many crowded trichomes; sheaths closed when young, open and disappearing at apex in maturity; trichomes 5-7 μ wide, cross-walls not constricted nor granulated; apical cells not capitate.

Specimens : Outside campus : Along the sidewalk of the westside of the University campus, 125, July 8; in a shallow lightly polluted water, 163, August 19.

Family 3. NOSTOCACEAE Kützing

Trichomes free or in a common mucilage; sheaths of various forms, thick or thin, distinct and gelatinous, oftentimes not visible in many species; trichomes not branched, of uniform cells; heterocysts present, intercalary or terminal; reproduction by vegetative division, hormogonia and akinetes.

Key to the Genera

1. Heterocysts basal, usually with a single adjacent akinete..... *Cylindrospermum*
1. Heterocysts intercalary and terminal 2
   2. Trichomes closely and regularly spiral ..... *Anabaenopsis*
   2. Trichomes usually flexuous, not spiral ..... *Nostoc*

Genus ANABAENOPSIS (Woloszynska) Miller sensu strict.

Anabaenopsis arnoldii Aptekarj Pl. IV, fig. 33

A. arnoldii Aptekarj. Desikachary, Cyanophyta, pl. 62, figs. 1-4, 1959.

Trichomes generally planktonic, single with hardly visible sheaths; conspicuously, closely and spirally coiled; heterocysts terminal and intercalary, the later observed solitary in the specimens available; cells adpressed spherical, with gas vacuoles; akinetes intercalary.

Communicated with Dr. Jeegi Bai of Kohlenstoffbiologishe Forschungstation at Dortmund, West Germany who suggested that more material be studied to distinguish further the species from *Anabaena spiroides* Klebahn. The illustration in Plate IV, fig. 33 should be improved to its natural form, especially the closer spiral of the species.

Specimen : Inside campus : Plankton in a small pond back of the Museum and Library, Faculty of Fisheries, 204, September 27.

Genus NOSTOC Vaucher

Nostoc comminutum Kützing Pl. IV, fig. 34

N. comminutum Kützing. Tilden, Minnesota Algae, p. 313, 1910

Thallus very small, hardly visible to the naked eye, light blue-green; trichomes 3-4 μ wide, flexuously curved, densely entangled; cells spherical or depressed spherical, strongly compressed; heterocysts exactly round, intercalary; cell contents homogenous.

Specimens : Outside campus : On moist soil and shallow water of a country road near a polluted pond, 153, August 5; brownish blue-green growth along the road, 167, August 19; on moist surface of soil along the road, 184, September 2.

Genus CYLINDROSPERMUM Kützing

Cylindrospermum muscicola Kützing ex Born. and Flah Pl. IV., fig. 35

C. musciola Kützing. Velasquez, Blue-Green Algae of the Philippines, pl. 9, fig. 118, 1962.

Filaments dark blue-green growing with other algae; trichoemes 3-4.7 μ wide, slightly constricted at cross-walls; heterocysts basal, oblong; wall of akinetes smooth next to the heterocyst; cell contents light blue-green.

Specimens : Inside campus : Growing with grasses along the canal, 43, April, 22. Outside campus : Growth with other blue-green algae and grasses, 122 July 8.

Family 4. SCYTONEMATACEAE Rabenhorst

Key to the Genera

1. Filaments several in a mother sheath, heterocysts usually basal ..... *Desmonema*
1. Filaments free, solitary, heterocysts usually intercallary 2
   2. False branches generally solitary and arising immediately next to the heterocyst ..... *Tolypothrix*
   2. False branches generally in pairs and arising between heterocysts ..... *Scytonema*

Genus DESMONEMA Berkeley and Thwaites

Desmonema wrangelii (Agardh) Born. and Flah Pl. V, figs. 36-36 a

D. wrangelii (Agardh) Born. and Flash. Tilden, Minnesota Algae. pl. XIV, fig. 10, 1910.

Thallus caepitose, dark green, several in a sheath; filaments somewhat flexuous; sheaths thin, colorless; trichomes 9-10 μ wide, constricted at cross-walls; heterocysts rare; cells short, finely granulated.

Specimens : Inside campus : Floating with other blue-green algae in a shallow water, 24, April 18; as very good growth on moist soil at the Biological Experimental Garden, 23, April 18.

Genus TOLYPOTHRIX Kützing

Tolypothrix tenuis (Kützing) Johs. Schmidt em Pl. V, fig. 37

T. tenuis (Kützing) Johs. Schmidt em. Desikachary, Cyanophyta, pl. 102, fig. 4, 1959.

Thallus caepitose, cushion-like, blue-green to yellow brown; filaments generally 6-10 μ wide, branches usually solitary; sheaths thin, colorless; often lamellated; trichomes usually 8 μ wide, not constricted at cross-walls; heterocysts oftentimes cylindrical.

Specimen : Outside campus : Floating as thick and luxuriant growth in a ricefield, 192, September 16.

Genus SCYTONEMA Agardh

Key to the Species

1. Filaments 7-12 μ wide, sheaths usually thin, not lamellose ..... S. *hofmanni*
1. Filaments 12-21 μ wide, sheaths usually thick, lamellose ..... S. *guyanense*

Scytonema hofmanni Agardh ex Born. and Flah Pl. V, fig. 38

S. hofmanni Agardh ex Born. and Flah. Desikachary, Cyanophyta, pl. 91, fig. 2, 1959.

Thallus cushion-like, much expanded, dark blue-green; filaments 7-12 μ wide; false branches usually short; trichomes generally 10 μ wide enclosed in usually narrow sheaths; cells rectangular or unequal in length.

Specimens : Inside campus : Scrapped from the wall of an old building, 42, April 22; pure growth at the bicycle stand, 60, May 13. Outside campus : On an old wooden bridge across a polluted canal, 120, July 1; growing on the bark of on old raintree, 124, July 8.

Scytonema guyanense (Montagne) Born. and Flah Pl. V, fig. 39

S. guyanense (Montagne) Born. and Flah. Velasquez, Blue-Green Algae of the Philippines, pl. 12, figs. 137-137 a, 1962.

Thallus much expanded, cushion-like; filaments 12-21 μ wide, false branches long and bent, sheaths usually lamellose; trichomes 10-16 μ wide ;cells generally quadrate.

Specimens : Inside campus : Growing on wall of an aquarium tank, 9, April 11; from a vertical wall of the Chemistry building, 80, May 15; in the greenhouse of the Rice Experiment Station, 101, May 27. Outside campus : Abundant with grasses along the road, 136, July 22; as felt-like growth along the narrow canal, 138, July 22; on an old cemented wall of a private house, 146, July 29.

Family 5. RIVULARIACEAE Rabenhorst

Filaments tapering from base to apex ending in a colorless hair; false branches usually arising as new trichomes from cells of main trichomes, oftentimes developing new sheaths; heterocysts present, usually basal; reproduction by cell division, hormogonia and akinetes.

Calothrix braunii (A. Br.) Born. and Flah Pl. V, figs. 40-40 a

C. braunii (A.Br.) Born. and Flah. Desikachary, Cyanophyta, pl. 144, fig. 3, 1959.

Thallus caespitose, blue-green; filaments 9-10 μ wide, swollen towards base; sheaths thin, colorless; trichomes long 6-8 μ wide ending into a hair; cross-walls constricted; heterocysts basal.

Specimen : Inside campus in a rain water tank at the Institute of Food Research and Product Development Laboratory, 44, April 22.

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2. Tilden, Josephine (1910) Minnesota Algae, Vol. I, Report of the Survey, Botanical Series VIII; Minneapolis, Minnesota, U.S.A.
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Illustrations

PLATE I

Fig. 1. *Synechocystis aquatilis* Sauvageau
Fig. 2. *Aphanocapsa virescens* (Hassall) Rabenhorst
Fig. 3. *Microcystis acruginosa* Kützing
Fig. 4. *Aphanothece stagnina* (Aprengel) A. Br.
Fig. 5. *Spirulina subsalsa* Oersted ex Gomont
Fig. 6. *Spirulina major* Kützing
Fig. 7. *Oscillatoria prolifica* (Greville) Gomont
Fig. 8. *Oscillatoria agardhii* Gomont
Fig. 9. *Oscillatoria sancta* Kützing
Fig. 10. *Oscillatoria tenuis* Agardh
Fig. 11. a. Var. *tergestina* (Kützing) Rabenhorst
Fig. 11. *Oscillatoria ornata* Kutzing
Fig. 12. *Oscillatoria chalybea* (Mertens) Gomont
Fig. 13. *Oscillatoria laetevirens* (Crouan) Gomont
Fig. 14. *Oscillatoria amphibia* Agardh

All figures, x 900

PLATE II

Fig. 15. *Oscillatoria princeps* Vaucher
Fig. 15. a. Showing a form of tip cell
Fig. 16. *Oscillatoria limosa* Agardh
Fig. 17. *Oscillatoria proboscidea* Gomont
Fig. 18. *Oscillatoria chlorina* Kützing ex Gomont
Fig. 19. *Oscillatoria animalis* Agardh ex Gomont
Fig. 20. *Phormidium luridum* (Kützing) Gomont
Fig. 21. *Phormidium uncinatum* (Agardh) Gomont
Fig. 22. *Phormidium inundatum* Kützing
Fig. 23. *Phormidium autumnale* (Agardh) Gomont
Fig. 24. *Phormidium retzii* (Agardh) Gomont

All figures, x 900

PLATE III

Fig. 25. *Lyngbya martensiana* Meneghini ex Gomont
Fig. 25. a. Parts of two hormogonia
Fig. 25. b. Part of trichome highly magnified
Fig. 26. *Lyngbya major* Meneghini

Fig. 27. *Lyngbya lagerheimii* (Möbius) Gomont
Fig. 28. *Symploca muscorum* (Agardh) Gomont
Fig. 29. *Symploca muralis* Kützing
Fig. *30*. *Porphyrosiphon fuscus* Gomont

All figures, x 900 except figures 25, x 60 and 25 a, x 450

PLATE IV

Fig. 31. *Microcoleus vaginatus* (Vaucher) Gomont
Fig. 31. a. Part of sheath and arrangement of trichomes
Fig. 31. b. Part of a trichome highly magnified
Fig. 32. *Microcoleus paludosus* (Kützing) Gomont
Fig. 32. a. Part of a trichome highly magnified
Fig. 33. *Anabaenopsis arnoldii* Aptekarj
Fig. 34. *Nostoc comminutum* Kützing
Fig. 35. *Cylindrospermum muscicola* Kützing

All figures, x 900 except figures 31 and 32, x 200

PLATE V

Fig. 36. *Desmonema wrangelii* (Agardh) Born. and Flah.
Fig. 36. a. Part of trichomes in a sheath highly magnified
Fig. 37. *Tolypothrix tenuis* (Kützing) Johs. Schmidt em.
Fig. 38. *Scytonema hofmanni* Agardh ex Born. and Fiah.
Fig. 39. *Scytonema guyanense* (Montagne) Born. and Flah.
Fig. 40. *Calothrix braunii* (A. Br.) Born. and Flah.
Fig. 40 a. Towards the end of trichome

All figures, x 900 except figure 36, x 450

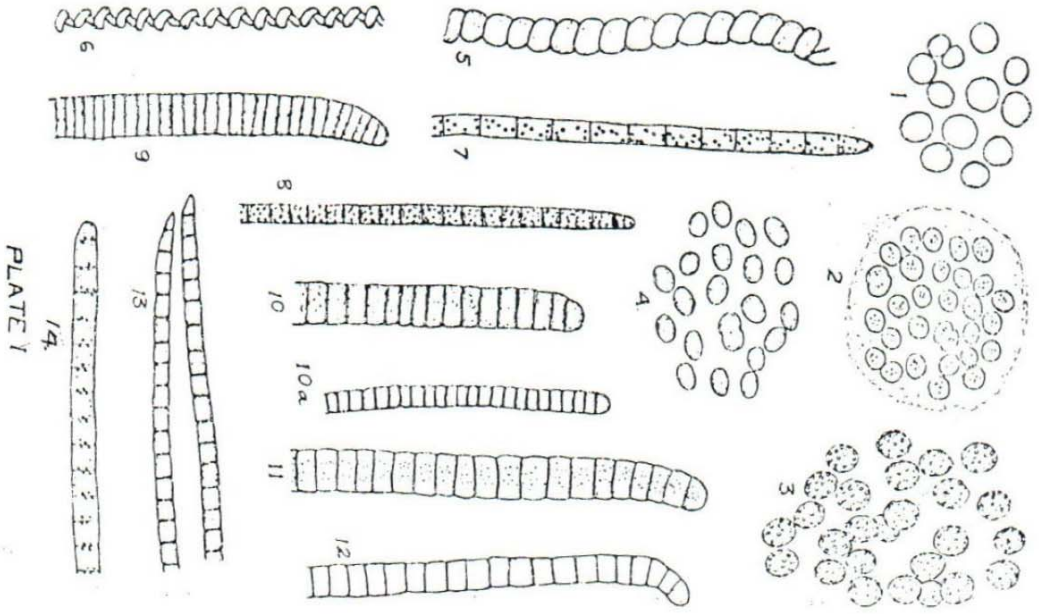


PLATE I

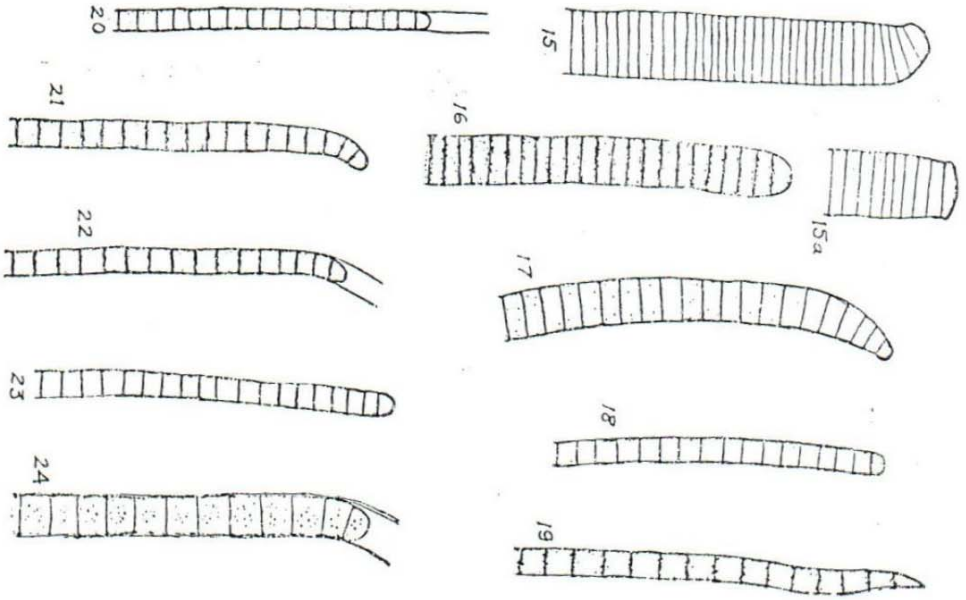


PLATE II

PLATE III

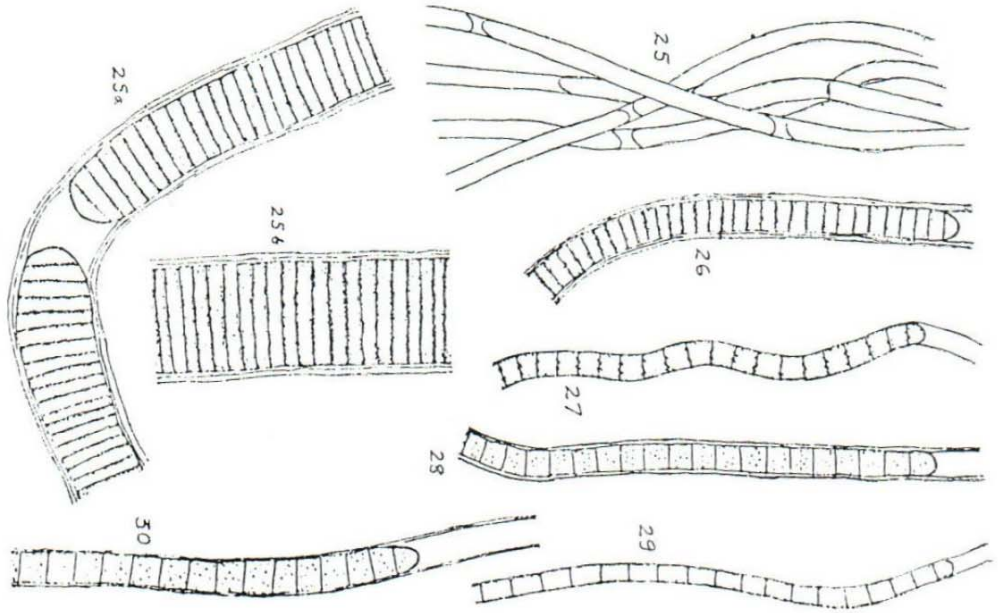
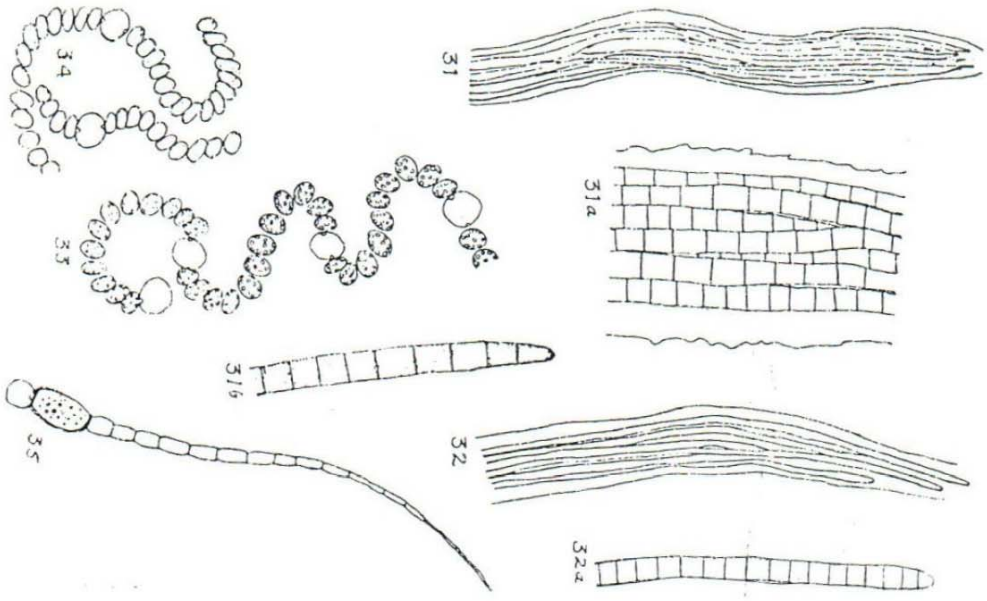


PLATE IV



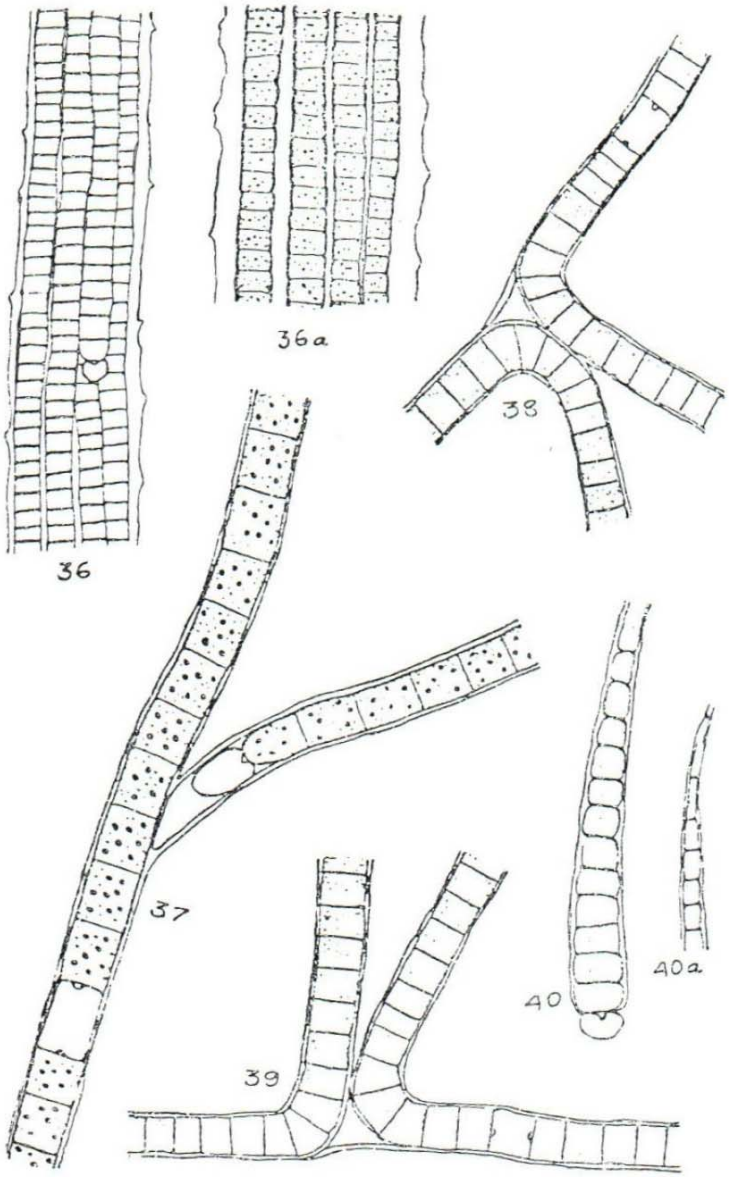
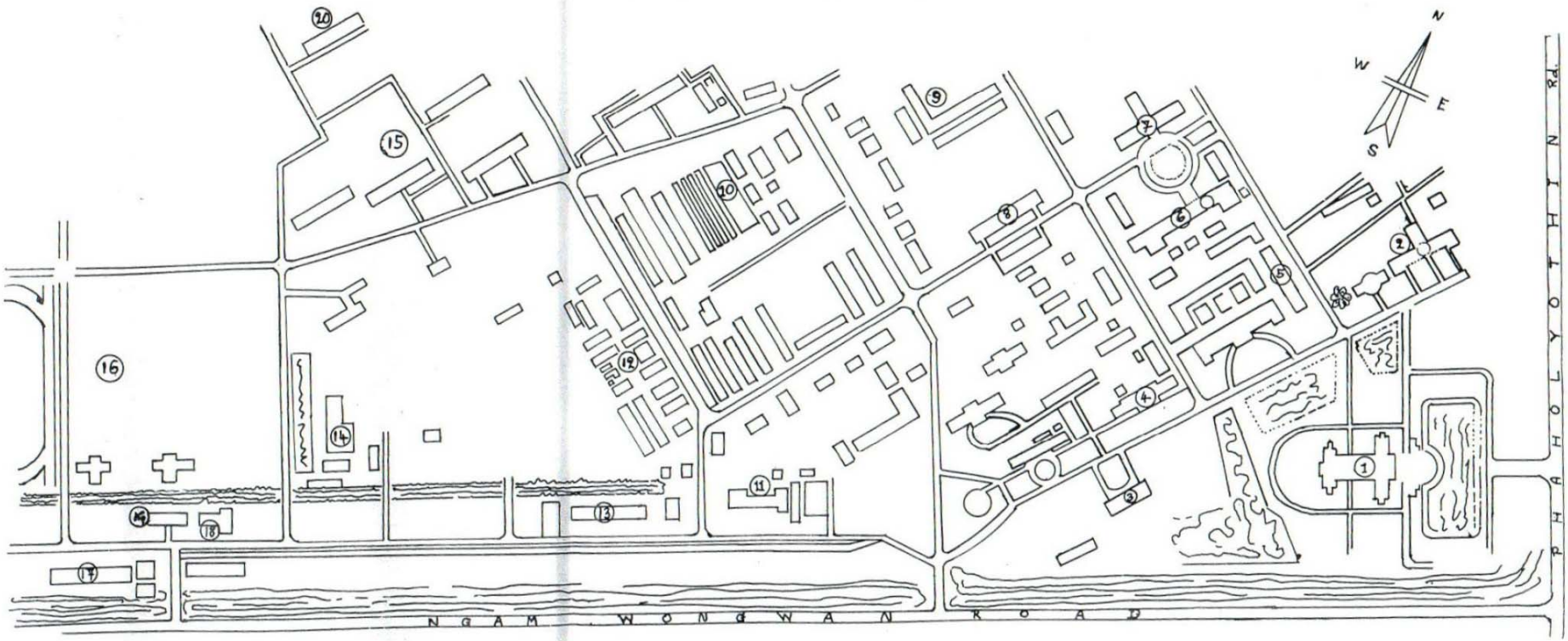


PLATE V

KASETSART UNIVERSITY CAMPUS



LEGEND

1. Administration
2. Faculty of Fisheries
3. Central Library
4. Old Biology Building
5. Rice Protection Research Centre
6. Chemistry Building
7. Faculty of Agriculture
8. Department of Languages
9. Faculty of Forestry
10. New Biology Building
11. Department of Home Economics
12. Institute of Food Research and Product Development
13. Faculty of Economics
14. Students' Centre
15. Men's Dormitory
16. Playground
17. Canteen
18. Radio Broadcasting Station
19. Department of Animal Science
20. Faculty of Education