STUDIES ON SOME SOIL ALGAE OF NORTH WEST FRONTIER PROVINCE (PAKISTAN)

By

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A B S T R A C T

STUDIES ON SOME SOIL ALGAE OF NORTH WEST FRONTIER PROVINCE (PAKISTAN)

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The present study, first of its nature in this region, dealt with the taxonomy and distribution of soil algal flora of North West Frontier Province of Pakistan. Soil was sampled from 0-1", 1-2", 2-3", 3-4", 4-5" and 5-6" depth from various localities and habitats of the province and stored separately.

Algae were cultured in 1N BBM, 3N BBM, Knop's Solution and Soil Extract using 9 cm petri dishes and 125 ml capacity Erlenmeyer flasks under 16 hour light period at room temperature till maturity. Mature specimens were identified and described taxonomically. All diagrams, made from Camera lucida, are original. Microphotographs were taken whenever necessary.

A total of 245 species distributed among 74 genera and belonging to Cyanophyceae, Chlorophyceae, Xanthophyceae and Euglenophyceae were recorded. Cyanophyceae with 146 species; followed by 93 species of Chlorophyceae were the most common classes while Xanthophyceae having 5 species and Euglenophyceae with only one species was the least represented.

Oscillatoria (23 spp.), Phormidium (20 spp.), Nostoc (14 spp.), Anabaena (13 spp.), Lyngbya (13 spp.), Chroococcus (7 spp.), Microcystis (5 spp.), Spirulina (5 spp.), Aphanothece (4 spp.), Calothrix (4 spp.), Aphanocapsa (3 spp.), Merismopedia (3 spp.), Schizothrix (3 spp.), Scytonema (3 spp.), Tolypothrix (3 spp.), Aulosira (2 spp.), Cylindrospermum (2 spp.), Gloeotrichia (2 spp.), Microcoleus (2 spp.), Nodularia (2 spp.), Plectonema (2 spp.), Symploca (2 spp.), Chlorogloea (1 sp.), Coelosphaerium (1 sp.), Gloeothece (1 sp.), Hydrocoleum (1 sp.), Microchaete (1 sp.), Rivularia (1 sp.), Stichosiphon (1 sp.), and Synechococcus (1 sp.), in all contributing 146 species among 31 genera representing Cyanophyceae.

Among Chlorophyceae, 38 genera with 93 species belonged to Chlorococcum (19 spp.), Tetracystis (6 spp.), Chlorosarcinopsis (5 spp.), Bracteacoccus (4 spp.), Characium (4 spp.), Chlamydomonas (4 spp.), Oocystis (4 spp.), Scenedesmus (4 spp.), Cosmarium (3 spp.), Tetraëdron (3 spp.), Chlorohormidium (2 spp.), Cladophora (2 spp.), Eremosphaera (2 spp.), Gloeocystis (2 spp.), Oedogonium (2 spp.), Palmella (2 spp.), Spongiochloris (2 spp.), Stigeoclonium (2 spp.), Ulothrix (2 spp.), Chlorella (1 sp.), Closterium (1 sp.), Coelastrum (1 sp.), Crucigenia (1 sp.), Dictyococcus (1 sp.), Mesotaenium (1 sp.), Microspora (1 sp.), Neochloris (1 sp.), Palmellococcus (1 sp.), Pandorina (1sp.), Physolinum (1 sp.), Planktosphaeria (1 sp.),

Protococcus (1 sp.), Chlorotetraëdron (1 sp.), Quadrigula (1 sp.), Radiosphaera (1 sp.), Rhizoclonium (1 sp.), Rova (1 sp.), and Spondylosium (1 sp.), were studied.

Tribonema (2 spp.), Gloeobotrys (1 sp.), Heterococcus (1 sp.), and Monallantus (1 sp.), were representatives of Xanthophyceae. Euglenophyceae was represented by Euglena proxima var. minima only.

The number and kind of various species decreased with the increasing depth of soil. Ninety-eight species were recorded in the top most first inch of soil and they gradually decreased to 39 at a depth of 6 inches. Some of the species having wide range of tolerance, were recorded at all the depths.

Species of Heterococcus, Lyngbya, Oscillatoria, Phormidium and Ulothrix were found to be efficient soil binders. Cyanophycean species binding the soil were more than the others.

Forty-seven species belonging to 11 genera Anabaena, Aulosira, Calothrix, Cylindrospermum, Gloeotrichia, Microchaete, Nodularia, Nostoc, Rivularia, Scytonema and Tolypothrix were recorded as possible nitrogen-fixers.

Forty-six species were recorded for the first time from Pakistan.

Some species reported in the text common in aquatic habitats, were isolated from the soil.

There were some species recorded from two or more habitats in different regions of N.W.F.P.

TABLE OF CONTENTS

	Page
ACKNOWLEDGEMENTS	iv
ABSTRACT	vi
INTRODUCTION	1
SOIL ALGAE	12
REVIEW OF LITERATURE ON SOIL ALGAE	22
MATERIALS AND METHODS	28
TAXONOMIC DESCRIPTION OF PLANTS	32
KEY TO THE CLASSES	32
CYANOPHYCEAE	32
Key to the genera of Cyanophyceae	32
Chroococcus	35
Microcystis	42
Coelosphaerium	48
Chlorogloea	50
Gloeocapsa	51
Gloeothece	52
Aphanothece	53
Aphanocapsa	57
Merismopedia	59
Stichosiphon	62
Synechococcus	64
Spirulina	65
Oscillatoria	70
Phormidium	91

Lyngbya 111
Symploca 123
Microcoleus 125
Hydrocoleum 127
Schizothrix 128
Cylindrospermum 131
Nostoc 133
Anabaena 147
Aulosira 159
Nodularia 161
Plectonema 163
Scytonema 165
Tolypothrix 168
Microchaete 171
Calothrix 172
Rivularia 176
Gloeotrichia 177
CHLOROPHYCEAE 180
Key to the genera of Chlorophyceae 180
Chlamydomonas 184
Pandorina 187
Palmella 188
Gloeocystis 190
Ulothrix 192
Chlorohormidium 194
Microspora 197

Stigeoclonium 198
Protococcus 200
Physolinum 201
Cladophora 203
Rhizoclonium 205
Oedogonium 206
Bracteacoccus 209
Chlorosarcinopsis 213
Tetracystis 218
Chlorococcum 225
Eremosphaera 241
Planktosphaeria 244
Dictyococcus 245
Neochloris 247
Spongiochloris 248
Radiosphaera 251
Chlorella 252
Oocystis 253
Crucigenia 257
Palmellococcus 258
Scenedesmus 259
Quadrigula 263
Tetraëdron 264
Chlorotetraëdron 267
Coelastrum 268
Characium 269

Mesotaenium. 273
Roya. 274
Closterium 275
Cosmarium. 276
Spondylosium 279
XANTHOPHYCEAE. 281
Key to the genera of Xanthophyceae 281
Gloeobotrys. 281
Monallantus. 282
Tribonema. 283
Heterococcus 285
EUGLENOPHYCEAE 287
Euglena 287
RESULTS 289
DISCUSSION AND CONCLUSION 319
LITERATURE CITED. 336
GLOSSERY OF TERMS USED IN THE PRESENT TEXT. 471
INDEX 477

LIST OF ILLUSTRATIONS

Page

Plate 1 366

Plate 2 368

Plate 3 370

Plate 4 372

Plate 5 374

Plate 6 376

Plate 7 378

Plate 8 380

Plate 9 382

Plate 10 384

Plate 11 386

Plate 12 388

Plate 13 390

Plate 14 392

Plate 15 394

Plate 16 396

Plate 17 398

Plate 18 401

Plate 19 403

Plate 20 406

Plate 21 408

Plate 22 410

Plate 23 412

Plate 24. 414
Plate 25. 416
Plate 26. 418
Plate 27. 420
Plate 28. 422
Plate 29. 424
Plate 30. 426
Plate 31. 428
Plate 32. 430
Plate 33. 432
Plate 34. 434
Plate 35. 436
Plate 36. 438
Plate 37. 440
Plate 38. 442
Plate 39. 444
Plate 40. 446
Plate 41. 448
Plate 42. 450
Plate 43. 452
Plate 44. 454
Plate 45. 456
Plate 46. 458
Plate 47. 460

Plate 48. 462
Plate 49. 464
Plate 50. 466
Plate 51. 468
Plate 52. 470

INTRODUCTION

PHYSIOGRAPHY

North West Frontier Province (Pakistan) is located in the North-West part of the country. It extends from latitude $31^{\circ}4'$ to $37^{\circ}8'$ North and from longitude $69^{\circ}16'$ to $74^{\circ}7'$ East, an area of 39, 283 sq. miles (Kureshi, 1977).

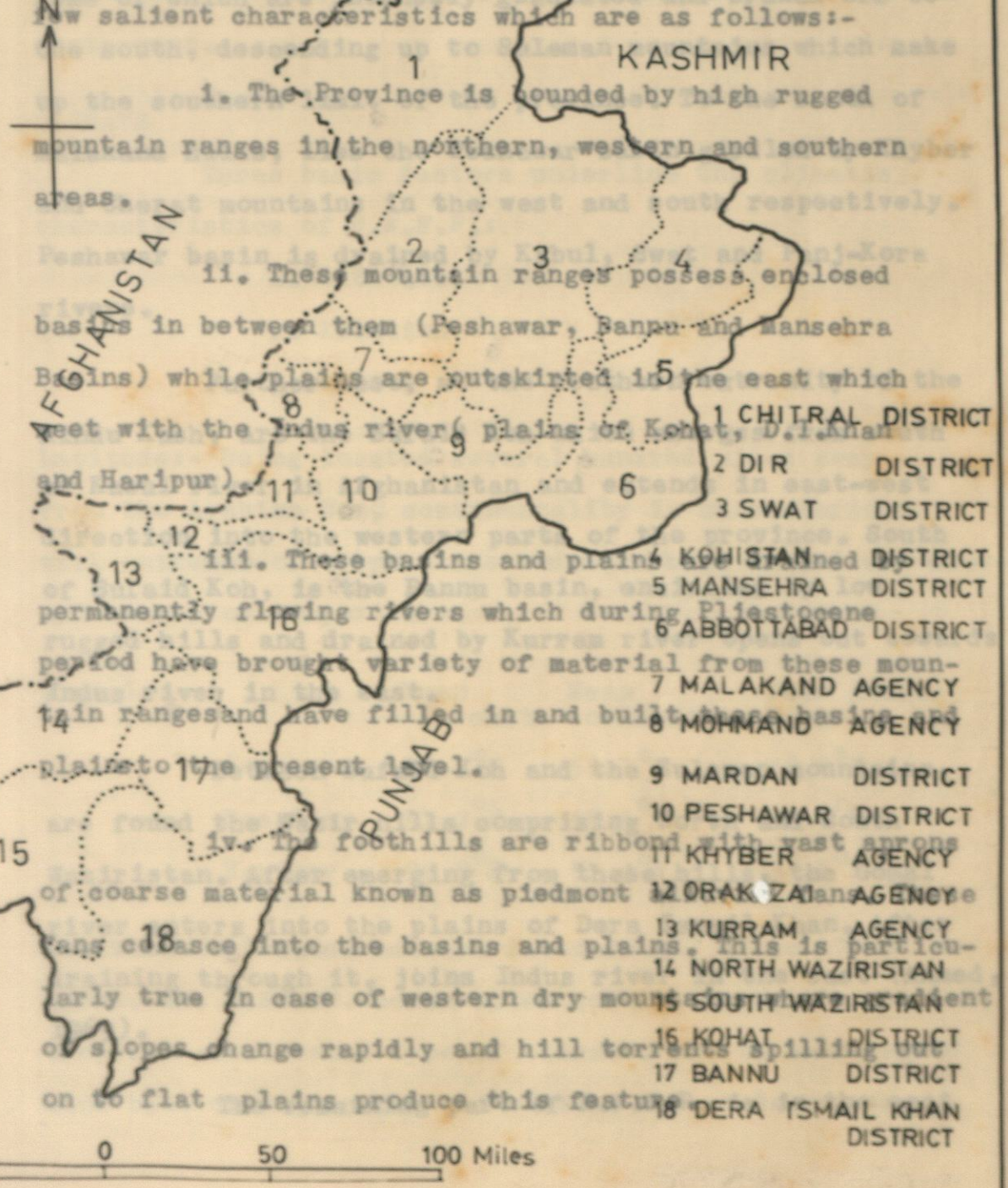
The evolution of Physiography of N.W.F.P. closely follow the geological history of Indo-Pakistan sub-continent, and most of the geological events have been found recorded in the lithology of various rocks.

The rocks exposed are highly indurated and structurally deformed sedimentary and metamorphic rocks ranging from the Pre-cambrian to the Pliestocene ages. The Pre-cambrian sequence is found in Attock slats of Hazara, Nowshera and Eastern areas of Kohat rangesand in the quatzits of Bara valley (Wadia, 1931; Hayden, 1968).

Kohat has coal bearing beds of Eocene age in Laki series while limestone of Cherat Mountains and sandstone of Hazara are known all over the world as examples of Jurrassic and Creteceous age, respectively.

The Pliestocene period exposes itself extensively in the form of fluviatile, lacustrine, glacial and

MAP OF NORTH WEST FRONTIER PROVINCE



eolian deposits of unconsolidated material and is found in various parts of the N.W.F.P.

Physiographic personality of N.W.F.P. exhibits few salient characteristics which are as follows:-

i. The Province is bounded by high rugged mountain ranges in the northern, western and southern areas.

ii. These mountain ranges possess enclosed basins in between them (Peshawar, Bannu and Mansehra Basins) while plains are outskirted in the east which meet with the Indus river (plains of Kohat, D.I.Khan and Haripur).

iii. These basins and plains are drained by permanently flowing rivers which during Pliestocene period have brought variety of material from these mountain rangesand have filled in and built these basins and plains to the present level.

iv. The foothills are ribbond with vast aprons of coarse material known as piedmont alluvium. These fans coalesce into the basins and plains. This is particularly true in case of western dry mountains where gradient of slopes change rapidly and hill torrents spilling out on to flat plains produce this feature.

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The north and north western area of the province is encircled by high lofty mountains of Hindu Kush (Tirch Mir, 25,000') and Swat Himalayas (Falak Sar, 23,000'), some of which are intensely glaciated and branch off to the south, descending up to Suleman mountains which make up the southern limit of the province. To the south of Malakand hills, lies the Peshawar basin girdled by Khyber and Cherat mountains in the west and south respectively. Peshawar basin is drained by Kabul, Swat and Panj-Kora rivers.

Further west, at the southern extremity of the Hindu Kush, are the Sufaid Koh which emerges from south of Kabul river in Afghanistan and extends in east-west direction into the western parts of the province. South of Sufaid Koh, is the Bannu basin, encircled by low rugged hills and drained by Kurram river opens out towards Indus river in the east.

Between Sufaid Koh and the Suleman mountains, are found the Wazir hills comprising North and South Waziristan. After emerging from these hills, the Gomal river enters into the plains of Dera Ismail Khan. After draining through it, joins Indus river in the east (Ahmed, 1969).

The remaining part of N.W.F.P. is in the east

of Indus river which is flanked by the ranges of Hazara mountains, streches further south-east into the Murree hills. This area consists valleys of Kunhar, Siran and Dor, Mansehra basin and skirts out Haripur plains in the south-west.

CLIMATE

Three basic factors underline the climatic characteristics of N.W.F.P.:

1. Latitude
2. Location
3. Relief

Latitude:- Being located several hundred miles away from the Arabian Sea, continentality is characterized with extremes of temperature and with high annual and diurnal ranges of temperature.

Example:-

	Mean Warmest	Mean coldest	Mean Annual Range
Peshawar	91.3°F	51.1°F	40.2°F
Resalpur	92.2°F	49.4°F	42.8°F
Haripur	92.9°F	53.4°F	39.5°F

Location:- Located between latitude 31° 4' to 37° 8' north, the N.W.F.P. comes under world wide belt of Sub-tropical continental type of climate. Due to shifting of wind belt during summer and winter, the whole province

comes under the influence of south-west summer monsoon and winter disturbances alternately. Therefore, during summer, rain bearing south-west monsoon winds bring rainfall to eastern parts and mountain slopes facing these winds, and as they approach towards west, become dry. Therefore, as a general rule during summer, the rain fall decreases, firstly, from east to west, and secondly, from plains to the mountains.

Example:-		Summer rain
1.	Terbela (East)	12.14"
	Peshawar (West)	5,97"
2.	Haripur (Plain)	17.40"
	Dunga Gali(8000')	45.0"

During winter, the N.W.F.P. comes under the direct control of storms of western disturbances which move toward south and eastern directions. Therefore, in winter and spring, rainfall decreases from west to east and from north to south.

During winter many areas (Peshawar, Saidu sharif and Drosh) receive more rainfall than in summer, thus give a climatic characteristics of Mediterranean region. High mountains of Chitral, Swat and Hazara receive plenty of snowfall during winter season.

Relief:- Because N.W.F.P. is characterised with contra-

sting relief, ranging from level plains to high mountsins. Therefore, variety of relief is encountered with corresponding regional differences and local variations in the distribution of almost all the climatic elements.

For a better understanding of the regional distribution of climatic conditions in N.W.F.P., it is better to study, regional variations of climate on the basis of factors such as climatic elements and relief etc. found on the earth surface and not on the basis of administrative units.

The type of study followed here is based on Dr. K.S.Ahmed's climatic regions of Pakistan, 1951. N.W.F.P. is classified as a broad region of Sub-continental Tropical type of climate with two sub types:

1. Sub-Tropical Continental Lowland
2. Sub-Tropical Continental Highland

Sub-Tropical Continental Lowland is further divided into:

a) Semi arid montane north west
b) Sub-montane west-part of Derajat

Sub-Tropical Continental Highland divided into:

a) Hazara-Kohistan
b) Chitral-Swat.

c) Kohat-Waziristan

Sub-Tropical Continental Lowland

i. Semi arid montane, north west

This region includes Peshawar and Bannu basins which are bounded on three sides by mountains. The mean annual rainfall is between 10" and 12" in Bannu basin and between 12" to 15" is Peshawar basin. Western disturbances become effective and the share of winter and spring rains increases.

Example:-	July - August	Nov.-April	Total
Bannu	3.1"	4.82"	11.11"
Peshawar	3.29"	8.15%	13.56"

Thunderstorms are very important feature of this region. Peshawar is the most thundry part of Pakistan.

Due to continentality, summers are hot and winters cold. Mean winter minimum of Peshawar and Bannu is about 40°F. Temperature below freezing are frequent. The mean maximum temperature for June is 106.1°F for Bannu and 105.8°F for Peshawar.

ii. Sub-montane west-parts of Derajat

This region includes plains of D.I.Khan and is dominated by the climatic conditions of western mountain-

ous region. The rainfall within this region is no index of its hydrological resources. Its water supply depends mostly upon the rainfall of the bare hills to its west. Due to torrential rainfall, the torrents are suddenly in high spade, spreading in water sheet and depositing coarse alluvium miles across in the form of alluvial fans. These fans have been cut deep by these torrents into various strips or blocks.

In D.I.Khan, the mean maximum temperature for June, the hottest month, is about 108°F, while daily temperature occasionally exceeds 112°F. Summer rainfall is 5.93". July isthe wettest month with 2.29", it, too has spring maxima.

Sub-Tropical Continental Highland

a) Hazara-Kohistan

This region includes parts of Murree hills, Hazara-Kohistan and the adjacent plains. Due to some variety of relief, there is regional variation in rainfall and temperature. Rainfall, both from the monsoons and western disturbances is higher:

Example:	Summer	Winter-Spring	Total
Haripur	18.2"	17.40"	26.42"
Kakul (5000')	30.1"	18.0"	48.1"
Dunga Gali (8000')	45"	25"	70"

Except plains, the summers are cool and winters cold, having snowfall on the mountains.

b) Chitral-Swat

This region too has regional variation of climatic elements, which is mainly due to its far-off location and remaining under rain shadow of the outer Himalayas. Therefore, rainfall decreases from south to north.

Example:	Summer rain	Winter Rain	Total
Saidu Sharif	11"	24"	35"
Drosh	5.73"	12.27"	18"

This region receives more rainfall during winter. This is because of its exposure to the development of storms of western disturbances.

c) Kohat-Waziristan

Under the influence of western disturbances the spring and late summer rainfall maxima are prominent.

Example:	Mareh-May	July-Sept.	Total
Parachinar	10.68"	9.33"	30.25"
Kohat	6.58"	12.00"	24.80"

In both these places March and August are the rainiest months.

SOIL ALGAE

Algae are universally distributed on or under the soil surface. They require little moisture, nutrients and light for growth. Such growth of algae at the surface as well as at varying depths, together with other micro-organisms, has a profound influence on the biology of soils. Algae are so abundant in some soils that a gram of well fertilized soil may contain as many as 1,000,000 individuals (Russell, 1952).

Soil algae are important for their enormous number, survival in the subsoil darkness, retention of vitality under prolonged drought periods, and as storage of energy (Waksmann, 1952); as colonizers of unfavourable substrats and poineers of succession on denuded areas controlling soil erosion (Treub, 1888; Stokes, 1940-1941; Osborne, 1950; Russell, 1952); for fixing nitrogen and symbiotic relationship with bacteria (Kassowitsch, 1894; Allison & Morris, 1930; Fritsch & De, 1938).

Edaphic algae, primarily members of Cyanophyta, Chlorophyta, Euglenophyta, Chrysophyta, and Rhodophyta, may be unicellular, colonial or filamentous (Alexander, 1961; Bold, 1970).

Soil algae were first studied in the late 18th century, without separating them from other Cryptogams.

The works of Esmarch (1911), Fritsch & Salisbury (1915), Bristol (1920), Bristol-Roach (1926) and Peterson (1935) reported some soil algal flora along with some aquatic species. However, MacEntee et al. (1972) indicated that edaphic flora is distinct from aquatic. Genera like Tetracystis, Chlorosarcinopsis, Chlorococcum, Botrydium and Protosiphon are rarely encountered in aquatic habitats while they are among the most widely distributed species of the soil algae.

Fritsch & Salisbury (1915) found species of Gloeocystis, Cystococcus, Trochiscia and Dactylococcus as the first algae growing on a burned heath in England.

Peterson (1935) reviewed the work of Graibner, on the heaths of Germany; Warming, on the biology of marshes; Fritsch, on the terrestrial algae of tropics and Treub, on the blue-green immigrants to Krakatu (vide, Tiffany, 1951).

Some species of Cyanophyceae may form a complete layer over large eroded areas. This layer may be replaced by higher perrenial plants, thus forming an initial stage in succession. This algal stabilized surface layer, binding the soil into a nonerosible layer, besides resisting the force of rainfall, improves infiltration of water (Booth, 1941; Jabeen, 1978),

decreases runoff (Elwell et al., 1939), produces humus after death (Aleksandrova, 1951) thus increasing the soil fertility (Allison & Morris, 1930; Lowe & Moyse, 1934; Waksman, 1952; Shields et al., 1957).

The soil algal flora is affected both by the chemistry and physical nature of the substrate. Moisture, depth in soil, substrate, light, temperature, pH and nutrition have a profound effects on the growth and distribution of soil algae.

SUBSTRATE

Terrestrial algae includes all those forms which live either between the soil particles or which inhabitat the surface or subsurface objects. Substrates may be of following two types.

1. Physical type of substrates

Growth of algae on the rock is influenced by the hardness of the substrate and insolation, both of which affect water supply. Blue-green algae are more abundant than greens on rocks (Fritsch, 1936). The algal growth on forest and grassland soil is sometimes more abundant than in arable soil (Tiffany, 1951).

2. Chemical type of substrates

The abundant growth, kind of algae and its

distribution in cultivated and uncultivated soils depends upon the mineral status, available moisture and the type of soil (Bristol-Roach, 1926; Gistle, 1932, 1933; Peterson, 1935; Pratt, 1941; Tiffany, 1951; Miller & Fogg, 1957; Tchan, 1959). Addition of commercial fertilizers to organically rich soil commonly leads to luxurious growth of green algae (Lund, 1947). Algae are nutrient specific. Blue-green algae are abundant, in calcium rich soils (Allen, 1956). However, Sodium and Cobalt are also required by some blue-greens (Allen & Arnon, 1955; Allen, 1956; Kratz & Myens, 1955).

MOISTURE

An optimum moisture in the subsurface strata is more important for enhancing algal growth than moisture on the surface (Stokes, 1940). The optimum range of moisture for soil algae is around 40-60 percent of the soil & moisture-holding capacity (Stokes, 1940). Moisture primarily influences the distribution of drought susceptible species, particularly Chlorophyceae. Drought susceptibility varies widely with physiologic properties of protoplast and the presence of enclosing sheath (Allen, 1956). Most of the Cyanophyceae are particularly protected against desiccation by gelatinous sheaths (Peterson, 1935; Drouet, 1951; Smith, 1951). Sheath retains water during drought and absorbs moisture readily when supplied with

water (Schroder, 1886; Fritsch, 1922; Peterson, 1935). Sheath-less Oscillatoria, often show resistance (Schroder, 1886; Glade, 1913-1914) because of the granulations which collect gradually into large masses (Piercy, 1917). Nitzchia palea can withstand prolonged drought periods (Bristol, 1919).

VIABILITY

During the period of quick desiccation, number of algal cell is reduced (Peterson, 1935). Some species viz: Anabaena laxa, A. oscillaroides var. terrestris, Cylindrospermum licheniforme, Chlorococcum humicola, Haplosiphon flexuosus, Nitzschia palea, Nodularia harveyana, Nostoc commune, N. muscorum, N. passerianum, Phormidium tenue, Plectonema battersii, Stichococcus bacillaris and Trochiscia aspera retained viability even after 87 years and resumed normal growth upon reculturing (Bristol, 1919). However, some Bacillariophyceae and Xanthophyceae are highly susceptible to severe and prolonged drought periods (Bristol, 1927).

SEASONAL VARIATION

Soil algae vary seasonally, particularly surface forms multiplying rapidly under favourable conditions (Bristol, 1926), but die during unfavourable periods (Peterson, 1935; Stokes, 1940). The diatom flora may vary

seasonally with shade on woodland and other soils (Lund, 1945).

Bristol-Roach (1927), working on the England soils, observednumber of algal cells at the surface that varied seasonally from 105-500 per gram during the warmer months to 91 per gram in November, according to counts by a dilution techniques.

Lund (1947) examining weed free garden soil over a period of 5 years, observed no seasonal succession in the algal species.

SOIL pH

Algae are influenced by pH of the soil or water in which they grow (Gollerbach, 1936; Shelhorn, 1936; John, 1942; Lund, 1945, 1947). It is difficult to assess the influence of acidity of the soil on algal growth although the dominant species are quite different on acidic and alkaline soils (Tiffany, 1951, 1958). Cyanophyceae generally prefer neutral or alkaline soils while Chlorophyceae may be present at any pH.

Though a fair tolerence of pH is characteristic of most algae; populations are greatest in moderately acidic or moderately alkaline habitats (Coyle, 1935; Blinks, 1951; Durrell, 1959).

Coyle (1935) working on Ohio soils, observed that diatoms, Chlorococcum humicola and some species of Ulothrix constitute the algal flora of acidic soils, with blue-greens appearing rarely.

Lund (1947) observed algae growing in soil with pH 3.7-4.8 in U.K. The characteristic algae were the Chlorophyceae, Zygogonium ericetorum, Mesotaenium violascens on high acidic soil; with some species of Gloeocystis, Hormidium, Dactylococcus, Cylindrocystis and Prasiola on less acidic soils. The only Cyanophyceae observed in these England-base-deficient soils was Phormidium sp.

Bacillariophyceae and Cyanophyceae are more abundant in alkaline environments. Chrysophyceae occur on various soil types and are favoured by enrichment (Lund, 1947).

DEPTH IN SOIL

The horizontal distribution of algae in homogeneous soil is uniform. However, its vertical distribution varies with the depth. The algal growth is primarily confined to the uppermost 6 inches of the soil due to its ability to withstand full sunlight and sudden changes in light intensity (Delarge, 1937; von Denffer, 1949). However, diatoms and some blue-greens have been collected at the depths of 4-10 feet (Tiffany, 1959;

Bold, 1970). Xanthophyceae are more abundant a few centimeters below the surface (Fritsch, 1936; John, 1942; Flint, 1958). It appears that Xanthophyceae can live in dark far better than green algae probably because of their food reserve and cell wall. The subsurface algae are carried down by cultivation, animals, water seepage and self motility (Peterson, 1935; Durrell, 1959).

TEMPERATURE

The survival of soil algae under high temperature depends upon the climatic conditions of the area. The growth of most algae declines above 30C° in tropical and arid climates. However, this range extends up to 50 C° under temperate conditions (Smith, 1944; Geiger, 1950; Clendenuing et al., 1956; Miller & Fogg, 1957). The response of algae against temperature depends upon the algal species and climatic conditions of the area. Lund (1947) and Shtina (1959), observed reduced density in cold weather. However, diatoms survived at -80°--192 C° (Chapman, 1975). Some blue-green algae when wet, are capable of surviving between 60°-100 C° but on drying, 110 C° seems fatal to all soil algae (Glade, 1914; Booth, 1946).

FERTILITY

Blue-green algae may be the most important

nitrogen-fixing agents in many agricultural soils (Allison & Morris, 1930). Certain investigators assumed that soil algae providing nitrogen live in symbiotic association with nitrogen-fixing bacterial (Kossowitsch, 1894). Nitrogen fixation by pure cultures of blue-green algae was first determined for Nostoc punctiforme and Anabaena variabilis (Drewes, 1928). Similarly, Nostoc muscorum, N. paludosum, Cylindiospermum licheniforme, C. meius, C. gorakhporense, Aulosira fertilissima, Tolypothrix tenuis, Calothrix brevissima, Anabaenopsis sp., Mastigocladus laminosus, Chlorogloea fritschii, Scytonema sp., and Coccochloris parictina fix nitrogen (Singh, 1942; Fogg, 1947, 1951; Watanabe, 1949, 1951; Willians & Burris, 1952; Fogg & Wolf, 1954; Cameron & Fuller, 1960; Fay & Fogg, 1962). Nostoc muscorum can fix nitrogen as much as 18 mg. per 100 cc. of medium in 85 days (Allison et al., 1937). Allen (1956), observed in culture solution that Anabaena cylindrica fixes the gaseous nitrogen in an organic form equivlant to 480 pounds per acre per month. Watanabe (1949) and Watanabe et al. (1951), reported the increase in rice crop from 15 - 25 % by Calothrix brevissima and Tolypothrix tenuis. Protococcus viridis prevent loss of soil ammonia and leaching-out of nitrates by converting them into organic nitrogen (Waksman, 1952). Nitrogenous compounds are constantly supplied to soil by surface growth of algae

either during their life time or during the decomposition of dead parts (Fogg, 1947; Shields et al., 1957).

REVIEW OF LITERATURE ON SOIL ALGAE

Much work has been done on soil algae in England (Bristol, 1919, 1920, 1926, 1927a,b; Fritsch, 1907, 1915, 1922, 1923, 1935, 1936, 1938, 1942, 1945, 1949; John, 1942; Lund, 1945, 1947), Canada (Lowe, 1934), Denmark (Peterson, 1932, 1935), Africa (Esmarch, 1910, 1914), Germany (Feher, 1936a,b, 1939), Scandinavia (Gistle, 1932), Brazil (Drouet, 1937), Congo (Duvigneand, 1950), Algeria (Behre, 1953), India (De, 1936, 1950a,b; Singh, 1940, 1942, 1961; Mitra, 1951; Gonzalves, 1960), Japan (Watanabe, 1949, 1951, 1952); New South Wales (Moewus, 1953), Australia (Moewus, 1953; Tchan, 1953), Cuba (Ar[cc] & Bold, 1958), Jamaica (Herndon, 1958), Russia (Bolyshev, 1952; Slobodchikov & Stroikina, 1953; Shtina, 1957, 1961) and America (Bold, 1942).

Starr (1955) working on Chlorococcales reported some new genera of soil algae. Later on, in Texas, Bold and his students contributed much to this field. Deason and Bold (1960) working on the soil algae of Texas reported new species of Chlamydomonas, Chlorococcum, Neochloris, Spongiococcum, Chlorohormidium, Pleurastrum and two new genera, Pseudoschizomeris and Pseudobumilleriopsis. The algal flora of arid soils from Saudi Arabia, U.S.A., and Israel was worked out by Chantanachat and Bold (1962). Bischoff and Bold (1963), working on

the soil algae of Enchanted Rocks and related algal species, reported 10 species belonging to 7 genera.

Brown and Bold (1964) added new species of soil algae to Tetracystis and Chlorococcum. Smith and Bold (1966), investigated species of Eremosphaera and Oocystis. Groover and Bold (1969) studied the taxonomy of Chlorosarcinales and some other edaphic algae. Kantz and Bold (1969) examined the morphology and taxonomy of Nostoc and Anabaena. Baker and Bold (1970) described taxonomy of Schizothrix, Microcoleus, Porphyrisiphon and Oscillatoria. Archibald and Bold (1970) explored some new species of Chlorococcales from boggy soils of Texas. Archibald and Bold (1975) reported 7 genera of blue green and 16 of green algae while examining 39 soil samples from 10 Coastal islands of Galapagos. Archibald (1972) worked on the relationships of Costa Rica and Samandreas Islands soils with 26 genera of algae. MacEntee and Bold (1974), studying soil from Pike County Pennsylvania, recorded 29 green and blue-green genera of algae.

In Pakistan, Khan (1957) cultured 86 species from rice fields of Kashmir using Beyerinck's, Bristol's, Detmer's, Knop's and Uspenski's culture media. Among them 37 species belonged to Chlorophyceae, 35 to Cyanophyceae, 12 to Bacillariophyceae and 2 to Euglenophyceae. The blue

green algae appeared first in Detmer's and Bristol's media and green algae in Uspenski's solution. Chlamydomonas, Chlorococcum, Chlorella, Euglena, Phormidium, Oscillatoria, Chroococcus and Lyngbya were the most common species. He observed that green algae prefered low concentration solution while blue-greens flourished well in high concentration solution, probably due to the presence of mucilage.

Ali and Sandhu (1972) working on the saline soils of the Punjab, reported 106 species of blue green algae distributed among 27 genera, with differential response to salinity. Among them nine genera with 29 species were capable of fixing nitrogen. The preference of various species varied from less saline to highly saline soils.

Ali et al. (1978) recorded 103 species belonging to 21 genera, including 32 nitrogen fixing species of blue-green algae from different rice fields of the Punjab. Nostoc, Anabaena, Nodularia, Aulosira, Tolypothrix, Fortiea, Calothrix, Rivularia, Gloeotrichia and Phormidium were the non-heterocystous common genera. Anabaena fertilissima and Aulosira sp. were common among the heterocystous types.

Shah (1977) isolated 47 species belonging to

29 genera from rice fields of Peshawar. Fourteen genera with 29 species and 15 genera with 18 species were classified as Cyanophyceae and Chlorophyta respectively. Among Cyanophyceae, the reported genera were Chroococcus, Aphanocapsa, Merismopedia, Microcystis, Coelosphaerium, Oscillatoria, Phormidium, Lyngbya, Hydrocoleum, Anabaena, Nostoc, Tolypothrix, Microchaete, Gloeotrichia. Among Chlorophyta, Chlamydomonas, Gloeocystis, Ulothrix, Microspora, Protococcus, Coleochaete, Cladophora, Rhizoclonium, Oedogonium, Chlorococcum, Tetracystis, Eremosphaera, Mesotaenium, Closterium and Chara were noted.

Fifteen genera with 19 species, mainly Cyanophyceae, were reported from dry soils of Peshawar by Shahwar (1977). Species of Microcystis, Entophysalis, Oscillatoria, Phormidium, Lyngbya, Cylindrospermum, Nostoc and Anabaena were blue-green. Chlorophycean members were Palmellococcus, Gloeocystis, Protococcus, Chlorosarcinopsis, Chlorococcum and Bracteacoccus. Gloeobotrys was the only Chrysophyta found in her cultures.

Species of Microcystis, Oscillatoria, Phormidium, Lyngbya, Cylindrospermum, Nostoc, Anabaena of blue-green and Pandorina, Palmella, Stigeoclonium of green algae

were cultured by Shams (1977) from wheat fields soil of Peshawar.

Thirty two soil-binding algae belonging to Phormidium (12 spp.), Oscillatoria (10 spp.), Lyngbya (4 spp.), Anabaena (3 spp.), Heterococcus (1 sp.), and Chlorohormidium (1 sp.), were reported from Peshawar by Jabeen (1978).

Tobacco field of Peshawar valley had 11 species of Cyanophyceae and 3 of Chlorophyceae (Marwat et al., 1979). The blue-greens were Chroococcus, Microcystis, Oscillatoria, Phormidium, Lyngbya, Anabaena, Nostoc, and Microchaete. Chlamydomonas, Coleochaete and Oedogonium were commonest among Chlorophyceae.

Akhtar (1980), reported 92 species of 32 genera from sugar-cane fields of Mardan district. Ninteen genera with 74 species of Cyanophyceae were: Anabaena, Aphanocapsa, Chroococcus, Camptylonemopsis, Dermocarpa, Dichothrix, Lyngbya, Microcoleus, Microcystis, Nodularia, Nostoc, Oscillatoria, Phormidium, Plectonema, Schizothrix, Spirulina, Stichosiphon, Symploca and Tolypothrix. Thirteen genera with 17 species of Chlorophyceae viz: Characium, Chlorococcum, Chlorohormidium, Chlorellidiopsis, Cladophora, Oocystis, Pandorina, Protococcus, Quadrigula, Roya, Scenedesmus, Sphaerella and Tetraëdron.

Heterococcus, a single genus, with one species belonged to Xanthophyceae. This work was done in the collaboration with the present author.

Soil algae, an important part of soil ecosystem, did not receive the due attention, in Pakistan; though some work has been done on the edaphic algae (Khan, 1957; Ali & Sandhu, 1972; Ali et al., 1978; Marwat et al., 1979) but many aspects remain unsolved due to its sporadic nature.

Terrestrial algae, besides increasing soil fertility are important as colonizers, soil binders thus preventing erosion and improving the substrate for subsequent species (Treub, 1888; Alison & Morris, 1930; Fritsch & De, 1938; Stokes, 1940-1941; Osborne, 1950; Russell, 1952).

Keeping in mind the aforementioned evidences regarding the importance of soil algae, the present exploratory study was, therefore, conducted to investigate the algal flora of various soils taken from forests, hills, plains, dry lands, garden soil, moist lands and cultivated fields from different areas of the N.W.F.P. The present study would help in finding the possible interrelationship between algae and soil of this region, providing a guide line for the future investigators in this field.

MATERIALS AND METHODS

Soils were separately sampled at 0-1, 1-2, 2-3, 3-4, 4-5 and 5-6" depths from different localities of N.W.F.P. and were placed in separate labelled plastic bags. Sealed bags with minute holes containing soil were stored in laboratory at room temperature. Five grams of each soil type was placed in a sterilized 125 ml capacity Erlenmeyer flask, containing 50 ml of sterile nutrient solution. It was cultured under 16 hour photoperiod. After two weeks, until sufficient algal growth appeared in the culture medium, the plants were identified and observed constantly. Original diagrams were made by Camera lucida. Microphotographs were also taken whenever necessary. Samples are stored in the Herbarium, Department of Botany, University of Peshawar. The habitats and geographical distribution of the recorded species are based on the personal observation and literature consulted.

For culturing the algae, 1N BBM (Bischoff & Bold, 1963), 3N BBM (Brown & Bold, 1964), Knop's solution (Bold, 1942) and Soil extract (Faridi, 1971) were used.

1. BOLD'S BASAL MEDIUM-1N BBM (Bischoff & Bold, 1963)

Ten ml of each of the following 6 macroelement stock solutions and 1 ml each of the following 4 micro-element stock solutions were added to 936 ml deionized

distilled water to get BBM. The major element stock solutions were made by dissolving the specific amount of salt in 400 ml deionized water.

$NaNO_3$	10.0 g
$CaCl_2$	1.0 g
$MgSO_4.7H_2O$	3.0 g
K_2HPO_4	3.0 g
KH_2PO_4	7.0 g
NaCl	1.0 g

The microelement solutions were made as follows:-

I. EDTA Stock Solution:

Fifty g EDTA (Ethylenediaminetetracetic acid) and 31 g KOH were diluted to a final volume of 1 liter in a volumetric flask with ddw.

II. Fe Stock Solution:

Ferous sulphate ($FeSO_4.7H_2O$) weighing 4.98 gram was diluted to a final volume of 1 liter with acidified water. The water was acidified by adding 1 ml of Conc. H_2SO_4 to 99 ml of ddw.

III. Boron Stock Solution:

Boric acid (H_3BO_3) weighing 11.42 gm was diluted to 1 liter with deionized water.

IV. Misc. Stock Solution:

The following elements, were diluted to a final volume of 1 liter with ddw.

$ZnSO_4.7H_2O$..... 8.82 g

$MnCl.4H_2O$..... 1.44 g

MnO_3..... 0.71 g

$CuSO_4.5H_2O$..... 1.57 g

$Co(NO_3).6H_2O$..... 0.49 g

2. 3N BBM (Brown & Bold, 1964)

1N BBM was modified to 3N BBM by using 30.0 g of $NaNO_3$ instead of 10.0 g.

3. KNOP'S SOLUTION (Bold, 1942)

Two stock solutions, required for Knop's medium were prepared by adding following materials to 500 ml of ddw.

Knop's solution A:

$Ca(NO_3)_2$..... 4.0 g

Knop's solution B:

KnO_3..... 1.0 g

KH_2PO_4..... 1.0 g

$MgSO_4.7H_2O$..... 1.0 g

Solutions A and B mixed in equal parts gave a 0.7 % solution by weight-volume. This 0.7 % solution was

then again diluted by half with ddw to yield a 0.35 % solution for culture.

4. SOIL EXTRACT (Faridi, 1971)

Fertile garden soil, mixed with distilled water in the ratio of 1 g to 10 cc. was boiled for 2 hours and filtered after cooling. Few drops of fresh spinach and carrot juices were mixed with the soil extract. The addition of a few drops of spinach and carrot juices enhances the rate of algal growth.

TAXONOMIC DESCRIPTION OF PLANTS

Key to the classes

1. Vegetative cells without nucleus, pigments scattered..... Cyanophyceae
1. Vegetative cells with nucleus, pigments in chromatophores..... 2
2. Chromatophores yellow-green..... Xanthophyceae
2. Chromatophores grass-green..... 3
3. Cells with starch..... Chlorophyceae
3. Cells with paramylum..... Euglenophyceae

C Y A N O P H Y C E A E

Key to the genera of Cyanophyceae

1. Cells unicellular or colonial..... 2
1. Cells united in filaments or pseudofilaments..... 11
2. Cells with endospores..... 3
2. Cells without endospores..... 4
3. Cells without stalk..... Synechococcus
3. Cells attached by means of a mucilaginous stalk..... Stichosiphon
4. Colony of a definite shape..... 5
4. Colony shapless..... 6
5. Colony flat, cells arranged in transversa and vertical rows..... Merismopedia
5. Colony rounded, hollow..... Coelosphaerium

6. Colony of hundreds of cells.. 7

6. Colony smaller..... 8

7. Cells remote from one another... Aphanocapsa

7. Cells close to one another..... Microcystis

8. Cells without evident sheaths. Aphanothece

8. Cells with evident sheaths.... 9

9. Cells cylindrical..... Gloeothece

9. Cells sphaerical or hemispherical. 10

10. Sheaths colourless..... Chroococcus

10. Sheaths variously coloured... Gloeocapsa

11. Pseudofilamentous, cells arranged in 2 or more rows..... Chlorogloea

11. Cells united in true trichomes. 12

12. Trichomes with heterocysts.... 21

12. Trichomes without heterocysts. 13

13. Trichomes without a sheath..... 14

13. Trichomes with a sheath..... 15

14. Trichomes straight, curved or in regular spirals..... Oscillatoria

14. Trichomes in regular spirals. Spirulina

15. Trichomes falsly branched..... Plectonema

15. Trichomes unbranched..... 16

16. One trichome within a sheath. 17

16. More than one trichome within a sheath..... 19

17. Sheath watery, confluent with one another..... 18

17. Sheath firm, not confluent with one another..... Lyngbya

18. Filaments growing in erect tufts..... Symploca

18. Filaments interwoven in an extended stratum..... Phormidium

19. Sheath firm..... Schizothrix

19. Sheath watery..... 20

20. Many trichomes within a sheath..... Microcoleus

20. Few trichomes within a sheath. Hydrocoleum

21. Filaments unbranched..... 22

21. Filaments falsely branched..... 26

22. Heterocysts at only one end of a trichome..... Cylindrospermum

22. Otherwise..... 23

23. Length of cells less than breadth..... Nodularia

23. Length of cells equal to or greater than breadth..... 24

24. Trichomes solitary or intertwined in an amorphous mass... 25

24. Trichomes much twisted into

a mass of definite form with a firm gelatinous envelope..... Nostoc

25. Sheaths of trichomes firm and narrow..... Aulosira

25. Sheaths of trichomes watery and broad..... Anabaena

26. False branching abundant..... 27

26. False branching sparse..... 28

27. False branching usually arising singly..... Tolypothrix

27. False branching usually arising in pairs..... Scytonema

28. Akinetes rare..... Calothrix

28. Akinetes absent..... Rivularia

28. Akinetes common..... 29

29. Akinetes single, next to the basal heterocyst..... Gloeotrichia

29. Akinetes single or in series, next to the basal heterocyst or away from it..... Microchaete

CHROOCOCCUS Naeg.

Gatt. einzell. Algen, 45. 1849.

Cells rarely solitary, mostly in groups of 2-4 individuals, sometimes 8-16, in a gelatinous matrix; cells

spherical, subspherical or hemispherical; individual cell sheath distinct, firm, generally lamellated, sometimes homogeneous, persistently or irregularly broken; reproduction by cell division in three directions; fragmentation of colonies; nannocytes sometimes present.

Key to the species

1. Cells with sheath 15-50 µm in diameter..... C. turgidus (6)
1. Cells with sheath 6-15 µm in diameter..... C. minutus (5)
1. Cells with sheath less than 6 um in diameter..... 2
2. Colony mostly of 16-32 cells. C. limnetius var. subsalsus (3)
2. Colony of fewer cells..... 3
3. Colonial mucilage yellow or pale-orange..... C. varius (7)
3. Colonial mucilage hyaline..... 4
4. Colony tabular..... C. dispersus (2)
4. Colony not tabular..... 5
5. Colony with cells almost of the same size, 3-4 µm in diameter.. C. minor (4)
5. Colony with cells of markedly different size, 2.5-7 µm in diameter..... C. cohaerens (1)

1. Chroococcus cohaerens (Bréb.) Naeg., Gatt. einzell. Algen, 46. 1849.

Drouet & Daily, p. 78. 1956 (=Anacystis thermalis (Menegh.) Dr. & Daily); Desikachary, p. 111, pl. 26, figs. 3,9. 1959.

Thallus gelatinous, slimy, blue or dark-green; cells solitary or 2-8 together, spherical, or hemispherical; cells without sheath 2-5 (-7) µm broad, with sheath 2.5-7 µm in diameter; cells sheath thin, colourless, unlamellated (pl.1, fig.6, photo, 1).

Anjum 123, June 8, 1978.

Habitat: Aquatic (Biswas, 1929); epiphytic (Skuja, 1949); terrestrial.

Local distribution: Dry land, Dera Ismail Khan.

Soil depth: 6 inch.

Geographical distribution: Bangladesh, Burma, Europe, India, North America, Pakistan.

2. Chroococcus dispersus (Keissler) Lemm., Ark. f. Bot., 2:102. 1904.

Prescott, p.447, pl.100, fig.7. 1951; Drouet & Daily, p.83. 1956 (=Anacystis thermalis f.

major (Lagerh.) Dr. & Daily); Desikachary, p.106, 1959; Huber-Pestalozzi, p.148, fig.32. 1962.

Colony 4-16 celled, mucilaginous, free-floating, tabular, with rounded margins, either solitary or aggregated, light or brilliant blue-green; cells without sheath 3-4 µm in diameter, with sheath 5-6 µm broad; individual envelopes often totally gelatinized, unlamellated, hyaline (pl.1, fig.5).
Anjum 28, April 26, 1977; April 30, 1977.

Habitat: Aquatic (Prescott, 1951); terrestrial.

Local distribution: Dry land, Dera Ismail Khan.

Soil depth: 5, 6 inches.

Geographical distribution: Europe, India, North America, Pakistan.

3. Chroococcus limneticus var. subsalsus Lemm., Forschungsber. f. biol. stat. in Ploen, 8:84. 1901.

Prescott, p.449, pl.100, fig.10. 1951; Drouet & Daily, p.83. 1956 (= Anacystis thermalis f. major (Lagerh.) Dr. & Daily); Desikachary, p.107. 1959; Huber - Pestalozzi, p.148, fig.33. 1962.

Colony 16-32 celled, free-swimming, tabular,

blue-green; cells spherical or ellipsoid, without sheath 3.5-4.5 µm in diameter, with sheath 4.5-5 µm broad, more or less closely arranged; colonial mucilage round or nearly quadrangular, broad (pl.1, fig.3, photo, 2).

Anjum, 106, March 15, 1978; Anjum 106A, Aug. 12, 1978.

Habitat: Aquatic (Prescott, 1951); terrestrial.

Local distribution: Dry land, Dera Ismail Khan; Maize field, Mardan.

Soil depth: 3rd, 4th inches.

Geographical distribution: Europe, India, North America, Pakistan.

4. Chroococcus minor (Kg.) Naeg., Gatt. einzell. Algen, 47, pl.1,A, fig.4. 1849.

Prescott, p.449, pl.100, fig.12. 1951; Drouet & Daily, p.162. 1956; Desikachary, p.105, pl.24, fig.1. 1959.

Thallus dirty blue-green or olive-green, slimy, gelatinous; cells spherical; sheath hyaline, very delicate; cells single or in pairs, seldom 4 or 8, 3-4 µm in diameter (pl.1, fig.4).

Anjum 27, April 21, 1977; Anjum 27A, Aug. 23, 1978; Anjum 27B, Oct. 5, 1978.

Habitat: Aquatic (Skuja, 1949; Prescott, 1951); terrestrial (Prescott, 1951).

Local distribution: Dry lands, Dera Ismail Khan.

Soil depth: 4, 5 and 6 inches.

Geographical distribution: Burma, Europe, India, North America, Pakistan.

5. Chroococcus minutus (Kg.) Naeg., Gatt. einzell. Algen, 46. 1849.

Prescott, p.449, pl.100, fig.9, 1951; Drouet & Daily, p.15. 1956 (= Coccochloris stagnina Sprengel); Desikachary, p.103, pl.24, fig.4 & pl.26, figs. 4, 15. 1959; Huber-Pestalozzi, p.147, fig.30. 1962.

Cells spherical, or oblong, single or in groups of 2-4; cells without sheath 4-10 µm in diameter, with sheath 6-15 µm broad, light blue-green; sheath unlamellated, hyaline (pl.1, fig.2).

Anjum 126, June 20, 1978.

Habitat: Aquatic (Crow, 1923; Skuja, 1949; Prescott, 1951); endophytic (Banerji, 1936); epiphytic (Bruhl & Biswas, 1922; Skuja, 1949); terrestrial (Rao, C.B., 1937; Singh, R.N., 1939; Frémy, 1942; Mitra, 1951).

Local distribution: Rice field Methra, District Peshawar.

Soil depth: 4 inches.

Geographical distribution: Burma, Europe, India, North America, Pakistan.

6. Chroococcus turgidus (Kg.), Naeg., Gatt. einzell. Algen, 46. 1849.

Prescott, p.450, pl.100, fig. 19. 1951; Tiffany & Britton, p.332, pl.91, fig.1048. 1952; Desikachary, p.102, pl.26, fig.6. 1959; Huber-Pestalozzi, p.147, fig.25. 1962.

Cells spherical, or ellipsoidal, single, or in groups of 2-4, very seldom many, blue-green, olive-green, or yellowish, without sheath 8-32 µm in diameter, with she 15-50 µm broad sheath sheath, not distinctly lamellated (pl.18, fig.199, photo,3). Anjum 182, Dec. 20, 1978.

Habitat: Aquatic (Prescott, 1951; Huber-Pestalozzi, 1962); epiphytic (vide, Desikachary, 1959); terrestrial.

Local distribution: Rice field Methra, District Peshawar.

Soil depth: 1 inch.

Geographical distribution: Burma, India, Europe, North America, Pakistan, Siri Lanka.

7. Chroococcus varius A.Br. in Rabenhorst, Alg. Eur., 246, 248, 2452, 2459. 1863-78.

Prescott, p.451, pl.100, fig.5. 1951; Drouet & Daily, p.48. 1956 (= Anacystis montana (Lightfoot) Dr. & Daily); Desikachary, p.107, pl.24, fig.5. 1959.

Thallus gelatinous, dirty olive-green, or brownish; cells globular, single or 2-4 together, seldom more, in small or large groups, irregularly arranged; cells without sheath 2-4 µm broad, with sheath 4-8 µm in diameter, cell contents pale-blue or olive-green, seldom yellowish or golden yellow; sheath apparently thick, indistinctly lamellated, colourless, yellowish or pale orange yellow (pl.1, fig.1).

Anjum 125, June 15, 1978.

Habitat: Aquatic (Prescott, 1951); epiphytic (Ghose, 1927; Skuja, 1949); terrestrial (Rao, C.B., 1937; Prescott, 1951).

Local distribution: Rice field Methra, District Peshawar.

Soil depth: 2 inch.

Geographical distribution: Burma, China, Europe, India, North America, Pakistan.

MICROCYSTIS Kg.

Tab. Phycologicae, 1:7. 1846.

= Microcystis Kg., Linnaea 8:372. 1833.

= Anacystis Menegh., Consp. Algol. Eugan., 6. 1836.

= Polycystis Kg., Tab. Phycologicae, 1:7. 1846.

= Clathrocystis Henfrey, Mier. Journ., 53. 1856.

Colonies spherical, ellipsoidal, irregularly

overlapping, or net-like, free-floating, often with attached daughter colonies; colonial mucilage homogenous, colourless, often diffluent; individual envelopes absent; cells spherical or ellipsoidal, in large numbers, mostly very densely arranged, gas-vacuoles often present; cell division in all directions, generally transverse in elongate cells.

Key to the species

1. Colonies 20 times longer than broad..M.pseudofilamentosa (4)
1. Otherwise..... 2
  2. Colonies clathrate..... M.aeruginosa (1)
  2. Colonies not clathrate..... 3
3. Cells without gas-vacuoles..... M.pulvera (5)
3. Cells with gas-vacuoles..... 4
  4. Colonial mucilage distinct..... M.marginata (3)
  4. Colonial mucilage indistinct..... M.flos-aquae (2)

1. Microcystis aeruginosa Kg., Tab. Phycologicae, 1:8, fig. 1, 1846.
Tilden, p.54, fig.1A, 2B. 1937; Tiffany & Britton, p.336, pl.91, fig. 1052; Drouet & Daily, p.36. 1956 (= Anacystis cyanea Dr. & Daily); Desikachary, p.93, pl.17, figs. 1,2, 6 & pl.18, fig.10. 1959; Huber-Pestalozzi, p.132, fig.4. 1962.

= Clathrocystis aeruginosa (Kg.) Henfrey, J. Roy, micr. Soc: 53, pl.4, figs. 28-36. 1856.

Young colonies rounded or slightly longer than broad, solid, on maturation becoming clathrate, with distinct hyaline mucilage; cells spherical, 3-7 µm in diameter, generally with gas-vacuoles (pl.1, fig.7, photo, 4,5).

Anjum 9, June 5, 1977; Anjum 9A, Jan. 5, 1978; Anjum 9B, Feb. 19, 1978; Anjum 9C, Feb. 20, 1978.

Habitat: Aquatic (Crow, 1923a,b; Biswas, 1926, 1927, 1929, 1942; Ghose, 1927a; Bharadwaja, 1935; Dixit, 1936; Randhawa, 1936; Rao, C.B., 1938a; Ganapathi, 1940a,b; Parukutty, 1940; Rao, C.S., 1940; Gonzalves & Joshi, 1943; Skuja, 1949; Prescott, 1951; Huber-Pestalozzi, 1962); epiphytic (Huber-Pestalozzi, 1962); terrestrial.

Local distribution: Dry lands, Dera Ismail Khan.

Soil depth: 1,2,3 and 4 inches.

Geographical distribution: Burma, Europe, India, North America, Pakistan.

2. Microcystis flos-aquae (Wittr.) Kichner in Engler and Prantl, Naturlichen, Pflanzen fam., I(1a): 56, fig.49(N). 1898.

Tilden, p.500, figs. 253, 254. 1937; Drouet &

Daily, p.36. 1956 (= Anacystis cyanea Dr. & Daily); Desikachary, p.94, pl.17, fig.11 & pl. 18, fig. 11. 1959; Fritsch, p.815, fig. 311,C.D. 1959; Huber-Pestalozzi, p.135, fig.5. 1962.

= Microcystis aeruginosa f. flos-aquae (Wittr.) Elenkin, Monogr. Algar. Cyano. Pars. spec., 1:103. 1938.

Colonies ellipsoidal, roughly spherical, or somewhat elongate, often squarish in optical section, not clathrate, with indistinct colonial mucilage; cells 3-7 µm in diameter, spherical, with gas-vacuoles, nannocytes present (pl.1, fig.8).

Anjum 35, June 1, 1977.

Habitat: Aquatic (Crow, 1923a,b; Biswas, 1926, 1942; Skvortzow, 1928; Bharadwaja, 1935; Banerji, 1936; Dixit, 1936; Rao, C.B., 1938a,b; Ganapathi, 1940a,b; Rao, C.S., 1940; Frémy, 1942; Skuja, 1948; Prescott, 1951); terrestrial.

Local distribution: Dry land, Dera Ismail Khan.

Soil depth: 2 inch.

Geographical distribution: Burma, Europe, India, North America, Pakistan, Russia.

3. Microcystis marginata (Menegh.) Kg., Tab., Phycologicae, 1:6, pl.8, 1845-49.

Drouet & Daily, p.46. 1956 (= Anacystis montana f. montana Dr. & Daily); Desikachary p.87, pl.17, figs.3-5. 1959; Huber-Pestalozzi, p.132, fig.3. 1962.

= Anacystis marginata Menegh., Consp. Algol. Eugan., 324. 1837.

= Microcystis aeruginosa f. marginata (Menegh.) Elenkin, Monogr. Algar. Cyano., pars. spec., 1:106. 1938.

Colonies spherical or irregularly flattened, more or less lenticular, generally simple; margins of colonial mucilage very distinct, refractive, sometimes stratified; cells spherical, 3-6 µm in diameter, closely arranged, with gas-vacuoles (pl.1, fig.9, photo,6).

Anjum 93, Jan. 28, 1978.

Habitat: Aquatic (Crow, 1923a,b; Banerji, 1936; Ganapathi, 1940; Biswas, 1942); epiphytic (Bruhl & Biswas, 1923); terrestrial.

Local distribution: Dry hill, Kohat.

Soil depth: 3 inch.

Geographical distribution: Burma, Europe, India, North America, Pakistan.

4. Microcystis pseudofilamentosa Crow, Tax. gen. Microcystis, New Phytol., 22:64, pl.1, fig.e.f. 1923.

Desikachary, p.94, pl.18, fig.9 & pl.20, fig.1. 1959.

= Microcystis aeruginosa f. pseudofilamentosa (Crow) Elenkin, Monogr. Algar. Cyano., pars. spec., 1:105. 1938.

= Anacystis cyanea (Kg.) Drouet & Daily. Rev. Coccoid Myxophyceae, 12:37. 1956.

Colonies long, narrow, consist of a series of parietal, smaller colonies, constricted at intervals, sometimes considerably widened at places, broken or reticulate; margins of colonial mucilage indistinct; colonies varying greatly in size, sometimes twenty times as long as broad; cells 3-7 µm diameter, spherical with gas-vacuoles (pl.18, fig. 202).

Anjum 183, Dec. 26, 1978.

Habitat: Aquatic (Crow, 1923a,b; Banerji, 1936); terrestrial.

Local distribution: Sugar-cane field, Mardan.

Soil depth: 2 inch.

Geographical distribution: Europe, India, North America, Pakistan, Sri Lanka.

5. Microcystis pulverea (Wood) Forti, in De Toni, Sylloge Algarum, 5:92. 1907.

Desikachary, p.96. 1959; Huber-Pestalozzi,

p.136. 1962.

= Microcystis pulverea (Wood) Elenkin, Monogr. Algar. pars. spec., 1:117. 1938.

= Anacystis montana (Kg.) Dr. & Daily, f. minor Dr. & Daily, Butler Univ. Bot. Studies, 10:221. 1952; Rev. Coccoid Myxophyceae, 66. 1956.

Colonies rounded, or ellipsoidal, often aggregated; colonial mucilage distinct; cells spherial, closely arranged, 2-3 µm in diameter, blue-green, or olive-green, without gas-vacuoles (pl.1, fig.10, photo, 7).

Anjum 74, Nov. 12, 1977.

Habitat: Aquatic (Crow, 1923a,b; Skuja, 1949; Prescott, 1951; Huber-Pestalozzi, 1962); epiphytic (Skuja, 1949); terrestrial (Parukutty, 1940; Huber-Pestalozzi, 1962).

Local distribution: Dry land, Dera Ismail Khan.

Soil depth: 5 inch.

Geographical distribution: Burma, Europe, India, North America, Pakistan.

COELOSPHAERIUM Naeg.

Gatt. einzell. Algen, 54. 1849.

Colonies free-swimming, hollow, somewhat irregular or spherical, with or without individual

envelope around cells; colonial mucilage homogeneous, or heterogeneous, hyaline; colonies dividing by breaking down through the middle; cells spherical or hemispherical. Single species was recorded for the genus.

1. Coelosphaerium dubium Grumow, in Rabenhorst, Fl. Eur. Algar, 2:55. 1856.

Prescott, p.470, pl.108, fig.1. 1951; Drouet & Daily, p.37. 1956 (= Anacystis cyanea (Kg.) Dr. & Daily); Desikachary, p.147, pl.28, figs. 10-11, 14-15. 1959; Fritsch, p.817, fig.312,C, D,H,J. 1959; Huber-Pestalozzi, p.155, fig.47. 1962.

Colony spherical or sometimes irregular-shaped, either solitary or aggregate in a common gelatinous envelope, free-floating; colonial mucilage firm, unlamellated, upto 8 µm thick; cells spherical, closely arranged, 5-7 µm broad, blue-green, gas-vacuoles present (pl.1, fig.11).

Anjum 130, July 12, 1978.

Habitat: Aquatic (Crow, 1923a,b; Prescott, 1951; Huber-Pestalozzi, 1962); terrestrial.

Local distribution: Rice field Methra, District Peshawar.

Soil depth: 6 inch.

Geographical distribution: Europe, India, North America, Pakistan.

CHLOROGLOEA Wille

Algol. Notizen, I-VI, Nyt Mag. Naturvid., 38:5. 1900.

Thallus hemispherical, or flat, irregularly lobed, colonial mucilage hyaline, thin, unlamellated, cells spherical, or ellipsoidal, with or without individual envelopes, in straight, erect or radial rows, rows sometimes indistinct; cell division may be in three planes but generally in a style determined direction; spores and nonnocytes present. Represented by one species.

1. Chlorogloea microcystoides Geitler, Neue Cyano. Gruppe Chamaesiphon., Arch. Protistenk., 51:359, fig. u.1925.

Desikachary, p.163, pl.19, fig.8. 1959; Fritsch, p.819, fig. 313, G-K. 1959.

Thallus lobed, thin, gelatinous, expanded, dull green to brown; colonial mucilage hyaline or yellowish; cells spherical, or ellipsoid, mostly densely arranged, polygonal in erect and radial rows, generally without a distinct individual sheath; cells 2-3.8 µm in diameter, blue-green to olive-green, or yellow; nannocytes 1.5-2 µm broad, found in somewhat broad cells by repeated division (pl.1, fig.12).

Anjum 98, Feb. 9, 1978.

Habitat: Epiphytic (Biswas, 1936; Skuja, 1949); terrestrial.

Local distribution: Dry land, Dera Ismail Khan.

Soil depth: 6 inch.

Geographical distribution: Burma, Europe, India, Pakistan.

GLOEOCAPSA Kg.

Phyc. generalis, 174. 1843.

Spherical cells 2-8, in colonies, seldom many with lamellated envelopes; colonies single or many together forming an expanded mass; individual sheaths lamellated or unlamellated; cell division regularly in three directions; cells in large colonies often with secondary colonies, arranged irregularly; nannocytes occasionally seen, resembling Aphanocapsa - stage; spores with firm thick walls often formed in a number of species. Only one species was recorded for the genus.

1. Gloeocapsa crepidinum Thuret, in Bornet and Thuret, Notes Algologiques 1:1, pl.1, figs. 1-3. 1876.

Desikachary, p.117, pl.27, figs. 4-5. 1959.

Thallus gelatinous, olivaceous, when dried become blackish, soft; cells in groups of 2-4, rarely more; colonies spherical or oval, 12-24 µm in diameter, closely arranged in the peripheral regions and loosely arranged in the middle; cells without sheath 4-8 µm in diameter; with a thin unlamellated, yellowish to brownish sheath in the peripheral regions and colourless or diffluent

inside; nannocytes 2.5-3.5 µm in diameter (pl.8, fig.94, photo, 9).

Anjum 90, Jan. 16, 1978.

Habitat: Terrestrial.

Local distribution: Dry land, Dera Ismail Khan.

Soil depth: 4 inch.

Geographical distribution: Europe, India, Pakistan.

GLOEOTHECE Naeg.

Gatt. einzell. Algen, 57. 1849.

Cells cylindrical or ellipsoidal, straight or bent, not attenuated towards the apices, but broadly rounded, in small colonies or forming an expanded thallus; cell division at right angles to the longitudinal axis, sometimes the daughter cells divide in all the three directions; sheath and colony structure similar with the Gloeocapsa; nannocytes present. Represented by one species.

1. Gloeothece rupestris (Lyngb.) Bornet, Alg. de Schousb., Mem. Soc. Sci. Nat. Math. de Cherbourg, 28:177. 1892.

Desikachary, p.127, pl.25, fig.4. 1959.

Cells ellipsoidal to cylindrical, without sheath 4-5.5 µm broad, 1.5-3 times as long as broad, with sheath 8-12 µm broad, contents blue-green, 2-4 rarely 8 in oval

D-26

to subspherical colonies; sheath colourless or brownish at the peripheries, lamellated or unlamellated, diffluent inside the colonies (pl.18, fig.201).

Anjum 184, Dec. 30, 1978; Anjum 184A, Jan. 2, 1978.

Habitat: Subaerial (Parukutty, 1940; Frémy, 1942); terrestrial.

Local distribution: Sugar-cane fields, Mardan.

Soil depth: 1, 3 inches.

Geographical distribution: Europe, India, Pakistan.

APHANOTHECE Naeg.

Neue Denkschr. Schweiz. Naturf. Ges. 10(7):59. 1849. Nom. Cons.

= Coccochloris C. Sprengel, Fl. Hal. Maut. 1:14. 1807.

= Aphanothece Naeg., Gatt. einzell. Algen, 59. 1849.

Thallus amorphous, expanded; colonial mucilage hyaline, homogeneous; cells ellipsoid to cylindric, straight or slightly bent, sometimes with individual lamellated, gelatinized envelopes; cell division transverse; nannocytes present.

Key to the species

1. Cells 1-2 µm broad..... A. saxicola (4)

1. Cells broader..... 2.

2. Thallus firm, globular..... A. gelatinosa (2)

2. Thallus amorphous, expanded.... 3

3. Cells 2-3.6 µm broad..... A. castagnei (1)

3. Cells 4.5 µm broad..... A. microscopica (3)

1. Aphanothece castagnei (Bréb.) Rabenh. Fl. Eur. Alg., 2:64. 1865. pl.105, figs.5,6.1951; Prouet & Daily, p.28.1956. Prescott, p.467, (= Coccochloris elabens Dr. & Daily); Desikachary, p.140, pl.21, fig.8. 1959; Huber-Pestalozzi, p.143. 1962.

Thallus gelatinous, amorphous, slimy, blue-green or brownish; colonial mucilage diffluent, colourless, or yellowish; cells ellipsoid, ovate, or subcylindric, densely arranged, 2-3.6 µm in diameter, 4-8 µm long, blue-green to olive-green, finally granular (pl.2, fig.15). Anjum 50, Aug. 15, 1977.

Habitat: Aquatic (Frémy, 1942; Gonzalves & Joshi, 1943; Skuja, 1949; Prescott, 1951; Huber-Pestalozzi, 1962); epiphytic (Ghose, 1927c); terrestrial.

Local distribution: Wheat field, Peshawar.

Soil depth: 6 inch.

Geographical distribution: Burma, Europe, India, North America, Pakistan.

2. Aphanothece gelatinosa (Henn.) Lemm., Des Phytoplankton des Menam. Hedwigia, 48:126-139. 1910.

Prescott, p.467, pl.104, fig.8. 1951; Drouet & Daily, p.69, fig.98. 1956 (= Anacystis montana f. gelatinosa Dr. & Daily).

Colony spherical, blue-green to brown, gelatinous; cells ovate, nearly spherical, 3.8-4 µm in diameter, 4.4-5 µm long, compactly arranged, blue-green (pl.2, fig.6).

Anjum 55, Sep. 10, 1977.

Habitat: Aquatic (Prescott, 1951); terrestrial.

Local distribution: Dry land, Peshawar.

Soil depth: 6 inch.

Geographical distribution: Europe, India, North America, Pakistan.

3. Aphanothece microscopica Naeg., Gatt. einzell. Algen. 59, pl.I,H. 1849.

Prescott, p.467, pl.104, figs.9,10. 1951; Drouet & Daily, p.18. 1956 (= Coccochloris stagnina Sprengel); Desikachary, p.142, pl.22, figs.4,5, 9. 1959; Huber-Pestalozzi, p.143, fig.21. 1962.

Young thallus spherical, old amorphous, small, gelatinous, upto 2 cm. in diameter; cells oblong-cylindric, 4.5 µm broad, 1½-2 times as long as broad, sometimes with distinct individual hyaline sheath; cell contents blue-green, finely granular. (pl.2, fig.13, photo,8).

Anjum 54, Sep. 6, 1977.

Habitat: Aquatic (Rao, C.B., 1936, 1938b; Frémy, 1942; Prescott, 1951; Huber-Pestalozzi, 1962); terrestrial (Rao, C.B., 1938a).

Local distribution: Dry land, Peshawar.

Soil depth: 2 inch.

Geographical distribution: Europe, India, North America, Pakistan.

4. Aphanothece saxicola Naeg., Gatt. einzell. Algen, 59. 1849.

Prescott, p.468, pl.104, fig.1. 1951; Drouet & Daily, p.31. 1956 (= Coccochloris peniocystis Dr. & Daily); Desikachary, p.138, pl.22, fig.11. 1959.

Thallus mucilaginous, colourless, or yellowish; cells cylindrical, with rounded ends, 1-2 µm in diameter, 2-3.5 µm long, loosely arranged, solitary or in pairs, seldom many in a homogeneous, amorphous, colourless mucilage; cell contents pale blue-green (pl.2, fig.14).

Anjum 177, Dec. 9, 1978.

Habitat: Aquatic (Prescott, 1951); terrestrial (Rao, C.B., 1936).

Local distribution: Dry land, Kohat.

Soil depth: 2 inch.

Geographical distribution: Europe, India, North America, Pakistan.

APHANOCAPSA Naeg.

Gatt. einzell. Algen, 52. 1849.

Colonies free-floating, amorphous, gelatinous, often a few centimeter in diameter; colonial mucilage homogeneous, colourless or yellowish, cells often with a thin more or less gelatinized individual sheath; cells loosely arranged, mostly in pairs as a result of recent division; cell division in two directions; cell contents homogeneous or finely granular, pale gray-green to bright blue-green; nannocytes present.

Key to the species.

1. Cells 4-6 µm broad..... 2
1. Cells 2.5-4 µm broad..... A. montana (3)
2. Cells with thick sheath..... A. banaresensis (1)
3. Cells without sheath..... A. littoralis (2)

1. Aphanocapsa banaresensis Bharadwaja, Myxophyceae of the United Provinces, Proc. Indian Acad. Sci., B, 2:96, fig. 1B. 1935. Desikachary, p.133, pl.22, fig. 8. 1959.

Thallus soft, spherical, hollow, irregularly hyaline or cream coloured; cells oval or almost spherical, 4-6.2 µm in diameter; sheath thick, unlamellated, hyaline, closely adpressed to the cells, upto 1 µm thick (pl.18, fig.200).

Anjum 185, Dec. 30, 1978.

Habitat: Aquatic (Bharadwaja, 1937); terrestrial.

Local distribution: Sugar-cane field, Mardan.

Soil depth: 1 inch.

Geographical distribution: India, Pakistan.

2. Aphanocapsa littoralis Hansg., Beitr. Zur Kenntnis der Meeresalg, und Bact. Fl., Sitzb. K. Boehm. Gas. Wiss., Math. Nat. Cl., 229. 1892.

Drouet & Daily, p.103, fig.248. 1956 (= Entophysalis deusta Dr. & Daily); Desikachary, p.131, pl.21, fig.1. 1959.

Thallus gelatinous, amorphous, blue-green or yellowish; cells spherical, or subspherical, 4-6 µm in diameter, single or in pairs, densely or loosely aggregated (pl.2, fig.17, photo, 10).

Anjum 127, June 22, 1978.

Habitat: Aquatic (Karsten, 1907; Iyengar & Desikachary, 1944; Parukutty, 1940; Venkataraman, 1957); terrestrial.

Local distribution: Rice field Methra, District Peshawar.

Soil depth: 3 inch.

Geographical distribution: Europe, India, North America, Pakistan.

3. Aphanocapsa montana Cramer in Wartmann and Schenk, Schweiz. Krypto no. 134. 1862.

Drouet & Daily, p.45, 1956 (= Anacystis montana f. montana Dr. & Daily); Desikachary, p.135, pl.20, fig.8, 1959.

Thallus amorphous, gelatinous, colourless or yellow-green, blue-green or olive coloured; cells spherical, 2.5-4 µm in diameter, light blue-green or yellowish, single or in pairs, mucilage hyaline, diffluent (pl.2, fig.18).

Anjum 128, June 30, 1978.

Habitat: Epiphytic (Banerji, 1936; Randhawa, 1936); terrestrial.

Local distribution: Rice field Methra, District Peshawar.

Soil depth: 5 inch.

Geographical distribution: Austria, India, North America, Pakistan, Switzerland.

MERISMOPEDIA Meyen

N. Syst. & Pflanzen-Physologie, 3:440. 1839; in wiegmann, Arch. f. Naturgesch., 2:67. 1839.

= Agmenellum Bréb., Mem. Soc. Acad. Sci., Art. & Belles. Lettres Falaise. 1839.

Colony plate like, quadrangular, becoming distorted in age; cells ovate or spherical, in division hemispherical, 4-16 or more, arranged in a homogeneous, hyaline, mucilage; cells arranged loosely or compactly in rows both transversely and longitudinally; cell contents blue-green, rarely olivaceous or reddish, rarely

with pseudovacuoles; individual cell sheath indistinct, usually confluent with the colonial mucilage; multiplication by the division in two directions perpendicular to the plane of colony.

Key to the species

1. Cells loosely arranged..... M. punctata (2)
1. Cells compact..... 2
   2. Cells 1.3-3 µm broad..... M. tenuissima (3)
   2. Cells 3-6 µm broad..... M. glauca (1)

1. Merismopedia glauca (Ehrenbeg) Naeg., Gatt. einzell. Algen, 55, pl.1D, fig.1. 1849.
   Prescott, p.459, pl.101, figs. 2-4. 1951; Tiffany & Britton, p.334, pl.91, fig.1042. 1952; Drouet & Daily, p.86. 1956 (= Agmenellum quadruplicatum Bréb.); Desikachary, p.155, pl.29, fig.5. 1959; Huber-Pestalozzi, p.160, fig.59. 1962.

Quadrangular colonies of mostly 16-64, rarely more cells; cells ovate, spherical or hemispherical, closely arranged, 3-6 µm broad, cell contents bright blue-green to pale blue-green, homogeneous (pl.2, fig.19). Anjum 129, July 7. 1978; Anjum 129A, June 12, 1979.
Habitat: Aquatic (Beck & Zahlbruehver, 1897; Turner, 1892; West & West, 1907; Crow, 1923; Banerji, 1936; Ganapathi, 1940; Skuja, 1949; Prescott, 1951; Huber-Pestalozzi, 1962); terrestrial.
Local distribution: Rice field Methra, District Peshawar.

Soil depth: 1,2 inches.

Geographical distribution: Burma, Europe, India, North America, Pakistan.

2. Merismopedia punctata Meyen. in Wiegmann, Archiv, 2:67. 1839.

Prescott, p.459, pl.102, fig.10. 1951; Drouet & Daily, p.86. 1956 (= Agmenellum quadruplicatum Bréb.); Desikachary, p.155, pl.23, fig.5 & pl.29, fig.6. 1959; Huber-Pestalozzi, pl.160, fig.58. 1962.

Rectangular colony of 4-16-64-128 ovate, or spherical cells; colonies about 60 µm broad; cells loosely arranged, sometimes in compact groups of 4-8 individuals, groups widely separated within a broad gelatinous envelope; cells 2.5-3.5 µm broad; cell contents homogeneous, pale blue-green (pl.2, fig.20).

Anjum 42, July 8, 1977; Anjum 42A, Sep. 25, 1977; Anjum 42B, Sep. 26, 1977; Anjum 42C, Sep. 30, 1977.

Habitat: Aquatic (Crow, 1923; Ganapathi, 1940; Rao, C.S., 1940; Singh, V.P., 1941; Prescott, 1951; Huber-Pestalozzi, 1962); terrestrial.

Local distribution: Wheat fields, Peshawar.

Soil depth: 1,2, 3 and 4 inches.

Geographical distribution: Europe, India, North America, Pakistan.

3. Merismopedia tenuissima Lemm., Beitr. Kennt. Planktonalg., II, Bot. Centralbl. 76, 154. 1898.

Prescott, p.459, pl.100, fig.17. 1951; Drouet & Daily, p.86. 1956 (= Agmenellum quadruplicatum

Bréb.); Desikachary, p.154, pl.29, fig.7 & pl.30, figs.8-9. 1959; Huber-Pestalozzi, p.160, fig.57. 1962.

Colonies rectangular, 16-100 celled; cells closely packed within a wide gelatinous envelope; individual sheaths sometimes distinct; cells ovate or spherical, 1.3-2 (-3) µm broad; cell contents pale blue-green or gray-green, homogeneous (pl.2, fig.21, photo 11). In the present study, however, cells were 2-3 µm broad. Anjum 85, Jan. 1. 1978.

Habitat: Aquatic (Crow, 1923; Skvortzow, 1928; Rao, C.S., 1940; Prescott, 1951; Huber-Pestalozzi, 1962); terrestrial.

Local distribution: Dry land, Dera Ismail Khan.

Soil depth: 6 inch.

Geographical distribution: Europe, India, North America, Pakistan.

STICHOSIPHON Geitler

Kryptogamenflora, 14:411. 1932.

Sporangia when young ellipsoid or pyriform, attached by means of a mucilaginous foot, sometimes growing elongate, contents dividing transversely to form a row of endospores; fully grown sporangia elongate, cylindrical or club-shaped with 4-12 or sometimes more endospores lying in a row, liberated by the gelatinization

of the apex of the sporangial wall. Represented by a single species in N.W.F.P.

1. Stichosiphon sansibaricus (Hieron.) Dr. & Daily, Butler Univ. Studies, 10:223. 1952.

Desikachary, p.176, pl.32, figs. 9-13 & pl.33, figs. 8-10. 1959.

= Chamaesiphon sansibaricus Hieron. in Engler, Pflanzenwelt Oestafr., C:8. 1895.

= Chamaesiphon filamentosa Ghose, Syst. Ecot. Account of blue-green Algae from Lahore & Simla, J. Linn. Soc. (Land.) Bot., 46. 337, pl.31, fig.1. 1924.

= C. willei Gardner, Myxo. Puerto Rico, Mem. N.Y. Bot. Gdn., 7:34, pl.7, fig.62. 1927.

= Stichosiphon filamentosus (Ghose) Geitler, Kryptogamenflora, 412, fig.240. 1932.

= S. indicus Rao, C.B. Orth. mut. De Toni, J. Rao, C.B. A new species of Stichosiphon (S. indica sp. nov.), Proc. Indian Acad. Sci. B., 2:535, figs. 1-10. 1935.

= S. indica var. tenuis Gupta, A.B. A contribution to the algal flora of Khajiar, Chamba state, Himachal Pradesh. Proc. nat. Acad. Sci., India, 20(3):109, figs. 1-3. 1950.

Plant microscopic, blue-green, olivaceous,

solitary, erect or curved, at first spherical, later cylindrical, 3-7 µm broad, contents dividing into a series of spherical, ovoid or cylindrical endospores; endospores generally uniseriate sometimes multiseriate; sheath hyaline, thin, somewhat stalked at the base and attached; content blue-green, olivaceous, or rose coloured, homogeneous (pl.18, fig.203).

Anjum 191, Jan. 6, 1979.

Habitat: Epiphytic (Ghose, 1931; Randhawa, 1936; Rao, C.B., 1935, 1936, 1938a,b; Fremy, 1942; Dr. & Daily, 1956; Gupta, 1956); terrestrial.

Local distribution: Sugar-cane field, Mardan.

Soil depth: 2 inch.

Geographical distribution: Burma, Europe, India, North America, Pakistan, Puerto Rico.

SYNECHOCOCCUS Naeg.

Gatt. einzell. Algen, 56. 1849.

Cells solitary or sometimes 2 to 4; cells seriately united as a result of cell division in one plane; free-floating; cell oblong, or elliptical, without sheath; cells contents pale blue-green or yellow, highly granular. Single species was cultured from soils of N.W.F.P.

1. Synechococcus aeruginosus Naeg., Gatt. einzell. Algan, 56. 1849.

Prescott, p.467, pl.102, figs. 6-8. 1951.

Cells solitary or in pairs, oblong to cylindric, 2-3 times their diameter in length, poles broadly rounded, 7-15 µm in diameter, 14-25 µm long (pl.18, fig. 204).

Anjum 190, Jan. 4, 1979.

Habitat: Aquatic (Prescott, 1951); terrestrial.

Local distribution: Sugar-cane field, Mardan.

Soil depth: 3 inch.

Geographical distribution: North America, Pakistan.

SPIRULINA Turpin

In Dict. Sci. nat. de Levrault, 50:309. 1829.

= Arthrospira Stizenb. Spirulina and Arthrospira, Hedwigia, 1:32. 1852.

Trichomes cylindrical, without sheath, loosely and regularly coiled, usually of relatively large diameter and also large spirals, with comparatively short and fewer coils; cross-walls distinct or indistinct, sometimes granular, sometimes scarcely discernible; cells quadrate or little longer than wide, apices slightly or not tapering, terminal cell rounded, calyptra absent. The species with distinct cross-walls were put in Arthrospira, while those with indistinct in spirulina formly. Recently experimental studies have shown that this

distinction is artificial (Huber-Pestalozzi, 1962).

Key to the species

1. Cross-walls distinct..... 2
1. Cross-walls indistinct..... 3
   2. Trichomes 2.5-3 µm thick, regularly coiled..... S. gomontiana (1)
   2. Trichomes 5-6 µm thick, loosely coiled..... S. massartii (3)
   2. Trichomes 6-8 µm thick, regularly coiled..... S. platensis (5)
3. Distance between spirals 3-5 µm... S. meneghiniana (4)
3. Distance between spirals 17-22 µm. S. laxissima (2)

1. Spirulina gomontiana (Setchell) Geitler in Pascher's Suesswasserflora, 12:344. 1925.

Prescott, p.481, pl.108, fig.21. 1951; Desikachary, p.192. 1959; Huber-Pestalozzi, p.224. 1962.

= Arthrospira gomontiana Setchell, Bull. Torrey bot. Cl., 22:430. 1895.

Trichomes free-swimming, 2.5-3 µm broad, attenuated at the apices, regularly spirally coiled, spirals 6 µm broad, 16-18 µm distant; cells 4-5 µm long, pale blue-green, cross-walls distinct, commonly granulated (pl.2, fig. 23).

Anjum 176, Dec. 8, 1978.

Habitat: Aquatic (Prescott, 1951; Huber-Pestalozzi, 1962); terrestrial.

Local distribution: Dry hill, Abbottabad.

Soil depth: 6 inch.

Geographical distribution: Europe, North America, Pakistan.

2. Spirulina laxissima West, G.S., J. Linn. Soc. (Lond.) Bot., 38, 78, pl.9, fig.6. 1907.

Prescott, p.480, pl.107, fig.17. 1951; Desikachary, p.196, pl.36, fig.5. 1959; Huber-Pestalozzi, p.226, fig.164. 1962.

Trichomes 0.7-0.8 µm broad, blue-green, spirals very loose, but regular, 4.5-5.3 µm broad; 17-22 µm distant from each other; end-cells rounded, obtuse; cross-walls indistinct (pl.18, fig.209).

Anjum 189, Jan. 1, 1979.

Habitat: Aquatic (Prescott, 1951); terrestrial.

Local distribution: Sugar-cane field, Mardan.

Soil depth: 1 inch.

Geographical distribution: Europe, India, North America, Pakistan.

3. Spirulina massartii (Kuff.) Geitler, in Pascher's Suesswasserflora, 12:346. 1925.

Desikachary, p.191, pl.35, figs.9,10. 1959.

= Arthrospira massartii Kuff. Contribution a l'etude Flore Algologique du Luxembourg meridional, II, Ann. biol. lacustre, 7:264, fig.16. 1914.

Trichomes cylindrical, loosely coiled; cells 5-6 µm broad, 2-4 µm long; spirals 28 µm broad, distance between spirals 60-90 µm; cell contents greyish blue-green; end-cell rounded-conical, cross-walls distinct, not granulated, no gas-vacuoles (pl.2, fig.22).

Anjum 49, Aug. 8, 1977.

Habitat: Terrestrial.

Local distribution: Dry land, Peshawar.

Soil depth: 2 inch.

Geographical distribution: Europe, Pakistan.

4. Spirulina meneghiniana Zanard ex Gomont, Monogr. Oscillariées, 250, pl.7, fig.28. 1892. Desikachary, p.195, pl.36, fig.8. 1959; Huber-Pestalozzi, p.226, fig.163. 1962.

Trichomes 1.2-1.8 µm in diameter, flexible, irregularly spirally coiled, bright blue-green, forming a thick blue-green thallus; spirals 3.2-5 µm broad and 3-5 µm distant from each other; cross-walls indistinct (pl.18, fig.210).

Anjum 189, Jan.3, 1979; Anjum 189A, Jan. 6, 1979;

Anjum 189B, Jan. 12, 1979.

Habitat: Aquatic (Banerji, 1938); terrestrial.

Local distribution: Sugar cane fields, Mardan.

Soil depth: 1,2 and 3 inches.

Geographical distribution: Europe, India, Pakistan.

5. Spirulina platensis (Nordst.)Geitler, in Pascher's Suesswasserflora, 12:344. 1925.

Desikachary, p.190, pl.35, fig.2. 1959; Huber-Pestalozzi, p.225, figs.156, 159. 1962.

= Arthrospira platensis (Nordst.) Gomont, Monogr. Oscillariées, 247, pl.7, fig.27. 1892.

Thallus blue-green; trichomes slightly constricted at the cross-walls, 6-8 µm broad, not attenuated at the ends or slightly attenuated, regularly spirally coiled; spirals 26-36 µm broad, distance between spirals 43-57 µm; cells quadrate or shorter than broad, 2-6 µm long, cross-walls distinct, granulated; end-cells broadly rounded (pl.18, fig.211, photo, 12).

Anjum 188, Jan.1, 1979; Anjum 188A Jan. 10, 1979.

Habitat: Aquatic (Biswas, 1927, 1942; Randhawa, 1936); terrestrial.

Local distribution: Sugar-cane fields, Mardan.

Soil depth: 4,5 inches.

Geographical distribution: Europe, India, Pakistan, Sri Lanka.

OSCILLATORIA Vaucher

Hist. Conf., 165. 1803.

Trichomes solitary, or forming expanded plant mass, or slimy layers on submerged objects, or on the bottom or on dry or moist soil; sheath mostly absent, rarely a very delicate sheath may present at hormogones stage; trichomes straight, twisted and entangled; motile, showing oscillating or gliding movements, especially active in the anterior portion of the trichome; trichomes end distinctly marked, pointed, bent like a sickle, or coiled in screw-like manner, or may be smoothly rounded or swollen and capitate; calyptra present or absent; cells mostly shorter than wide, but may be quadrate or longer than broad; with or without constrictions at the cross-walls; septa granular or not; hormogones formed by the division of trichome.

Key to the species

1. Trichomes constricted at the cross-walls..... 2
1. Trichomes unconstricted at the cross-walls..... 7
2. Trichomes distinctly constricted at the cross-walls..... 3

2. Trichomes slightly constricted
at the cross-walls..... 4

3. Trichomes 3 µm broad..... O. foreaui (10)

3. Trichomes 5-7 µm broad..... O. lacustris (13)

4. End-cell capitate..... O. amoena (3)

4. End-cell not capitate..... 5

5. Apices attenuated..... 6

5. Apices not attenuated..... O. tenuis (22)

6. Trichomes 3-5 µm broad..... O. laete-virens (12)

6. Trichomes 5.5-8 µm broad..... O. cortiana (8)

7. Trichomes 16-60 µm broad..... O. princeps (16)

7. Trichomes narrower..... 8

8. End-cell capitate..... 9

8. End-cell not capitate..... 13

9. Trichomes not attenuated at the
apices..... O. lutea (15)

9. Trichomes attenuated at the apices. 10

10. Trichome ends bent in screw-
like manner..... O. splendida (20)

10. Otherwise..... 11

11. Gas-vacuoles absent..... O. anguina (5)

11. Gas-vacuoles present..... 12

12. Trichomes 2.2-5 µm broad..... O. prolifica (17)

12. Trichomes 4-6 µm broad..... O. agardhii (12)

12. Trichomes 6-8 µm broad..... O. rubescens (19)

13. Trichomes 1-2 µm broad..... 14

13. Trichomes broader..... 15

14. Septa granulated..... O. quadripunctulata (18)

14. Septa not granulated..... O. acutissima (1)

15. Trichomes 11-20-(22) µm broad..... O. limosa (14)

15. Trichomes narrow..... 16

16. Septa granulated..... 17

16. Septa not granulated..... 19

17. Two granules at the septa..... O. amphibia (4)

17. Many granules at the septa..... 18

18. Trichomes 4-6 µm broad..... O. formosa (11)

18. Trichomes 10-17 µm broad..... O. curviceps (9)

19. End-cell acute-conial..... O. animalis (6)

19. End-cell rounded..... 20

20. Trichome ends bend in a screw-like manner..... O. terebriformis (23)

20. Trichome ends straight or coiled..... 21

21. Trichomes 2.8-3 µm broad..... O. articulata (7)

21. Trichomes 5-6 µm broad..... O. subbrevis (21)

1. Oscillatoria acutissima Kufferath, Contribution a l'etude Flore algologiques du Luxembourg meridionale, II, Ann. biol. Lac. 7: fig. 15. 1914.

Prescott, p.484, pl.109, fig.1. 1951; Desikachary, p.237. 1959; Huber-Pestalozzi, p.232. 1962.

Trichomes free-floating or forming gelatinous and leathry, blue-green thallus; trichomes at the ends attenuated and curved, unconstricted at the cross-walls, 1.5-2 µm in diameter; cells 2-7 µm long; end-cell acute-conical, calyptrate; septa not gramulated (pl.19, fig.216). Anjum 186, Dec. 31, 1978; Anjum 186A, Jan.4, 1979.

Habitat: Aquatic (Skuja, 1949; Prescott, 1959); terrestrial.

Local distribution: Sugar-cane fields, Mardan.

Soil depth: 1 and 2 inches.

Geographical distribution: Burma, Europe, North America, Pakistan.

2. Oscillatoria agardhii Gomont, Monogr. Oscillariées, 205. 1892.

Prescott, p.484, pl.108, figs.15, 16. 1951; Tiffany & Britton, p.346, pl.94, fig. 1082. 1952; Desikachary, p.235. 1959; Huber-Pestalozzi, p.240, fig.190. 1962.

Trichomes interwoven forming a bundle or a leathry, blue-green, free-swimming thallus; trichomes straight or somewhat curved, not constricted at the septa,

gradually attenuated at the apices; cells 4-6 µm broad, mostly shorter than long, quadrate, 2.5-4 µm long, granulated at the septa, with gas-vacuoles; end cells convex, sometimes bluntly conical, or more or less pointed with a convex calyptra, seldom capitate (pl.2, fig.29).

Anjum 149, Sep. 30, 1978.

Habitat: Aquatic (Crow, 1923b; Rao, C.B., 1936; Ganapathi, 1940b; Biswas, 1942; Singh, V.P., 1941; Prescott, 1951; Huber-Pestalozzi, 1962); terrestrial (Skuja, 1949).

Local distribution: Dry land, Peshawar.

Soil depth: 3 inch.

Geographical distribution: Burma, Europe, India, North America, Pakistan, Sri Lanka.

3. Oscillatoria amoena (Kg.) Gomont, Monogr. Oscillariées, 225, pl.7, fig. 9. 1892.

Prescott, p.484, pl.109, figs.2-4. 1951; Tiffany & Britton, p.344, [illegible] pl.93, fig. 1073. 1952; Desikachary, p.230, pl.40, fig.12. 1959.

Thallus more or less blue-green; trichomes straight, slightly constricted at the cross-walls, ends gradually attenuated, 2.5-5 µm broad, dull blue-green;

cells nearly as long as broad, 2.5-4 µm long, septa granulated; end cells capitate, broadly conical, with calyptra (pl.19, fig.217).

Anjum 192, Jan. 10, 1979.

Habitat: Aquatic (Skuja, 1949; Prescott, 1951); terrestrial (Skuja, 1949).

Local distribution: Sugar-cane field, Mardan.

Soil depth: 1 inch.

Geographical distribution: Burma, Europe, North America, Pakistan.

4. Oscillatoria amphibia Ag., Aufzaehlung etc., Flora, 10:632. 1827.

Tilden, p.66, figs. 18 A-E. 1937; Prescott, p.485, pl.109, fig.6. 1951; Desikachary, p.229, pl.37, fig.6. 1959; Huber-Pestalozzi, p.231. 1962.

Thallus deep blue-green; trichomes straight, not attenuated at the apices, not constricted at the cross-walls; cells 2-3 (-3.5) µm broad, 2-3 times longer than broad, 4-8.5 µm long, with two granules at the septa; end cell not capitate, rounded, calyptra absent; cell contents pale blue-green (pl.2, fig.34).

Anjum 134, July 18, 1978.

Habitat: Aquatic (Martens, 1870; Prain, 1905; Bruhl &

Biswas, 1922, 1926; Prescott, 1951); terrestrial (Biswas, 1925; Banerji, 1938).

Local distribution: Rice field Methra, District Peshawar.

Soil depth: 6 inch.

Geographical distribution: Burma, Europe, India, North America, Pakistan.

5. Oscillatoria anguina (Bory) Gomont, Monogr. Oscillariées, 214, pl.6, fig.16. 1892.
Prescott, p.485, pl.108, fig.24. 1951; Desikachary, p.210, pl.38, fig.11. 1959; Fritsch, p.808, fig. 308B. 1959; Huber-Pestalozzi, p.230. 1962.

Trichomes entangled and interwoven forming dark blue-green mass; trichomes straight, at the ends spirally coiled and distinctly attenuated, not constricted at the cross-walls; cells (5)-6-8 µm broad, 1/6-1/3 as long as broad, 1.5-2.5 µm long; cross-walls sometimes granulated; end cell capitate, with slightly thickened membrane (pl.2, fig.26).

Anjum 70, Oct. 31, 1977.

Habitat: Aquatic (Lemmermann, 1907; Prescott, 1951); terrestrial (Rao, C.B., 1937b, 1938a,b; Rao, C.S., 1940).

Local distribution: Dry hill, Kohat.

Soil depth: 6 inch.

Geographical distribution: Europe, India, North America, Pakistan.

6. Oscillatoria animalis Ag., Aufzaehlung, Flora 10:632. 1827.

Desikachary, p.239, pl.40, fig.4. 1959; Huber-Pestalozzi, p.232. 1962.

Thallus dark blue-green; trichomes straight, unconstricted at the cross-walls, slightly attenuated and bent at the ends; cells 3-4 µm broad, mostly shorter, upto ½ as long as broad, seldom longer, 1.6-5 µm long, not granulated at the septa, blue-green; end cell pointed-conical or acute, without calyptra, not capitate (pl.2, fig.32).

Anjum 15, Feb. 8, 1977.

Habitat: Aquatic (Ghose, 1927a; Biswas, 1942); epiphytic (Rao, C.B. 1937); terrestrial (Biswas, 1925; Rao, C.B., 1938).

Local distribution: Dry land, Peshawar.

Soil depth: 4 inch.

Geographical distribution: Burma, Europe, India, Pakistan, Sri Lanka.

7. Oscillatoria articulata Gardner, Mem. New York Bot. Gard., 7:34, pl.7, fig.64. 1927.

Prescott, p.486, pl.107, fig.22. 1951; Tiffany

& Britton, p.347, pl.94, fig.1090. 1952;
Desikachary, p.216. 1959.

= Oscillatoria grunowiana var. articulata (Gard.) Drouet, Brazilian Myxophyceae, I, Amer. J. Bot., 24:608, fig.5. 1937.

Trichomes solitary or aggregated, straight or coiled, unconstricted at the cross-walls, cross-walls conspicuously thickened, as much as the length of the cell cavity; trichomes not attenuated at the apices; cells 2.8-3.2 µm in diameter, quadrate or 0.3-0.5 µm as long as broad; end cell rounded, not capitate, without a calyptra (pl.19, fig.218).

Anjum 193, Jan. 10, 1979.

Habitat: Aquatic (Rao, C.B., 1938b); terrestrial.

Local distribution: Sugar-cane field, Mardan.

Soil depth: 1 inch.

Geographical distribution: Europe, India, North & South America, Pakistan.

8. Oscillatoria cortiana Menegh., ex Gomont, Monogr. Oscillariées, 231, pl.7, fig.17. 1892.
Desikachary, p.233, pl.38, fig.14. 1959.

Thallus dull blue-green, trichomes straight, slightly constricted at the cross-walls, 5.5-8 µm broad, gradually tapering towards the apex, bent, not capitate,

blue-green; cells as long as broad or longer or shorter than broad, 5.4-8.2 µm long; at the ends upto 14 µm long; septa not granulated; end cell obtuse, without calyptra (pl.19, fig.219).

Anjum 194, Jan. 11, 1977; Anjum 194A, Jan. 15, 1979.

Habitat: Aquatic (Martens, 1870; Crow, 1923b; Yoneda, 1938; Rao, C.S., 1940); epiphytic (Prain, 1905); terrestrial.

Local distribution: Sugar-cane fields, Mardan.

Soil depth: 2, 3 inches.

Geographical distribution: Europe, India, Japan, Pakistan, Sri Lanka.

9. Oscillatoria curviceps Ag., ex Gomont, Monogr. Oscillariées, 213, pl.6, fig.14. 1892.
Prescott, p.487, pl.108, figs.17,18. 1951; Tiffany & Britton, p.334, pl.94, fig.1081. 1952; Desikachary, p.209, pl.389, fig.2. 1959.

Trichomes forming an expanded plant mass, light or dark blue-green; trichomes more or less straight, bent at the end or spirally coiled, not constricted at the cross-walls, not or very slightly attenuated at the apices; cells 10-17 µm broad, 1/6-1/3 as long as broad, 2-5 µm long, cross-walls sometimes granulated; end cell flat-rounded, not capitate, calyptra absent (pl.2, fig.36, photo, 13).

Anjum 132, July 13, 1978; Anjum 132A, July 18, 1978.

Habitat: Aquatic (Lemmermann, 1907; Prescott, 1951); terrestrial.

Local distribution: Rice fields Methra, District Peshawar.

Soil depth: 1, 2 inches.

Geographical distribution: Europe, India, North America, Pakistan, Sri Lanka.

10. Oscillatoria foreaui Frémy, Cyanophycees de l'Inde Meridionale, Blumea, Suppl. II. Jubilee, Vol., p.23, fig.2. 1942.

Desikachary, p.219, pl.40, fig.18. 1959.

Trichomes elongate, bent or suberect; apex gently curved, distinctly constricted at the cross-walls; cells 3 µm broad, ½ as long as broad, cell contents blue-green, somewhat granular; apex not attenuate; end cell obtuse-conical, not capitate; calyptra absent (pl.2, fig.27).

Anjum 97, Feb. 8, 1978.

Habitat: Aquatic (Frémy, 1942); terrestrial.

Local distribution: Dry land, Dera Ismail Khan.

Soil depth: 3 inch.

Geographical distribution: India, Pakistan.

11. Oscillatoria formosa Bory, Dict. Class. d'hist. nat., 12:474. 1827; Gomont, Monogr. Oscillariées,

230, pl.7, fig.16. 1892.

Prescott, p.487, pl.109, figs.10,11. 1951; Smith, p.278, fig.161A. 1955; Desikachary p.232, pl.40, fig.15. 1959; Huber-Pestalozzi, p.231. 1962.

Thallus blue-green; trichomes straight and rather firm, slightly or unconstricted at the cross-walls, 4-6 µm broad, bright blue-green, attenuated at the apices and bent; cells nearly quadrate, upto ½ as long as broad, 2.5-5 µm long, septa sometimes obtuse, without calyptra, not capitate (pl.2, fig.31, photo, 14).

Anjum 60, Oct. 3, 1977.

Habitat: Aquatic (Martens, 1870; Schmidle, 1900; Bruhl & Biswas, 1922; Biswas, 1926, 1942; Dixit, 1936; Rao, C.B., 1937a; Prescott, 1951; Gupta, 1956); epiphytic (Parukuthy, 1940); terrestrial (Rao, C.B., 1938a,b; Rao, C.S., 1939, 1940; Skuja, 1949).

Local distribution: Dry land, Peshawar.

Soil depth: 4 inch.

Geographical distribution: Burma, Europe, India, North America, Pakistan.

12. Oscillatoria laete-virens (Crouan) Gomont, Monogr. Oscillariées, 226, pl.7, fig.11. 1892.

Desikachary, p.213. 1959.

Thallus thin, membranous, green; trichomes yellowish-green, straight, fragile, slightly constricted at the cross-walls, apices attenuated, undulate or bent, 3-5 µm broad; cells nearly as long as broad, 2.5-5 µm long, sometimes granulated at the cross-walls; end cell not capitate, more or less obtuse or conical, without calyptra (pl.19, fig.229).

Anjum 195, Jan. 13, 1979.

Habitat: Aquatic (Biswas, 1926); terrestrial (Skuja, 1949).

Local distribution: Sugar-cane field, Mardan.

Soil depth: 1 inch.

Geographical distribution: Burma, Europe, India, Pakistan.

13. Oscillatoria lacustris (Klebs.) Geitler, Cyanophyceae, In. A. Pascher, Die Suesswasserflora Deutschland, Oesterreichs und der Schweiz. Haft, 12: 362. 1925.

Prescott, p.488, pl.109, fig.15. 1951; Huber-Pestalozzi, p.234, fig.176. 1962.

= Trichodesmium lacustre Kleb., Gasvacuolen, ein Bestandtheit Zellen der Wasserbluethebildende Phycochromoceen. 80:241-282, pl.4. 1895.

Thallus free-floating; trichomes straight, in bundles, distinctly constricted at the cross-walls, not

tapering towards the apices; cells compressed globose or barrel-shaped, sometimes semiquadrate or little longer or shorter than broad, 5-7 µm in diameter, 3-7 µm long, contents with many pseudo-vacuoles; end cell broadly rounded, not calyptrate (pl.19, fig.221).

Anjum 196, Jan. 16. 1979.

Habitat: Aquatic (Prescott, 1951; Huber-Pestalozzi, 1962); terrestrial.

Local distribution: Sugar-cane field, Mardan.

Soil depth: 2 inch.

Geographical distribution: Europe, North America, Pakistan.

14. Oscillatoria limosa Ag. ex Gomont, Monogr. Oscillariées, 210, pl.6, fig.13. 1892.

Tilden, p.67, fig.19A-D. 1937; Prescott, p.489, pl.109, fig.17. 1951; Tiffany & Britton, p.342, fig.1976. 1952; Desikachary, p.206, pl.42, fig.11. 1959; Huber-Pestalozzi, p.233, fig.174. 1962.

Thallus dark blue-green to brown; trichomes rarely solitary or loosely entangled among filamentous algae, more or less straight, dull blue-green, brown or olive-green, not constricted at the cross-walls, 11-20 (-22) µm, commonly 13-16 µm broad; cells 1/3-1/6 as long as broad, 2-5 µm long, cross-walls frequently granulated;

end cell flately rounded with slightly thickened membrane (pl.2, fig.30).

Anjum 133, July 17, 1978.

Habitat: Aquatic (Martens, 1870, 1871; West, 1902; Prain, 1905; Biswas, 1926, 1929, 1942; Rao, C.B., 1938b; Ganapathi, 1940; Skuja, 1949; Prescott, 1951; Huber-Pestalozzi 1962); terrestrial.

Local distribution: Rice field Methra, District Peshawar.

Soil depth: 5 inch.

Geographical distribution: Burma, Europe, India, Malaya, North America, Pakistan, Sri Lanka.

15. Oscillatoria lutea Agardh (vide, Baker & Bold, 1970).

Baker & Bold, p.42, figs.95-97. 1970.

Trichomes yellowish-green, curved, in fascicles, unconstricted at the cross-walls; cells 5-7 µm in diameter, 1-4 µm long; apical cell rounded or capitate, gas-vacuoles of sparse occurrance (pl.2, fig.24).

Anjum 46, July 26, 1977.

Habitat: Terrestrial (Baker & Bold, 1970).

Local distribution: Dry land, Dera Ismail Khan.

Soil depth: 1 inch.

Geographical distribution: North America, Pakistan.

16. Oscillatoria princeps Vaucher, ex Gomont, Monogr.

Oscillariées, 206, pl.6, fig.9. 1892.

Prescott, p.489, pl.110, fig.1. 1951; Tiffany & Britton, p.334, pl.93, fig.1080. 1952; Desikachary, p.210, pl.37, figs. 1, 10. 1959; Huber-Pestalozzi, p.234, fig.175. 1962.

Trichomes solitary, or loosely entangled forming small floating plant masses; trichomes blue-green, more or less brownish, violet, reddish or black-green in colour, mostly straight, unconstricted at the cross-walls, septa not granulated, very slightly or attenuated at the apices and bent; cells 16-60 µm broad, commonly 25-60 µm broad, 1/11-1/4 as long as broad, 3.5-7 µm long; without or with slightly thickened membrane; cell contents densely granular (pl.2, fig.35, photo,15).

Anjum 131, July 12, 1978; Anjum 131A, July 13, 1978.

Habitat: Cosmopolitan, often forming mats on wet or dry soils.

Local distribution: Rice fields Methra, District Peshawar.

Soil depth: 1, 2 inches.

Geographical distribution: World wide.

17. Oscillatoria prolifica (Grev.) Gomont. Monogr.

Oscillariées, 205, pl.6, fig.8. 1892.

Prescott, p.490, pl.110, figs.2,3. 1951; 1959 Desikachary, p.234; Huber-Pestalozzi, p.240,

fig. 189. 1962.

= Lyngbya prolifica Grev. (vide, Huber-Pestalozzi, 1962).

Trichomes straight, or curved, unconstricted at the septa, gradually attenuated at the ends, 2.2-5 µm broad, seldom single, mostly forming purple red, irregular groups, or bundles; cells nearly quadrate or long, seldom shorter than broad, 4-6 µm long, septa often granulated, gas-vacuoles present; end cell capitate, calyptrate (pl.19, fig.222).

Anjum 198, Jan. 16, 1979; Anjum 198A, Jan. 20, 1979.

Habitat: Aquatic (Rao, C.B., 1938a; Prescott, 1951; Huber-Pestalozzi, 1962); terrestrial.

Local distribution: Sugar-cane fields, Mardan.

Soil depth: 1,2 inches.

Geographical distribution: Europe, India, North America, Pakistan.

18. Oscillatoria quadripunctulata Bruhl & Biswas, Algae of Bengal Filter Beds, J. Dept. Sci., Culcutta Univ., 4:5, pl.1, fig.6. 1922.

Desikachary, p.227, pl.37, fig.5. 1959.

Trichomes curved, or nearly straight, closely associated into a delicate, pale greenish blue membrane, 1-1.5 µm in diameter; cells 3.5-5 µm long, 2-4 times as

long as broad, unconstricted at the cross-walls, contents minutely granular, transverse walls rather obscure, marked by a pair of somewhat larger granules on either side (pl.19, fig.223).

Anjum 197, Jan. 16, 1979.

Habitat: Aquatic (Bruhl & Biswas, 1922); epiphytic (Rao, C.B., 1937b); terrestrial (Rao, C.B., 1938a).

Local distribution: Sugar-cane field, Mardan.

Soil depth: 3 inch.

Geographical distribution: India, Malasia, Pakistan.

19. Oscillatoria rubescens DC., Notice Sur la Matiere qui colora en rouge la lac de Morat un printemps de 1825, Mem. Soc. Phys. Sc. Hist. Nat. Geneve, 3(2):29. 1825; Gomont, Monogr. Oscillariées, 204, pl.6, figs. 6,7. 1892.

Tilden, p.408, figs.251, 1-5, 255, 256. 1937 Prescott, pl.107, fig.21. 1951; Desikachary, p.235, pl.42, fig.12. 1959; Huber-Pestalozzi, p.238, fig.188. 1962.

Trichomes straight, not constricted at the cross-walls, sometimes forming purple red or violet, free-swimming bundles, at the ends generally attenuated; cells 6-8 µm broad, 1/2-1/3 as long as broad, 2-4 µm long, often granulated at the septa, with gas-vacuoles (pl.2, fig.25).

Anjum, 14, Feb. 2, 1977.

Habitat: Aquatic (Crow, 1923; Prescott, 1951; Huber-Pestalozzi, 1962); terrestrial (Rao, C.B., 1937b, 1938a).

Local distribution: Dry land, Peshawar.

Soil depth: 1 inch.

Geographical distribution: Europe, India, North America, Pakistan, Sri Lanka.

20. Oscillatoria splendida Grev., ex Gomont, Monogr. Oscillariées, 224, pl.7, figs. 7,8. 1892. Prescott, p.491, pl.110, figs.5-7. 1951; Tiffany & Britton, p.346, pl.94, figs. 1085, 1086. 1952; Desikachary, p.234, pl.37, figs.7, 8; pl.38, fig.10 and pl.40, fig.11. 1959; Huber-Pestalozzi, p.237, fig. 187. 1962.

Thallus brilliant blue-green or olive-green; trichomes straight or curved, unconstricted at the cross-walls, gradually attenuated at the ends, 2-3 µm broad; cells 2-4 times longer than broad, rarely quadrate, 3-9 µm long; septa often granulated; ends more or less bent, sometimes screw-like or a sickle; end cells capitate, rarely rounded, mostly without calyptra (pl.19, fig.224).

Anjum 199, Jan. 18, 1979.

Habitat: Aquatic (Bruhl & Biswas, 1922; Banerji, 1938;

Biswas, 1942; Skuja, 1949; Prescott, 1951; Huber-Pestalozzi, 1962); terrestrial.

Local distribution: Sugar cane field, Mardan.

Soil depth: 4 inch.

Geographical distribution: Burma, Europe, India, North America, Pakistan.

21. Oscillatoria subbrevis Schmidle, Engler's Bot. Jahrb., 30, 243, pl.4, fig.7. 1901.

Prescott, p.491, pl.107, fig.23. 1951; Desikachary, p.207, pl.37, fig.2 & pl.40, fig.1. 1959; Huber-Pestalozzi, p.229. 1962.

Trichomes solitary, nearly straight, not tapering towards the apices, unconstricted at the cross-walls; cells 5-6 µm broad, 1-2 µm long; cross-walls not granulated; end cell rounded, calyptra absent; cell contents pale grey-green (pl.2, fig.33, photo 16).

Anjum 135, July 20, 1978; Anjum 135A, July 22, 1978; Anjum 135B, July 30, 1978.

Habitat: Aquatic (Prescott, 1951); terrestrial (Singh, V.P., 1941).

Local distribution: Dry land, Bannu; Rice fields Methra, District Peshawar.

Soil depth: 4, 5 and 6 inches.

Geographical distribution: Europe, India, North America, Pakistan.

22. Oscillatoria tenuis Ag., ex Gomont, Monogr. Oscillariées, 220, pl.7, figs.2,3. 1892. Prescott, p.491, pl.110, figs.8,9,14. 1951; Tiffany & Britton, p.346, pl.93, fig.1074. 1952; Desikachary, p.222, pl.42, fig.15. 1959; Huber-Pestalozzi, p.234, fig.180. 1962.

Thallus thin, blue-green, or olive-green, slimy; trichomes straight, fragile, slightly constricted at the cross-walls, 4-10 µm broad, blue-green, sometimes, bent at the ends, not attenuated at the apices, not capitate; end cell more or less hemispherical with thickened outer membrane; cells upto 1/3 as long as broad, 2.6-5 µm long, at the septa mostly gramulated (pl.19, fig.225).

Anjum 202, Jan. 21, 1979; Anjum 202A, Jan. 30, 1979.

Habitat: Aquatic (Bruhl & Biswas, 1922, 1926; Ghose, 1927e; Banerji, 1938; Rao, C.B., 1937b, 1938b; Frémy, 1942; Skuja, 1949; Prescott, 1951; Huber-Pestalozzi, 1962); terrestrial.

Local distribution: Sugar-cane fields, Mardan.

Soil depth: 1, 3 inches.

Geographical distribution: Burma, Europe, India, North America, Pakistan, Sri Lanka.

23. Oscillatoria terebriformis Ag., ex Gomont, Monogr.

Oscillariées, 234, pl.7, fig.24. 1892.

Tilden, p.498, figs. 251, 13-15. 1937;

Prescott, p.492, pl.107, figs.25, 26. 1951;

Desikachary, p.217, pl.38, fig.16. 1959.

Thallus dull blue; trichomes end bent in a screw-like manner, slightly attenuated at the ends, not constricted at the cross-walls; cells 4-6.5 µm broad, 2.5-6 µm long; end cell rounded, not capitate, calyptra absent (pl.2, fig.28, photo 17).

Anjum 13, Jan. 25, 1977; Anjum 13A, Feb. 9, 1977; Anjum 13B, March 15, 1977; Anjum 13C, March 19, 1977.

Habitat: Aquatic (Ghose, 1919; Biswas, 1934; Rao, C.B., 1936, 1938b; Rao, C.S. 1940; Prescott, 1951); terrestrial (Singh, R.N., 1939; Rao, C.S., 1939).

Local distribution: Dry lands, Bannu, Peshawar; Maize fields, Mardan.

Soil depth: 1,2,3 and 4 inches.

Geographical distribution: Europe, India, North America, Pakistan.

PHORMIDIUM Kg.

Phyc. gen. 190. 1843.

Thallus consisting of simple, unbranched filaments forming a gelatinous and leathery stratum, attached by the lower side, or floating in water with

torn margins, sheath present, more or less firm, sometimes agglutinated, sometimes partly diffluent, thin, colourless; trichomes cylindrical, constricted at the cross-walls in some species, often attenuated at the apices, straight or bent, but never regularly spirally coiled; cells shorter than wide, or quadrate or sometimes longer than broad; apical cell conical, blunt-pointed or capitate, with or without calyptra.

Key to the species

1. Trichomes constricted..... 2
1. Trichomes unconstricted..... 8
2. Trichomes attenuated at the apices..... 3
2. Trichomes not attenuated at the apices..... 5
3. Cells longer than broad..... P. tenue (17)
3. Cells nearly quadrate..... 4
4. Trichomes 1.2-2.3 µm broad.... P. fragile (7)
4. Trichomes 4-6 µm broad..... P. jadinianum (9)
4. Trichomes 6-8 µm broad..... P. truncicola (18)
5. Cells 4-6 µm broad..... P. ambiguum (2)
5. Cells narrow..... 6
6. Cells twice as long as broad.. P. mucicola (11)
6. Cells less long..... 7
7. Cells 1.5 µm broad, end cell

rounded..... P. foveolarum (6)

7. Cells 2-2.6 µm broad, end cell rounded-truncated..... P. jenkelianum (10)

8. End cell capitate..... 9

8. End cell not capitate..... 10

9. Trichomes 4-7 µm broad, straight..... P. autumnale (3)

9. Trichomes 6-9 µm broad, curved or spiral..... P. uncinatum (19)

10. End cell truncated..... P. retzii (15)

10. End cell rounded..... 11

10. End cell obtuse-conical.. 15

11. Sheath thick..... P. muscorum (12)

11. Sheath thin..... 12

12. Septa granulated..... 13

12. Septa not granulated..... 14

13. Trichomes 1.5-2.5 x 2-4.5 µm in diameter..... P. purpurascens (14)

13. Trichomes 2-2.5 x 3.3-6.7 µm in diameter..... P. valderianum (20)

14. Trichomes 1.7-2 µm broad. P. bohneri (4)

14. Trichomes 5-6.5 µm broad. P. subincrustatum (16)

15. Sheath thick, visible..... P. abronema (1)

15. Sheath thin, not very visible..... 16

16. Trichomes with calcium incrustation, hard..... P. incrustatum (8)

16. Otherwise..... 17

17. Cells quadrate or shorter than broad, 2-4 µm long..... P. papyraceum (13)

17. Cells quadrate or longer than broad, 3.4-8 µm long..... P. corium (5)

1. Phormidium abronema Skuja, Zur Suesswasseralgenflora Burmas, 50, pl.8, fig.25. 1949.

Desikachary, p.257. 1959.

Thallus lamellated, coriaceous, olivaceous, blackish-green to light blue; trichomes flexuous, more or less loosely spirally coiled, unconstricted at the cross-walls, briefly attenuated at the apices, 4-7 µm broad; sheath moderately thick, hyaline, mucilaginous, commonly diffluent; cells 3/4-2 times as long as broad, 3-4.5 µm long, cylindrical or barrel-shaped; end cell more or less rounded-conical; septa not granular (pl.3, fig.42).

Anjum 76, Nov. 18, 1977.

Habitat: Terrestrial (Skuja, 1949).

Local distribution: Dry land, Dera Ismail Khan.

Soil depth: 6 inch.

Geographical distribution: Burma, Pakistan.

2. Phormidium ambiguum Gomont, Monogr. Oscillariées, 178, pl.5, fig.10. 1892.

Prescott, p.493, pl.111, fig.1. 1951; Tiffany & Britton, p.350, pl.95, fig.1104. 1952; Desikachary, p.266, pl.44, fig.16 & pl.45, figs.5-8. 1959.

Thallus more or less expanded, bright blue-green, dark or yellowish green; filaments flexuous, variously entangled; trichomes slightly constricted at the cross-walls, not attenuated at the ends, not capitate, 4-6 µm broad; sheath thin, firm or diffluent, sometimes thick and more or less lamellated, coloured violet by chlor-zinc-iodide; cells shorter than broad, 1.5-2.7 µm long, rarely granulated at the cross-walls, sometimes with gas-vacuoles; end cell rounded, calyptra absent (pl.3, fig.46, photo 18).
However, in this collection, trichomes were 4-7.5 µm in diameter.
Anjum 84, Dec. 23, 1977.
Habitat: Aquatic (Parukutty, 1939; Prescott, 1951); epiphytic (Ghose, 1927c); terrestrial (Mitra, 1951).
Local distribution: Sorghum field, Peshawar.
Soil depth: 3 inch.
Geographical distribution: Burma, Europe, India,

North America, Pakistan,
Sri Lanka.

3. Phormidium autumnale (Ag.) Gomont, Monogr. Oscillariées, 187, pl.5, figs. 23, 24. 1892.
Prescott, p.493, pl.107, figs.19,20. 1951;
Tiffany & Britton, p.348, pl.96, fig.1108.
1952; Desikachary, p.276, pl.44,
figs.24,25. 1959.
= Oscillaria antilaria Mert., in juergens, Alg. aquat., Dec. 14, n.4. 1822.

Thallus expanded, dark blue-green or brownish-green, sometimes yellowish or violet; filaments straight, rarely flexuous, variously entangled; sheath firm, mucilaginous, distinct or diffluent in an amorphous mucilaginous matrix, not coloured violet by chlor-zinc-iodide; trichomes blue-green, unconstricted at the cross-walls, ends mostly briefly attenuated, rarely gradually attenuated, straight or scarcely curved, prominently capitate, 4-7 µm broad; cells quadrate or 1/2 as long as broad, 2-5 µm long, septa frequently granulated; end cell with a rounded or truncated conical calyptra (pl.19, fig.226, photo, 19).

Anjum 201, Jan. 20, 1979.

Habitat: Aquatic (Rao, C.B., 1938b; Prescott, 1951);

epiphytic (Martens, 1870); terrestrial (Mitra, 1951).

Local distribution: Wheat field, Peshawar.

Soil depth: 1 inch.

Geographical distribution: Burma, Europe, India, North America, Pakistan.

4. Phormidium bohneri Schmidle, Beitr. 2. Algenfl. Afrikas, Engler's Bot. Jahrb., 30:59, pl.2, fig.11. 1901.
Desikachary, p.261, 1959.

Thallus membranous, thin, mucilaginous, green; trichomes straight, more or less parallel, unconstricted at the cross-walls, not attenuated at the ends; sheath hyaline, diffluent, not coloured violet by chlor-zinc-iodide; cells contents blue-green; cells 1.7-2 µm broad, mostly shorter than broad, 1.5 µm long, seldom quadrate or somewhat longer than broad; end cell rounded, not capitate (pl.3, fig.39).

In this collection, cells were 2-3 µm broad.

Anjum 245, March 15, 1979.

Habitat: Epiphytic (Rao, C.B., 1938a); terrestrial (Ghose, 1927).

Local distribution: Dry land, Peshawar.

Soil depth: 2 inch.

Geographical distribution: Africa, India, Pakistan.

5. Phormidium corium (Ag.) Gomont, Monogr. Oscillariées, 172, pl.5; figs. 1,2. 1892.

Prescott, p.496, 1951; Desikachary, p.269, pl. 44, fig.10, 11. 1959.

Filaments forming an expanded, membranous, leathery plant mass, long, more or less flexuous, densely entangled; trichomes blue-green, unconstricted at the cross-walls, ends straight, slightly attenuated, not capitate; sheath diffluent, gelatinizing, coloured violet by chlor-zinc-iodide; cells 3-4.5 µm broad, nearly quadrate or longer, 3.4-8 µm long, not granulated at the septa; end cell obtuse-conical, without calyptra (pl.3, fig.43, photo 20).

Anjum 68, Oct. 20, 1977.

Habitat: Aquatic (Prescott, 1951); terrestrial (Biswas, 1924; Rao, C.B., 1938a,b; Banerji, 1935; Parukutty, 1939, 1940).

Local distribution: Dry land, Dera Ismail Khan.

Soil depth: 1 inch.

Geographical distribution: Europe, India, North America, Pakistan.

6. Phormidium foveolarum (Mont.) Gomont, Monogr. Oscillariées, 164, pl.4, fig.16. 1892.

Tiffany & Britton, p.348, pl.95, fig.1095. 1952; Desikachary, p.254. 1959.

Thallus dark green, thin; trichomes flexuous, not attenuated at the ends, constricted at the cross-walls, 1.5 µm in diameter; sheath colourless, diffluent in amorphous gelatinous mucilage, not coloured violet by chlor-zinc-iodide; cells nearly quadrate or somewhat shorter than broad, 0.8-1.8 µm long, septa not granulated, contents pale blue-green; end cells rounded, calyptra absent (pl.3, fig.41).

Anjum 16, Feb.16. 1977; Anjum 16A, April 13, 1977.

Habitat: Terrestrial (Banerji, 1938; De, P.K., 1939; Parukutty, 1940; Rao, C.S., 1940; Gonzalves & Gangla, 1949; Mitra, 1951).

Local distribution: Dry land, Peshawar; Wheat field Peshawar.

Soil depth: 1,2 inches.

Geographical distribution: Europe, India, North America, Pakistan.

7. Phormidium fragile (Menegh.) Gomont. Monogr. Oscillariées, 163, pl.4, figs. 13-15. 1892. Desikachary, p.253, pl.44, figs.1-3. 1959.

Thallus mucilaginous, lamellated, yellowish or brown blue-green; trichomes more or less flexuous,

entangled or nearly parallel, distinctly constricted at the cross-walls, attenuated at the ends, 1.2-2.3 µm broad; cells nearly quadrate, 1.2-3 µm long; end cell acute-conical, calyptra absent; cell contents blue-green to pale blue-green; cross-walls not granulated (pl.3, fig.37, photo 21).

Anjum 31, May 16, 1977; Anjum 31A, Sep. 8, 1977; Anjum 31B, Sep. 9, 1977; Anjum 31C, Oct. 12, 1977; Anjum 31D, Oct. 14, 1977; Anjum 31E, Oct. 15, 1977.

Habitat: Aquatic (Banerji, 1938; Rao, C.S., 1940); terrestrial (Biswas, 1924; Mitra, 1951).

Local distribution: Wheat field, Peshawar; Dry lands, Dera Ismail Khan, Bannu and Kohat; Rice field Methra, District Peshawar; Pine forest, Parachinar.

Soil depth: 1,2,3,4,5 and 6 inches.

Geographical distribution: Europe, India, Pakistan.

8. Phormidium incrustatum (Naeg.) Gomont, in Bornet and Flahault, Sur quelques plantes vivant dans le test calcaire des Mollusques, Bull. Soc. bot. Fr., 36:154. 1889.

Prescott, p.494. 1951; Desikachary, p.269, pl.44, fig.12. 1959.

Thallus brownish-red or violet, with calcium

incrustation, very hard; trichomes entangled or erect and parallel, unconstricted at the cross-walls, 4-5 µm broad, ends briefly attenuated, erect, not capitate; sheath thin mucilaginous, not coloured violet by chlor-zinc-iodide; cells nearly quadrate, 3.5-5.2 µm long, cross-walls generally invisible sometimes granulated; end cell obtuse-conical, calyptra absent (pl.19, fig.227).

Anjum 203, Jan. 23, 1979.

Habitat: Aquatic (Prescott, 1951); epiphytic (Rao, C.S., 1939); terrestrial.

Local distribution: Sugar-cane field, Mardan.

Soil depth: 1 inch.

Geographical distribution: Europe, India, North America, Pakistan.

9. Phormidium jadinianum Gomont, Bull. Soc. Bot. Fr., 40. 151. 1893.

Desikachary, p.256, pl.55, fig.9. 1959.

Thallus amorphous, thin, dark-green to olive-green; filaments more or less parallel; trichomes olive-green, distinctly constricted at the cross-walls, ends straight, long, acuminate, 4-6 µm broad; sheath thin, diffluent, agglutinated, not coloured violet by chlor-zinc-iodide; cells shorter than broad to nearly quadrate, 2-3.5 µm long, contents granulated with a hyaline central

area, septa not granulated; end cell acute-conical, calyptra absent (pl.3, fig.45).

Anjum 86, Jan. 6, 1978.

Habitat: Epiphytic (Ghose, 1919); terrestrial.

Local distribution: Dry land, Dera Ismail Khan.

Soil depth: 6 inch.

Geographical distribution: Europe, Pakistan.

10. Phormidium jenkelianum Schmidle, Ber. dtsch. bot. Ges., 32:126, fig.2. 1914.

Desikachary, p.255, pl.54, fig.7. 1959.

Thallus slimy, brownish-black; trichomes flexuous, not attenuated at the ends, distinctly constricted at the cross-walls, 2-2.6 µm broad; sheath delicate, not coloured violet by chlor-zinc-iodide; cells 1/3-1/2 as long as broad, 0.6-1.3 µm long, contents brownish blue-green; end cell rounded, truncated, calyptra absent (pl.3, fig.48).

However, in the present study the trichomes were 3 µm broad, 1.5 µm long. It appears that its forms [illegible] are more robust.

Anjum 79, Nov. 24, 1977; Anjum 79A, Nov. 26, 1977.

Habitat: Aquatic (Parukutty, 1940); terrestrial (Gonzalves & Gangla, 1949).

Local distribution: Dry lands, Bannu and Dera Ismail Khan.

Soil depth: 1,2 inches.

Geographical distribution: Europe, India, Pakistan.

11. Phormidium mucicola Hub.-Pestalozzi et Haumann Ber. dtsch. bot. Ges., 47:86, figs. 1-6. 1929.
Prescott, p.495, pl.111, figs.4,5. 1951;
Desikachary, p.254, pl.15, fig.13. 1959.

Filaments short, straight; trichomes not attenuated at the ends, more or less distinctly constricted at the cross-walls, 1.3-2 µm broad; sheath very thin, not coloured blue by chlor-zinc-iodide; cells more or less twice as long as broad, 2.5-4 µm long, end cell rounded, seldom slightly conical, without calyptra; contents granulated, pale bluish (pl.19, fig.229).

Anjum 204, Jan. 25, 1979.

Habitat: Aquatic (Rao, C.B., 1938; Skuja, 1949; Prescott, 1951); terrestrial.

Local distribution: Sugar-cane field, Mardan.

Soil depth: 1 inch.

Geographical distribution: Burma, Europe, India, Pakistan.

12. Phormidium muscorum Gardner, New Myxophyceae from Porto Rico, Mem. N.Y. bot. Gdu, 7:43, pl.9, fig.84. 1927.
Desikachary, p.265, pl.43, figs. 6,7. 1959.

Filaments 7.2-7.8 µm broad, long, straight, or

curved; trichomes 2.5-3.4 µm broad, unconstricted at the cross-walls; sheath apparantly thick, more or less gelatinous, colourless, unlamellated; cells 2-2½ times as long as broad, pale blue-green; end cell rounded (pl.19, fig. 228).

Anjum 205, Jan. 23, 1979.

Habitat: Terrestrial.

Local distribution: Sugar-cane field, Mardan.

Soil depth: 2 inch.

Geographical distribution: North America, Pakistan, Porto Rico.

13. Phormidium papyraceum (Ag.) Gomont, Monogr. Oscillariées, p.173, pl.5, figs.3,4. 1892.

Desikachary, p.271. 1959.

Thallus dark green, expanded, thin, leathery, fragile on drying; trichomes elongate, very flexuous, densely entangled, unconstricted at the cross-walls, blue-green, 3-5 µm in diameter; sheath thin, papery, persistent, sometimes diffluent, coloured violet by chlor-zinc-iodide; cells mostly subquadrate or shorter than broad, 2-4 µm long; end cell obtuse-conical, not capitate, without calyptra (pl.3, fig.40).

Anjum 112, April 18, 1978; Anjum 112A, April 24. 1978.

Habitat: Aquatic (Biswas, 1942); epiphytic (Rao, C.B., 1938b); terrestrial.

Local distribution: Dry lands, Peshawar.

Soil depth: 2,3 inches.

Geographical distribution: Europe, India, Pakistan.

14. Phormidium purpurascens (Kg.) Gomont, Monogr. Oscillariées, 166, pl.4, fig.19. 1892.

Desikachary, p.262, pl.44, fig.4 & pl.45, figs. 1-4. 1959.

Thallus purple to brownish violet, compact, leathery; trichomes strongly bent, entangled, unconstricted at the cross-walls, not attenuated at the ends, 1.5-2.5 µm broad; sheath more or less diffluent, not coloured violet by chlor-zinc-iodide; cells nearly quadrate or upto nearly two times longer than broad, 2-4.5 µm long, cross-walls marked by two granules on either side; end cell rounded, calyptra absent (pl.3, fig.49, photo 22).

Anjum 56, Sep. 16, 1977; Anjum 56A, Sep. 30, 1977.

Habitat: Epiphytic (Rao, C.B., 1938b; Gupta, 1956); terrestrial.

Local distribution: Dry land, Dera Ismail Khan; Wheat field, Peshawar.

Soil depth: 1, 2 inches.

Geographical distribution: Europe, India, Pakistan.

15. Phormidium retzii (Ag.) Gomont, Monogr. Oscillariees,

175, pl.5, figs.6-9. 1892.

Prescott, p.495, pl.111, fig.6. 1951; Tiffany & Britton, p.352, pl.95, figs.1105-1107. 1952; Desikachary, p.268, pl.44, figs.13,15. 1959.

= Phormidium papyrinum Kg., Phyc. germ., 195. 1843.

Thallus thick, compact, penicillate or branched tufts, bright blue-green to dark in colour, attached at the base, upper portions floating; trichomes straight, parallel, unconstricted at the cross-walls, not attenuated at the ends, not capitate, 4.5-12 µm broad; sheath thin, firm, or mostly diffluent, not coloured violet by chlor-zinc-iodide; cells shorter or longer than broad, 4-9 µm long, cross-walls not granulated, contents dull blue-green; end cell truncated, with a thickened outer membrane, calyptra absent (pl.3, fig. 47).

Anjum 62, Oct. 8. 1977.

Habitat: Aquatic (Crow, 1923b; Rao, C.B., 1937b; Prescott, 1951); terrestrial.

Local distribution: Maize field, Mardan.

Soil depth: 4 inch.

Geographical distribution: Burma, Europe, India, North America, Pakistan, Sri Lanka.

16. Phormidium subincrustatum Fritsch et Rich., Trans.

Roy. Soc. S. Afr., 18:82, figs.27 J-L. 1929.

Desikachary, p.267. 1959.

Thallus calcified; filaments straight, more or less parallel, not erect; trichomes 5-6.5 µm broad, unconstricted at the cross-walls, not attenuated towards apices; sheath thin slimy, unlamellated, often not diffluent; cells shorter than broad, 2.5 µm long; end cell rounded or slightly conical, not capitate, without calyptra (pl.3, fig.44).

Anjum 173, Dec. 5, 1978.

Habitat: Terrestrial (Rao, C.B., 1937b).

Local distribution: Pine forest, Parachinar.

Soil depth: 2 inch.

Geographical distribution: Africa, India, Pakistan.

17. Phormidium tenue (Menegh.) Gomont, Monogr. Oscillariées, 169, pl.4, figs.23-25. 1892.

Prescott, p.496, pl.111. fig.7. 1951; Tiffany & Britton, p.347, pl.95, fig.1098. 1952; Desikachary, p.259, pl.43, figs. 13-15 & pl.44, figs. 7-9. 1959.

= Leptothrix subtilissima Kg., Tab. Phyc. 1: pl.65. 1845.

= Hyphaeothrix subtilissima Rabenh., Fl. Eur. Alg., 2:77. 1865.

Thallus membranous, expanded, pale blue-green to blue-green; trichomes straight, or slightly bent, attenuated at the apices, densely entangled, constricted at the cross-walls, 1-2 µm broad; sheath thin, diffluent, coloured violet by chlor-zinc-iodide; cells upto 3 times longer than broad, 2.5-5 µm long, croas-walls commonly visible, not granulated; end cell acute-conical, calyptra absent; cell contents pale blue-green (pl.3, fig.38, photo 23).

Anjum 30, May 9, 1977; Anjum 30A, Feb. 11, 1979.

Habitat: Aquatic (Prain, 1905; Wille, 1915; Ghose, 1919; Bruhl & Biswas, 1922; Biswas, 1925, 1926, 1929, 1942; Rao, C.S., 1940; Skuja, 1949; Prescott, 1951); terrestrial.

Local distribution: Dry land, Dera Ismail Khan; Sugar-cane field, Mardan.

Soil depth: 1, 2 inches.

Geographical distribution: Burma, Europe, India, Malasia, North America, Pakistan, Sri Lanka.

18. Phormidium truncicola Ghose, A systematic and ecological account of a collection of blue-green algae from Lahore and Simla, J. Linn. Soc., Bot. Lond., 56:338, pl3, fig.9. 1924.
Desikachary, p.258, pl.59, fig.9. 1959.

Thallus expanded, membranous, yellow-green or

blue-green; trichomes 6-8 µm broad, nearly parallel, distinctly constricted at the cross-walls, attenuated at the apices; sheath diffluent, fibrous; cells nearly as long as broad, without calyptra (pl.19, fig.230). Anjum 206, Jan. 23, 1979; Anjum 206A, Jan. 25, 1979.

Habitat: Terrestrial.

Local distribution: Sugar-cane fields, Mardan.

Soil depth: 1, 3 inches.

Geographical distribution: India, Pakistan.

19. Phormidium uncinatum (Ag.) Gomont. Monogr. Oscillariées, 184, pl.5, figs.21,22. 1892.

Prescott, p.496, pl.107, fig.18. 1951; Tiffany & Britton, p.348, pl.94, fig.1091, 1092. 1952; Desikachary, p.276, pl.43, figs.1,2 & pl.45, figs.9,10. 1959.

= Oscillaria antliara d. physiodes Raben., F. Eur. Alg., 2:101. 1865.

= Lyngbya rupestris Ag. in Turner, The fresh water Algae of East India, K. Sv. Vet. Akad. Handl., 25:13. 1892.

Thallus broadly expanded, dark green to brownish black, adherent, thin, firm, or floating, attached at the base, thick, torn; filaments straight or slightly bent; trichomes blue-green, unconstricted at the cross-

walls, 6-9 µm broad, ends slightly attenuated, capitate, curved or shortly spirally coiled; sheath mucilaginous, distinct or diffluent in amorphous mucilage, not coloured violet by chlor-zinc-iodide; cells ½-1/3 as long as broad, rarely subquadrate, 2-6 µm long, cross-walls frequently granulated; end cell with a round or depressed conical calyptra (pl.19, fig.231).

Anjum 208, Jan. 27, 1979; Anjum 208A, Jan. 29, 1979.

Habitat: Aquatic (Zeller, 1873; Turner, 1892); terrestrial (Frémy, 1942; Mitra, 1951; Prescott, 1951).

Local distribution: Sugar-cane fields, Mardan.

Soil depth: 4, 5 inches.

Geographical distribution: Europe, India, North America, Pakistan.

20. Phormidium valderianum (Delp.) Gomont, Monogr. Oscillariées, 167, pl.4, fig.20. 1892.

Desikachary, p.263, pl.44, fig.5. 1959.

Thallus lubricous, expanded, lamellated, outer surface dull green, inner surface colourless; trichomes flexuous, densely entangled, unconstricted at the cross-walls, ends not attenuated, not curved, 2-2.5 µm broad, blue-green; sheath thin, firm, finally becoming more or less diffluent, coloured violet by chlor-zinc-iodide; cells longer than broad, 3.3-6.7 µm long, cross-walls with

1 or 2 granules on either side; end cell rounded, calyptra absent (pl.19, fig.232).

Anjum 207, Jan. 26, 1979.

Habitat: Terrestrial (Banerji, 1935, 1938; Rao, C.B., 1938a).

Local distribution: Sugar-cane field, Mardan.

Soil depth: 5 inch.

Geographical distribution: Europe, India, Pakistan, Sri Lanka.

LYNGBYA Ag. ex Gomont

Monogr. Oscillariées, 118. 1892.

Trichomes single or free in a thin or very massive thick, firm sheath; sheath mostly colourless, seldom coloured yellow to brown or red, blue to purple red; filaments sometimes spirally coiled or attached at the base or in the middle or the entire filament attached, mostly without such attachment, or free-floating or forming free thallus.

Key to the species

1. Filaments spirally coiled..... 2
1. Otherwise..... 4
2. Cells 14-16 µm in diameter.... L. spirulinoides (11)
2. Cells narrow 3
3. Filaments irregularly spirally

coiled, coils nearly straight.. L. lagerheimii (6)

3. Filaments regularly spirally coiled, coils nearly circular.. L. contorta (3)

4. Trichomes constricted..... 5

4. Trichomes unconstricted..... 8

5. Filaments attached by a basal cell..... L. gardneri (4)

5. Filaments free..... 6

6. Trichomes attenuated at the apices..... L. nordgaardii (8)

6. Trichomes not attenuated at the apices..... 7

7. Cells 2 µm broad..... L. polysiphonae (9)

7. Cells 7.5-13 µm broad..... L. putealis (10)

8. Cells 12-14 µm broad..... L. truncicola (13)

8. Cells smaller..... 9

9. Septa granulated..... 10

9. Septa not granulated..... 11

10. Cells 4-6 µm broad, end cell with a slightly thickened membrane..... L. aerugineo-caerulea (1)

10. Cells 6-10 µm broad, end cell without thickened membrane..... L. martensiana (7)

11. Filaments attached by basal cell..... L. kuetzingii (5)

11. Filaments free-floating..... 12

12. Cells 4-7 µm broad..... L. taylorii (12)

12. Cells 3.5-4 µm broad..... L. allorgei (2)

1. Lyngbya aerugineo-cœrulea (Kg.) Gomont, Monogr. Oscillariées, 146, pl.4, figs.1-3. 1892. Prescott, p.498, pl.111, figs.10,11, 1951; Tiffany & Britton, p.339, pl.92, figs.1059, 1060. 1952; Desikachary, p.315, pl.48, fig.9. 1959.

Filaments solitary or aggregated, forming a dull blue-green expanded, flexuous, fragile thallus; trichomes unconstricted at the cross-walls, apex occasionally capitate, cross-walls sometimes granulated; sheath diffluent; cells 4-6 µm broad, 1-1½ as long as broad, 2.3-3 µm long; cell contents pale blue-green; end cell flattened, conical or rounded, with a slightly thickened membrane (pl.3, fig.52).

Anjum 152, Oct. 18, 1978; Anjum 152A, Oct. 21, 1978.

Habitat: Cosmopolitin.

Local distribution: Sugar-cane field, Mardan; Wheat field, Peshawar.

Soil depth: 1, 3 inches.

Geographical distribution: World wide.

2. Lyngbya allorgei Frémy, Myxo. d'Afr. equat. franc.,

189, fig. 156. 1929.

Desikachary, p.313, pl.54, fig.6. 1959.

Filaments solitary or united and caespitose, fasciculate; trichomes pale violet, unconstricted at the cross-walls, 3.5-4 µm broad; sheath very thin, papyraceous, colourless, not coloured violet by chlor-zinc-iodide; cells nearly quadrate or up to 1½ times as long as broad, cross-walls not granulated; end cell rounded, calyptra absent (pl.19, fig.233).

Anjum 209, Jan. 29, 1979.

Habitat: Aquatic, epiphytic, terrestrial (Dixit, 1936).

Local distribution: Sugar-cane field, Mardan.

Soil depth: 5 inch.

Geographical distribution: Africa, Europe, India, Pakistan.

3. Lyngbya contorta Lemm. Phytoplanet. Sachs Teiche in Ploener Forschber., 6:202, pl.5, figs.10-13. 1898.

Prescott, p.500, pl.112, fig.1. 1951;

Desikachary, p.290, pl.48, fig.5 & pl.50, figs.5, 9. 1959. Huber-Pestalozzi, p.247, fig.202. 1962.

Filaments single, free-floating, regularly spirally coiled, nearly circular coils, 1-1.5 µm broad; sheath narrow, colourless; cells 1-2 µm broad, 3-5 µm long, unconstricted at the cross-walls, granulated with

a single granule or without them (pl.19, fig.234).

Anjum 148, Sep. 26, 1978.

Habitat: Aquatic (Rao, C.B., 1940; Prescott, 1951; Huber-Pestalozzi, 1962).

Local distribution: Sugar-cane field, Mardan.

Soil depth: 1 inch.

Geographical distribution: Europe, India, North America, Pakistan.

4. Lyngbya gardneri (Setchell & Gardner) Geitler, Kryptogamenflora, 1037. 1932.

Desikachary, p.284, pl.49, fig.4. 1959.

= Lyngbya erecta Setchell and Gardner, Proc. Calif. Acad. Sci., 4th Ser., 122. 1930 now L. erecta Setchell and Gardner. 1927.

Filaments attached by a basal cell, forming thick or dense, straight or slightly bent masses, 2.6-3 µm broad; trichomes 1.3-1.6 µm broad, slightly constricted at the cross-walls; sheath indistinct, colourless, smooth; cells quadrate or somewhat longer or shorter than broad; end cell rounded (pl.19, fig.236).

Anjum 212, Feb. 2, 1979; Anjum 212A, Feb. 6, 1979.

Habitat: Epiphytic (Iyengar & Desikachary, 1944); terrestrial.

Local distribution: Sugar-cane field, Mardan; Rice field Methra, District Peshawar.

Soil depth: 2, 3 inches.

Geographical distribution: Europe, India, North America, Pakistan.

5. Lyngbya kuetzingii Schmidle, Algol. Notiz. IV, Allg. Zeitscher., 58. 1896.

Desikachary, p.282, pl.48, fig.2. 1959.

Filaments straight or slightly curved or bent, rigid, single or many and gregarious, 1-3.5 µm broad, often short, with one end fixed or attached; sheath thin, colourless, coloured violet by chlor-zinc-iodide; cells 1.5-2 µm broad, ½-1/3 as long as broad, unconstricted at the cross-walls, septa not granulated; cell contents pale blue-green (pl.19. Fig.237).

Anjum 210, Jan. 31, 1979; Anjum 210A, Jan. 2, 1980; Anjum 210B, Jan. 4, 1980.

Habitat: Aquatic (Banerji, 1938; Frémy, 1942); epiphytic (Crow, 1923b); terrestrial.

Local distribution: Sugar-cane fields Mardan, and Sorghum field, Peshawar.

Soil depth: 4,5 and 6 inches.

Geographical distribution: Europe, India, Pakistan, Sri Lanka.

6. Lyngbya lagerheimii (Moeb.) Gomont, Monogr. Oscillariées, 147, pl.4, figs.6,7. 1892.

Desikachary, p.290, pl.48, fig.6 & pl.53, fig.2. 1959.

Filaments single or entangled with one another, irregularly spirally coiled or occasionally straight; sheath thin, colourless; trichomes about 2 µm broad; cells 1.2-3 µm long, unconstricted at the cross-walls, with or without a single granule on either side, pale blue-green; end cell rounded, not attenuated (pl.3, fig.51).

Anjum 172, Dec. 4, 1978; Anjum 172A, Dec. 18, 1978.

Habitat: Aquatic (Rao, C.S. 1940); terrestrial.

Local distribution: Maize fields, Mardan.

Soil depth: 2, 3 inches.

Geographical distribution: Europe, India, Pakistan.

7. Lyngbya martensiana Menegh. ex Gomont, Monogr. Oscillariées, 145, pl.3, fig.17. 1892. Tilden, p.65, fig.17F. 1937; Prescott, p.502, pl.112, fig.11. 1951; Desikachary, p.318, pl.52, fig.6. 1959.

Thallus expanded, entangled, dark blue-green; trichomes straight, unconstricted at the cross-walls, apices not attenuated, 6-10 µm broad, rarely up to 13 µm broad; sheath thick, colourless, not coloured violet by chlor-zinc-iodide; cells ½-1 as long as broad, 1.75-3.3 µm long; end cell rounded, without calyptra; cross-walls

sometimes granulated; cell contents pale blue-green (pl. 3, fig.50, photo 24, 25).

Anjum 100, Feb. 15, 1978.

Habitat: Aquatic (Biswas, 1930; Parukutty, 1940; Skuja, 1949); terrestrial.

Local distribution: Sorghum field, Peshawar.

Soil depth: 2 inch.

Geographical distribution: Burma, Europe, India, North America, Pakistan.

8. Lyngbya nordgaardii Wille, Algol. Notizen, XXVIII, Nyt. Mag. Natur. 56:32. 1917.
Prescott, p.503, pl.113, figs.1,2. 1951;
Desikachary p.287, pl.54, figs. 1-3. 1959.
= Lyngbya epiphytica Wille, Nyt. Mag. Natur., 51:25, pl.1, figs. 14-17. 1913.
= L. willei Setchell & Gardner, in Gardner New Pacific Coast Alg., 3, Univ. Calif. Publ. Bot., 3:468. 1918.

Thallus small, caespitose, grey violet or grey brown, filaments very long, straight, or more or less bent or curved; trichomes constricted at the cross-walls, attenuated, grey violet, 1.5-2 µm broad; sheath thin, delicate, smooth, not coloured violet by chlor-zinc-iodide; cells 1-½ as long as broad, 4 µm long; end cell rounded, without a thickened outer membrane (pl.19, fig.238).

Anjum 211, Jan. 31, 1979.

Habitat: Epiphytic (Rao, C.B., 1938a; Iyengar & Desikachary, 1944; Prescott, 1951); terrestrial.

Local distribution: Sugar-cane field, Mardan.

Soil depth: 1 inch.

Geographical distribution: Europe, India, North America, Pakistan.

9. Lyngbya polysiphonae Frémy, Myxo. d'Afr. equat. franca., 194, fig. 161. 1929.

Desikachary, p.287, pl.53, figs. 4,5. 1959.

Filaments solitary or aggregated, straight or curved; trichomes pale blue-green or violet, constricted at the cross-walls, apices not attenuated, 2 µm broad; sheath very delicate, papyraceous, hyaline, not coloured violet by chlor-zinc-iodide; cells ½-1/3 as long as broad, 1-1.5 µm long, cross-walls visible, not granulated; end cell convex, not capitate (pl.3, fig.55).

Anjum 23, March 30, 1977.

Habitat: Aquatic (Parukutty, 1940); terrestrial.

Local distribution: Dry land, Dera Ismail Khan.

Soil depth: 1 inch.

Geographical distribution: Africa, India, Pakistan.

10. Lyngbya putealis Mont. ex Gomont, Monogr. Oscillariées, 143, pl.3, fig.14. 1892.

Tiffany & Britton, p.338. pl.92, fig.1063. 1952; Desikachary, p.317, pl.52, fig.12. 1959.

Thallus caespitose, expanded, up to 1 cm long, penicillate, dull blue-green, on drying becoming violet; filaments curved or nearly straight, at the base intricate, above more or less parallel; trichomes 7.5-13 µm broad, distinctly constricted at the cross-walls, septa sometimes granulated, not attenuated, not capitate, blue-green; sheath thin, papyraceous, colourless, coloured violet by chlor-zinc-iodide; cells quadrate, up to 1/3 as long as broad, 3-10 µm long; end cell rounded (pl.19, fig.239).

Anjum 213, Feb. 3, 1979.

Habitat: Aquatic (Gomont, 1892; West & West, 1907; Rao, C.B., 1937b, 1938b); in river (Crow, 1923b); terrestrial.

Local distribution: Sugar-cane field, Mardan.

Soil depth: 2 inch.

Geographical distribution: Burma, Europe, India, North America, Pakistan, Sri Lanka.

11. Lyngbya spirulinoides Gomont, Monogr. Oscillariées, 146, pl.3, figs. 18,19. 1892.

Prescott, p.503, pl.131, fig.1. 1951; Desikachary, p.289, pl.52, figs.4,5. 1959; Huber-Pestalozzi, p.247, fig.205. 1962.

Thallus free-floating, olive-green; filaments entangled, regularly and loosely spirally coiled, either partially or throughout its length, often straight, distance between two spirals 73-108 µm; trichomes not constricted at the cross-walls, septa sometimes granulated; sheath thin, colourless, lamellated, somewhat mucilaginous, not coloured violet by chlor-zinc-iodide; cell 14-16 µm broad, ½-1/3 as long as broad, 3.4-6.8 µm long, contents pale blue-green; end cell rounded, without calyptra (pl.3, fig.53).

Anjum 136, July 28, 1978.

Habitat: Aquatic (Prescott, 1951; Huber-Pestalozzi, 1962); terrestrial.

Local distribution: Rice field Methra, District Peshawar.

Soil depth: 4 inch.

Geographical distribution: Europe, India, North America, Pakistan.

12. Lyngbya taylorii Dr. & Strickland in Strickland, the Oscillatoriaceae of Virginia. Amer. J. Bot., 27:631. fig.1. 1940.

Prescott, p.503, pl.113, fig.3. 1951; Tiffany & Britton, p.339, pl.92, figs.1068, 1069. 1952.

Thallus free-floating or forming tufts of parallel and flexuous filaments on submerged objects; trichomes unconstricted or slightly constricted at the cross-walls,

not attenuated towards the apices, 4-7 µm in diameter; sheath thin and colourless, or thick, obscurely lamellose, coloured blue by chlor-zinc-iodide; cells quadrate, about as long as broad, or a little shorter, 2-7 µm long, cell contents granular; end cell broadly convex (pl.19, fig.240).

Anjum 215, Feb. 6, 1979.

Habitat: Aquatic, terrestrial (Prescott, 1951).

Local distribution: Sugar-cane field, Mardan.

Soil depth: 3 inch.

Geographical distribution: North America, Pakistan.

13. Lyngbya truncicola Ghose, A systematic and ecological account of a collection of blue-green algae from Lahore and Simla, J. Linn. Soc., Bot., 46. 339, pl.31, fig.6. 1924.

Desikachary, p.308, pl.51, fig.4. 1959.

Thallus thin, expanded, blue-green; filaments straight, more or less parallel; sheath at first hyaline and delicate, later becomes firm and yellowish, unlamellated; trichomes blue-green, unconstricted at the cross-walls, not attenuated, septa not granulated; cells 12-14 µm broad, 3-4 µm long, contents granular; end cell rounded, calyptra absent (pl.3, fig.54, photo 26).

Anjum 137, Aug. 7, 1978.

Habitat: Epiphytic (Rao, C.B., 1937b); terrestrial.

Local distribution: Rice field Methra, District Peshawar.

Soil depth: 3 inch.

Geographical distribution: India, Pakistan.

SYMPLOCA Kg.

Phyc. gen., 201. 1843.

Trichomes single, in a thin sheath; filaments at first prostrate, later mostly forming erect bundles, partly falsely branched; sheath firm or later gelatinizing; trichomes straight, sometimes slightly attenuated; end cell not capitate, sometimes with a thickened outer membrane.

Key to the species

1. Trichomes 2-3 µm broad..... S. cartilaginea (1)

1. Trichomes 5-8 µm broad..... S. muscorum (2)

1. Symploca cartilaginea (Mont.) Gomont, Monogr. Oscillariées, 113, pl.2, figs.13-14. 1892.

Desikachary, p.339, pl.59, figs.1,2. 1959.

Filaments arranged densely and parallel, forming bundles up to 1 cm. high, dull blue-green; trichomes 2-3 µm broad, mostly longer than broad, 3-56 µm long, unconstricted at the cross-walls, blue-green; end cell obtuse with a slightly thickened outer membrane; sheath

somewhat thick, firm, coloured violet by chlor-zinc-iodide (pl.3, fig.56).

Anjum 101, Feb. 17, 1978; Anjum 101A, March 15, 1978; Anjum 101B, March 17, 1978.

Habitat: Terrestrial (Ghose, 1927e; Dixit, 1936).

Local distribution: Sorghum fields, Peshawar.

Soil depth: 2,3 and 4 inches.

Geographical distribution: Burma, Europe, India, Pakistan.

2. Symploca muscorum (Ag.) Gomont, Monogr. Oscillariées, 110, pl.2, fig.9. 1892.

Prescott, p.504, pl.113, fig.7. 1951; Tiffany & Britton, p.356, pl.97, fig.1122. 1952; Desikachary p.337, pl.59. figs.3,4. 1959.

Filaments forming a thin prostrate or creeping thallus, rarely erect, in fascicles, blue-green or blackish; trichomes unconstricted at the cross-walls, septa not granulated; sheath thin, firm or somewhat gelatinous, coloured violet by chlor-zinc-iodide; cells 5-8 µm broad, nearly quadrate; end cell broadly rounded, with slightly thickened outer membrane (pl.18, fig.212).

Anjum 214, Feb. 6, 1979.

Habitat: Aquatic (Prescott, 1951); epiphytic (Dixit, 1936); terrestrial (Frémy, 1927; Banerji, 1938; Skuja, 1949).

Local distribution: Sugar-cane field, Mardan.

Soil depth: 1 inch.

Geographical distribution: Burma, Europe, India, North America, Pakistan.

MICROCOLEUS Desnazieres

Catal. pl. Botanagr belg., 7. 1823.

Filaments unbranched, or sparsely branched; sheath mostly colourless, more or less regularly cylindrical, not lamellated, sometimes when old, gelatinizing; trichomes many in each sheath, densely aggregated, often coiled or contorted like a rope; ends straight, mostly attenuated, end cell more or less conical, seldom capitate.

Key to the species

1. End cell pointed-conical, sheath thick..... M. chthonoplastes (1)

1. End cell rounded-conical, sheath delicate..... M. lacustris (2)

1. Microcoleus chthonoplastes Thuret ex Gomont, Monogr. Oscillariées, 353. pl.14, figs. 5-8. 1892.

Desikachary, p.343, pl.60, figs. 7-9. 1959.

= Chthonoblastus salinus Kg., Phyc. gen., 197. 1843.

= Chthonoblastus lyngbyei Kg., Phyc. gen., 197. 1843.

Filaments single, or an expanded dirty to dark green, lamellated thallus, coiled, seldom branched; trichomes constricted at the cross-walls, 2.5-6 µm broad, not granulated at the cross-walls; sheath sometimes gelatinizing, uneven, thick, not coloured violet by chlor-zinc-iodide, having many closely grouped trichomes; cells 1-3 times as long as broad, blue-green, 3.6-10 µm long; end cell not capitate, pointed-conical (pl.18, fig. 213).

Anjum 216, Feb. 7, 1979.

Habitat: Aquatic (Martens, 1870, 1871; Prain, 1905; Biswas, 1926, 1932, 1942; Banerji, 1938); terrestrial.

Local distribution: Sugar-cane field, Mardan.

Soil depth: 1 inch.

Geographical distribution: Burma, Cape Comorin, Europe, Galle, India, Pakistan, Sri Lanka.

2. Microcoleus lacustris (Rabenh.) Farlow, Alg. exsic. Am. Bor., nr. 227 bis. 1877.

Prescott, p.505, pl.113, fig.6. 1951; Tiffany & Britton, p.352, pl.96, figs.1113, 1114. 1952; Desikachary, p.345, pl.60, figs.4,5. 1959.

Thallus blackish-green; filaments contorted, seldom branched; trichomes distinctly constricted at the

cross-walls, 4-5 µm broad; sheath colourless, slimy, not coloured violet by chlor-zinc-iodide, sometimes gelatinizing, many trichomes in each; cells cylindrical, 1-3 times as long as broad, 6-12 µm long, bright blue-green; end cell more or less rounded-conical, not capitate (pl.3, fig.57).

Anjum 57, Sep. 21, 1977.

Habitat: Aquatic (Prescott, 1957); terrestrial.

Local distribution: Dry land, Peshawar.

Soil depth: 5 inch.

Geographical distribution: Burma, Europe, North America, Pakistan.

HYDROCOLEUM Kg.

Phyc. gen., 196. 1843.

Trichomes few to several in wide, lamellated, colourless sheath; sheath in older ones diffluent; filaments more or less branched, forming a tuft of membranous thallus; trichomes straight towards apices, more or less attenuated and capitate; end cell often with calyptra. One species was recorded for the genus.

1. Hydrocoleum oligotrichum A. Br., in L. Rabenh. Fl. Europaea algarum aquae dulcis et submarinae 2. 1865.

Prescott, p.504, pl.136. fig.8. 1951.

Thallus cushion-like, lime encrusted, brownish in colour; trichomes clustered in fascicles, 2-6 within a lamellated sheath, golden brown, attenuated at the apices, 3.5-8 µm in diameter; cells 2.5-5 µm long; end cell capitate (pl.4, fig.58).

Anjum 138, Aug. 12, 1978; Anjum 138A, Aug. 18, 1978.

Habitat: Aquatic (Prescott, 1951); terrestrial.

Local distribution: Dry land, Bannu; Rice field Methra, District Peshawar.

Soil depth: 2, 3 inches.

Geographical distribution: Europe, North America, Pakistan.

SCHIZOTHRIX Kg.

Phyc. gen., 230. 1843.

Trichomes many, seldom single, in large soft to firm thallus, enclosed in a thin or thick sheath, often each trichome with its own sheath; sheath colourless to yellow-brown, red or seldom violet or blue; often pointed at the ends; filaments densely packed, forming a leathery stratum; trichomes twisted, interwined, cylindric, sometimes constricted at the cross-walls, attenuated at the apices; cells cylindrical or shorter than wide.

Key to the species

1. Trichomes 3-6 µm broad..... S. friesii (1)

1. Trichomes narrower..... 2

2. Trichomes constricted at the cross-walls..... S. tinctoria (2)

2. Trichomes unconstricted at the cross-walls..... S. vaginata (3)

1. Schizothrix friesii (Ag.) Gomont, Monogr. Oscillariées, 316, pl.9, figs.1,2. 1892.

Prescott, p.507, pl.114, fig.5. 1951;

Desikachary, p.328, pl.57, figs.1,6. 1959.

Thallus blackish or greenish steel blue; filaments contorted in lower portion, rarely straight above, parallel; trichomes distinctly constricted at the cross-walls, 3-6 µm broad; sheath colourless, lamellated, pointed at the ends, coloured violet by chlor-zinc-iodide, with a single or few trichomes; cells nearly quadrate, or up to 2 times as long as broad, 4-11 µm long, blue-green; end cell obtuse-conical (pl.19, fig.241).

Anjum 219, Feb.10, 1979.

Habitat: Epiphytic (Prescott, 1951); terrestrial.

Local distribution: Sugar-cane field, Mardan.

Soil depth: 1 inch.

Geographical distribution: Europe, India, North America, Pakistan.

2. Schizothrix tinctoria Gomont, Monogr. Oscillariées,

351. 1890.

Prescott, p.508, pl.131, figs. 7,8. 1951.

Thallus blue-green, expanded, gelatinous, free-floating; filaments branched at the apices; trichomes numerous, twisted, not tapering towards the apices, 1.4-2.4 µm broad, constricted at the cross-walls; sheath diffluent, coloured violet by chlor-zinc-iodide; cells 1.4-3 µm long, blue-green; end cell bluntly rounded (pl.19, fig. 243).

Anjum 217, Feb. 9, 1979.

Habitat: Aquatic, epiphytic (Prescott, 1951); terrestrial.

Local distribution: Sugar-cane field, Mardan.

Soil depth: 1 inch.

Geographical distribution: Europe, North America, Pakistan.

3. Schizothrix vaginata (Naeg.) Gomont, Monogr. Oscillariées, 302, pl.7, figs. 1-4. 1892.

Prescott, pl.509. 1951; Desikachary, p.325, pl.58, figs.9, 10,11. 1959.

Thallusexpanded, crustaceous, warty, with or without incrustion, greyish brown or dark blackish green; filaments straight, more or less erect and parallel, or entangled, branched at the tips; trichomes not constricted at the cross-walls, septa granulated; sheath thick, sometimes lamellated, acuminate at the ends, coloured violet

by chlor-zinc-iodide, with a single or few trichomes; cells 2-3 µm broad, mostly shorter than broad, 1-2 µm long; end cell rounded (pl.19, fig.242).

Anjum 218, Feb.9, 1979; Anjum 218A, Feb.12, 1979; Anjum 218B, March 1, 1979.

Habitat: On rocks and entangled among colonial mucilaginuous algae (Prescott, 1951); terrestrial.

Local distribution: Sugar-cane fields, Mardan.

Soil depth: 3, 4 and 5 inches.

Geographical distribution: Europe, India, North America, Pakistan.

CYLINDROSPERMUM Kg.

Phyc. gen., 211. 1843.

Thallus mucilaginous, dull blue-green; trichomes uniformly broad, short, without sheath, but in a common, mostly very delicate and often imperceptible, mucilage of thin consistency; cells cylindrical, constricted at the cross-walls; heterocysts terminal, at both ends or at one end only, sometimes intercalary; spores single, rarely in series, next to the heterocyst on one side, much bigger than the vegetative cells.

Key to the species

1. Spores 8-9 µm long..... C. minimum (1)

1. Spores 32-40 µm long..... C. stagnale (2)

1. Cylindrospermum minimum G.S. West, Fresh water algae of Columbia, Mem. Soc. Neuchat. 5:1013-1051. 1914. Prescott, p.530, pl.122, figs.14,15. 1951; Huber-Pestalozzi, p.188. 1962.

Filaments solitary, or in small clusters, straight or curved; cells rectangular to short cylindric, 1.8-3.5 µm long; heterocysts subglobose to ellipsoidal, 2 µm in diameter, 2.5-2.7 µm long; spores subcylindric, 3.5-3.8 µm in diameter, 8-9 µm long, with a thick smooth wall (pl.4, fig.60).

Anjum 153, Oct. 20, 1978.

Habitat: Aquatic (Prescott, 1951); terrestrial.

Local distribution: Wheat field, Peshawar.

Soil depth: 2 inch.

Geographical distribution: Columbia, Europe, North America, Pakistan.

2. Cylindrospermum stagnale (Kg.) Born. et Flah., Revision des Nostocacées heterocystées, 250. 1888. Tilden, p.98, fig.45A. 1937; Prescott, p.531, pl.122, figs.17,18. 1951; Desikachary, p.363, pl.65, fig.9. 1959; Huber-Pestalozzi, p.189, fig.87. 1962.

= Anabaena stagnalis Kg., Phyc. gen., 210. 1843.

= Cylindrospermum macrospermum Kg., Phyc. gen., 173. 1845.

Thallus floccose, expanded, attached or free-floating, blue-green; trichomes 3.8-4.5 µm broad, constricted at the cross-walls; cells nearly quadrate, or cylindrical, often 3-4 times as long; heterocysts sub-spherical or oblong, 6-7 µm broad, 7-16 µm long; spores cylindrical with rounded ends, 12-16 µm broad, 32-40 µm long, with smooth yellowish brown outer layer (pl.4, fig.59).

Anjum 29, April 30, 1977.

Habitat: Cosmopolitan.

Local distribution: Garden soil, Peshawar.

Soil depth: 5 inch.

Geographical distribution: World wide.

NOSTOC Vaucher

Histoire des Confervees d'eau douce, 203. 1803.

Thallus mucilaginous, gelatinous or coriaceous, first globose to oblong, later globose, foliose, filiform, bullose, solid or hollow, free or attached, the periphery dense and dark coloured; filaments flexuous, curved or entangled; sheath sometimes distinct, generally diffluent, trichomes torulose; cells depressed, spherical, barrel-shaped or cylindrical; heterocysts intercalary, in young conditions terminal; spores spherical, or oblong, formed centrifugally in series in between the heterocysts.

Key to the species

1. Thallus without a firm outer mucilage, more or less soft and shapless..... 2

1. Thallus with a firm outer mucilage..... 9

2. Trichomes very densely coiled.. N. punctiforme (11)

2. Trichomes loosely coiled..... 3

3. Cells 2.5 µm broad..... N. calcicola (1)

3. Cells broader..... 4

4. Sheath broad..... N. paludosum (9)

4. Sheath thin..... 5

5. Trichomes loosely entangled..... 6

5. Trichomes densely entangled..... 8

6. Cells twice as long as broad... 7

6. Cells nearly quadrate..... N. comminutum (4)

7. Heterocysts 4.5-6 µm broad, spores round..... N. piscinale (10)

7. Heterocysts 6 µm broad, spores oval..... N. carneum (2)

7. Heterocysts 7-8 µm broad, spores oblong..... N. spongiaeforme (5)

7. Heterocysts 6-7 µm broad, spores ellipsoid or oblong-cylindric.... N. ellipsosporum (5)

8. Trichomes 3.7-6 µm broad cells spherical, ellipsoidal..... N. hatei (6)

8. Trichomes 3.5-4 µm broad, cells short barrel-shaped..... N. linckia (7)

9. Trichomes 3-3.5 µm broad..... N. verrucosum (14)

9. Trichomes broader..... 10

10. Trichomes loosely entangled.... N. microscopicum (8)

10. Trichomes densely entangled.... 11

11. Sheath distinctly lamellated..... N. commune (3)

11. Sheath unlamellated..... N. sphaericum (12)

1. Nostoc calcicola Bréb. ex Born. et Flah., Revision des Nostocacées heterocystées, 202. 1888.
Desikachary, p.384, pl.68, fig.1. 1959; Kantz & Bold, p.32, figs.6,30. 1969.
= Stratonostoc linckia (Roth) Elenkin, p.595. 1938.

Thallus mucilaginous, slightly diffluent, expanded, olive, grey or blue-green; filaments loosely entangled; sheath mostly indistinct, or distinct only at the periphery of the thallus, colourless or yellowish brown; trichomes 2.5 µm broad, pale blue-green; cells barrel-shaped, subspherical, rarely longer than broad; heterocysts subspherical, 4-5 µm broad; spores subspherical, 4-5 µm broad, with smooth yellowish membrane (pl.5, fig. 71).

Anjum 139, Aug.20, 1978; Anjum 139A, Aug. 29, 1978.

Habitat: Terrestrial (Gonzalves & Gangla, 1949).

Local distribution: Rice fields Methra, District Peshawar.

Soil depth: 1, 2 inches.

Geographical distribution: Europe, India, North America, Pakistan.

2. Nostoc carneum Ag. ex Born. et Flah., Rev. des Nostocacées heterocystées, 196. 1888. Prescott, p.522, pl.119, fig.9. 1951; Tiffany & Britton, p.366, pl.101, fig.1154. 1952; Desikachary, p.381, pl.69, fig.6. 1959; Huber-Pestalozzi, p.196, fig.95. 1962.

= Nostoc purpurascens Kg., Phyc. gen., 208. 1843.

Thallus at first globose, later bulbose-tuberculate, leathery, irregularly expanded, gelatinous, flesh-coloured, reddish-brown, violet, rose, or blue to olive-green; filaments loosely contorted, flexuous; sheath indistinct, colourless; trichomes 3-4 µm broad; cells oblong cylindrical, up to twice as long as broad; heterocysts oblong, 6 µm broad; spores oval to ellipsoidal, 6 µm broad, 5-10 µm long, epispore smooth, hyaline (pl.5, fig.70, photo 27).

Anjum 115, April 26, 1978.

Habitat: Aquatic (Zeller, 1873; Prescott, 1951); terrestrial.

Local distribution: Dry hill, Kohat.

Soil depth: 4 inch.

Geographical distribution: Europe, India, North America, Pakistan.

3. Nostoc commune Vaucher ex Born. et Flah., Rev. des Nostocacées heterocystées, 203. 1888. Prescott, p.523, pl.119, fig.13. 1951; Smith, p.288, fig.1688. 1955; Desikachary, p.387, pl.68, fig.3. 1959; Fritsch, p.805, fig.305 L-M. 1959; Kantz & Bold, p.33, figs.7,31. 1969. = Nostoc kurzianum Zeller, Algae collected in Arracan etc., J. Asiatic Soc., Bengal, 42:179. 1873; Hedwigia, 12:171. 1873.

Thallus firm, gelatinous, at first globose, later flattened, expanding, undulated, membranous or leathery, sometimes irregularly torn, often perforated, many centimeters diameter; blue-green, olivaceous or brown; filaments flexuous, densely entangled; sheath mostly distinct only at the periphery, thick, yellowish brown, often lamellated, inside the thallus more or less distinct, but hyaline; trichomes 4.5-6 µm broad, cells short barrel-shaped, or nearly spherical, mostly shorter or little longer than broad, 5 µm long; heterocysts nearly spherical about 7 µm broad; spores not observed (pl4, fig.67, photo 28).

Anjum 119, May 19, 1978.

Habitat: Aquatic (Prescott, 1951); terrestrial (Banerji, 1935, 1938).

Local distribution: Rice field Methra, District Peshawar.

Soil depth: 4 inch.

Geographical distribution: Burma, Europe, India, North America, Pakistan.

4. Nostoc comminutum Kg., Tab. Phyc., 2:3. 1849-1869.

Prescott, p.522, pl.119, fig.12. 1951.

Thallus irregularly lobed, membranous, golden-brown; sheath delicate; trichomes twisted, somewhat entangled; cells globose or compressed-globose, 3.7-4 µm in diameter, 3-4 µm long; heterocysts spherical, 6 µm in diameter; spores unknown (pl.18, fig.207).

Anjum 220, Feb. 12, 1979.

Habitat: Aquatic (Prescott, 1951); terrestrial.

Local distribution: Sugar-cane field, Mardan.

Soil depth: 1 inch.

Geographical distribution: Europe, North America, Pakistan.

5. Nostoc ellipsosporum Rabenh. ex Born. et Flah., Rev. des Nostocacées heterocystées, 198. 1888.

Prescott, p.523. 1951; Tiffany & Britton, p.364, pl.100, fig.1148. 1952.

Thallus irregularly globular, reddish-brown;

gelatinous,expanded; trichomes flexuous, loosely entangled; cells cylindric or sub-cylindric, 4 µm in diameter, 6-14 µm long, pale blue-green or olive-green; heterocysts more or less spherical or oblong, 6-7 µm in diameter, 6-14 µm long; spores ellipsoid or oblong-cylindric, 6-8 um in diameter; 14-19 um long, with smooth transparent or yellowish wall. (pl.18, fig.205).

Anjum 222, Feb. 15, 1979.

Habitat: Aquatic (Zeller, 1873; Rao, C.B., 1938; Prescott, 1951); terrestrial (Singh, R.N., 1939).

Local distribution: Sugar-cane field, Mardan.

Soil depth: 3 inch.

Geographical distribution: Burma, Europe, India, North America, Pakistan.

6. Nostoc hatei Dixit. The Myxophyceae of the Bombay Presidency-I, Proc. Indian Acad. Sci., B,3:101, fig.30. 1936.

Desikachary, p.389, pl.67, fig.2, 1959.

Thallus spherical, at first attached, later free-floating; trichomes 3.7-6 µm broad, irregularly curved, densely entangled; cells spherical or ellipsoidal; heterocysts single or in short chains of 2-5, almost spherical, rarely slightly barrel-shaped, sometimes flattened, 3.6-5 µm broad, 5 µm long, sporeshot observed (pl.4, fig.68).

Anjum 94, Jan. 30, 1978.

Habitat: Epiphytic (Dixit, 1936); terrestrial.

Local distribution: Dry hill, Kohat.

Soil depth: 1 inch.

Geographical distribution: India, Pakistan.

7. Nostoc linckia (Roth) Born. et Flah., Rev. des Nostocacées heterocystées, 192. 1888. Prescott, p.523, pl.119, figs.14-16. 1951; Desikachary, p.377, pl.69, fig.4. 1959; Fritsch, p.834, fig.321 A,F. 1959; Huber-Pestalozzi, p.196, fig.93. 1962; Kantz & Bold, p.34, figs.11,35. 1969.

Thallus varying in shape, punctiforme or tuberculate, at first spherical, latter irregularly expanding, torn, gelatinous, blue-green to violet or blackish-green to brown; filaments densely entangled, flexuous or highly coiled; sheath diffluent, hyaline inside, distinct only at the periphery; trichomes 3.5-4 µm broad, pale blue-green; cells short barrel-shaped; heterocysts subspherical, 5-6 µm broad; spores subspherical, 6-7 µm long, epispore smooth (pl.4, fig.63).

Anjum 33, May. 24, 1977.

Habitat: Aquatic (Prescott, 1951; Huber-Pestalozzi, 1962); epiphytic (Gupta, 1956); terrestrial (Gonzalves & Gangla, 1949; Skuja, 1949).

Local distribution: Pine forest, Parachinar.

Soil depth: 2 inch.

Geographical distribution: Burma, Europe, India, North America, Pakistan.

8. Nostoc microscopicum Carm. ex Born. et Flah., Rev. des Nostocacées heterocystées, 210. 1888. Prescott, p.523, pl.120, fig .5. 1951; Desikachary, p.387. 1959.

Thallus spherical or ellipsoidal, soft, with firm outer surface, small, rarely large, blue-green or olive-green; filaments loosely entangled; sheath more or less distinct, yellowish; trichomes 5-8 µm broad, blue-green or olive-green; cells subspherical or barrel shaped; heterocysts nearly spherical, 7 µm broad; spores oval, 6-7 µm broad, 9-15 µm long, olivaceous, epispore smooth (pl.18, fig.206, photo 29).

Anjum 221, Feb. 12, 1979; Anjum 221A, Feb. 20, 1979.

Habitat: Aquatic (Prescott, 1951); epiphytic (Ghose, 1927a,c,d; Skuja 1949); terrestrial (Frémy, 1942).

Local distribution: Sugar-cane fields, Mardan.

Soil depth: 5, 6 inches.

Geographical distribution: Burma, Europe, India, North America, Pakistan, Sri Lanka.

9. Nostoc paludosum Kg. ex Born. et Flah., Rev. des Nostocacees heterocystees, 191. 1888. Prescott, p.524, pl.121, figs. 1-3. 1951; Desikachary, p.375, pl.69, fig.2. 1959; Huber-Pestalozzi, p.196, fig.92. 1962.

Thallus minute, punctiforme, gelatinous; sheath broad, hyaline, or yellowish-brown, trichomes 3-3.5 µm broad; cells as long as broad, barrel-shaped, pale blue-green; heterocysts broader than vegetative cells; spores oval, 4-4.5 µm broad, 6-8 µm long, with smooth colourless membrane (pl.4, fig.62, photo 30).
Anjum 21, March 20, 1977.
Habitat: Aquatic (Prescott, 1951; Huber-Pestalozzi, 1962); terrestrial (Mitra, 1951).
Local distribution: Dry land, Peshawar.
Soil depth: 1 inch.
Geographical distribution: Europe, India, North America, Pakistan.

10. Nostoc piscinale Kg. ex Born. et Flah., Rev. des Nostocacees heterocystees, 194. 1888. Desikachary, p.378, pl.69, fig.3. 1959; Huber-Pestalozzi, p.196, fig.94. 1962; Kantz & Bold; p.32, fig.6,30. 1969.
= Nostoc linckia Roth (= Stratonostoc linckia (Roth) Elenk. 595. 1938).

Thallus at first spherical, but later bulbose, or variously tuberculate, mucilaginous, or gelatinous, light blue-green, or olive-green to brown; filaments flexuous, loosely entangled; sheath distinct at the periphery of the thallus, brownish, diffluent in the inner portions of the thallus, hyaline; trichomes 3-7 µm broad, up to nearly twice as long as broad; heterocysts subspherical or oblong, 4.5-6 µm broad; spores globose, 6-7 µm broad, in long chains, epispore smooth (pl.4, fig.64, photo 31,32).

Anjum 65, Oct. 16, 1977.

Habitat: Aquatic (Gupta, 1956; Huber-Pestalozzi, 1962); terrestrial (Beck & Zahlbruchner, 1897).

Local distribution: Garden soil, Peshawar.

Soil depth: 5 inch.

Geographical distribution: Europe, India, Pakistan.

11. Nostoc punctiforme (Kg.) Hariot, f. de Bot., 5:31. 1891.

Prescott, p.525, pl.121, figs.4-5. 1951. Desikachary, p.374, pl.69, fig.1. 1959; Fritsch, p.805, fig.308C-F,Q. 1959; Kantz & Bold, p.36, figs.16,40. 1969.

= Nostoc hederulae Menegh. in Kg., Sp. Alg., 287. 1849.

Thallus subglobose, scattered or confluent, attached; filaments flexuous, densely entangled; sheath delicate, hyaline, mucous; trichomes 3-4 µm broad; cells short barrel-shaped or ellipsoidal, blue-green; heterocysts 4-6.5 µm broad, spores subspherical, or oblong, 5-6 µm broad, 5-8 µm long, epispore smooth and thick (pl.4, fig.61, photo 33).

Anjum 22, March 24, 1977; Anjum 22A, Nov. 6, 1977; Anjum 22B, Dec. 9, 1977; Anjum 22C, Dec. 16, 1977; Anjum 22D, Sep. 3, 1978; Anjum 22E, Sep. 9, 1978.

Habitat: Aquatic, epiphytic on submerged objects, endophytic (Prescott, 1951); terrestrial.

Local distribution: Dry lands, Peshawar; Maize fields, Mardan.

Soil depth: 1, 2, 3, 4, 5, and 6 inches.

Geographical distribution: Europe, India, North America, Pakistan.

12. Nostoc sphaericum Vaucher ex Born. et Flah., Rev. des Nostocacées heterocystées, 208. 1888.

Prescott, p.525, pl.121, figs. 6-9. 1951;

Desikachary, p.390. 1959.

= Stratonostoc commune (Vaucher) Elenkin. 1938.

Thallus free, globose at first, later irregularly delicate-tuberculate, thick, olive-green, yellow

or violet-brown, with firm outer layer; filaments flexuous, densely entangled; trichomes 4, rarely 5 µm broad; cells compressed, spherical or barrel-shaped; heterocysts 4-6 µm broad, subspherical;spores oval, 5-6 µm broad, 7-8 µm long, epispore thick, & brownish (pl.4, fig.65).

Anjum 66, Oct. 20, 1977.

Habitat: Terrestrial (Biswas, 1925; Banerji, 1938; Frémy, 1942; Mitra, 1951; Prescott, 1951).

Local distribution: Dry land, Dera Ismail Khan.

Soil depth: 5 inch.

Geographical distribution: Europe, India, North America, Pakistan.

13. Nostoc spongiaeforme Ag. ex Born.et Flah,, Rev. des Nostocacées heterocystées, 197. 1888.

Prescott, p.525, pl.121, fig.10. 1951; Tiffany & Britton, p.366, pl.100, fig.1150. 1952; Desikachary, p.380. 1959; Huber-Pestalozzi, p.197, fig.96. 1962; Kantz & Bold, p.36, figs.17,41. 1969.

= Nostoc linckia f. spongiaeforme (Ag.) Elenkin, (= Stratonostoc linckia (Roth) Elenkin, p.595. 1938).

Thallus at first globose, gelatinous, later expanding, verrucose, bullose, light blue-green, violet

or brownish; filaments flexuous, loosely entangled; sheath diffluent inside, more or less distinct along the periphery, yellowish-brown; trichomes about 4 µm broad, blue-green to violet; cells partly cylindrical and up to 7 µm long, partly short barrel-shaped; heterocysts subspherical or oblong, 7-8 µm broad, somewhat longer than broad; spores oblong, 6-7 µm broad, 10-12 µm long, epispore smooth, at first colourless, later yellowish (pl.4, fig.66).

Anjum 52, Aug. 30, 1977.

Habitat: Aquatic (Rao, C.S., 1939; Frémy, 1942; Skuja, 1949; Prescott, 1951; Huber-Pestalozzi, 1962); terrestrial.

Local distribution: Dry land, Dera Ismail Khan.

Soil depth: 4 inch.

Geographical distribution: Burma, Europe, India, North America, Pakistan.

14. Nostoc verrucosum Vaucher ex Born. et Flah., Rev. des Nostocacées heterocystées, 216. 1888.
Prescott, p.526, pl.121, figs.11-13. 1951; Tiffany & Britton, p.366, pl.101, fig.1155. 1952; Desikachary, p.388, pl.70, fig.1. 1959; Huber-Pestalozzi, p.197, fig.98. 1962; Kantz & Bold, p.37, figs.18,42. 1969.
= Stratonostoc verrucosum (Vauch.) Elenkin. 1938.

Thallus at first spherical or subspherical, solid, gelatinous, firm, surface undulate, or verrucose; later hollow, vesicular, soft, torn, blackish-green or olive-green, or brownish-green; filaments flexuous and densely entangled at the periphery; sheath thick, yellowish brown in the peripheral layers, inner ones hyaline, and diffluent; trichomes 3-3.5 µm broad; cells short barrel-shaped, shorter than broad; heterocysts 8 µm broad, subspherical; spores oval, 5 µm broad, 7 µm long; epispore smooth, yellowish (pl.4, fig.69).

Anjum 116, April 29, 1978.

Habitat: Aquatic (Prescott, 1951; Huber-Pestalozzi, 1962); terrestrial (Singh, V.P., 1941).

Local distribution: Dry hill, Kohat.

Soil depth: 3 inch.

Geographical distribution: Europe, India, North America, Pakistan.

ANABAENA Bory.

Dict. class. d'hist. nat., 1:307. 1822.

Trichomes uniformly broad or sometimes slightly attenuated towards the apices, straight, flexuous or spirally coiled; sheath absent or more or less diffluent, forming a free, torn or floccose or soft mucilaginous thallus; cells torulose, barrel-shaped or cylindrical; heterocysts numerous, intercalary, spherical, ovate or

cylindrical; spores single or in long chains, either adjacent to or remote from the heterocysts, rounded, ovate.

Key to the species

1. Trichomes spirally coiled..... 2
1. Otherwise..... 3

2. Spores in chains..... A. gelatinicola (7)
2. Spores single..... A. spiroides (11)

3. Trichomes circinate..... A. circinalis (4)
3. Trichomes straight..... 4

4. Cells 2-3 µm broad..... 5
4. Cells broader.....6

5. Heterocysts terminal and intercalary..... A. oryzae (9)
5. Heterocysts intercalary..... A. anomala (1)

6. Cells with gas-vacuoles..... 7
6. Cells without gas-vacuoles..... 8

7. Spores adjacent with the heterocyst..... A. aphanizomenoides (2)
7. Spores away from the heterocyst... A. variabilis (13)

8. End cell conical..... A. orientalis(8)
8. End cell rounded..... 9

9. Spores 54-58 µm long..... A. subcylindrica (12)
9. Spores shorter..... 10

10. Heterocysts 8-12 µm broad... A. spheerica (10)

10. Heterocysts narrower..... 11

11. Spores 25-50 µm long..... A. augstumalis (3)

11. Spores shorter..... 12

12. Spores in long chains..... A. fertilissima (6)

12. Spores not in chain..... A. cylindrica (5)

1. Anabaena anomala Fritsch, The genus Anabaena etc., J. Indian bot. Soc., 28:146, figs.60-73. 1949. Desikachary, p.398, pl.73, fig.2. 1959. = Anabaena thermalis Vouk var. indica Fritsch, ex De, Proc. Roy. Soc., Lond., B, 127:125. 1939.

Thallus thin, gelatinous, blue-green; trichomes commonly densely or irregularly aggregated, more or less contorted, moniliform, apical cell rounded, or subconical, apex obtuse; cells generally 2-3 µm broad, as long as broad, spherical or barrel-shaped, sometimes up to 1½ times as long as broad, about 3.5 µm in diameter; heterocysts rare, commonly single, intercalary, spherical, 3.5-5.5 µm broad, commonly isolated; exospore solid, endospore thin (pl.5, fig.75). Anjum 150, Oct. 5, 1978.

Habitat: Terrestrial (De, 1939; Fritsch, 1949).

Local distribution: Rice field Methra, District Peshawar.

Soil depth: 1 inch.

Geographical distribution: India, Pakistan.

2. Anabaena aphanizomenoides Forti, Atti Mem. ac. d'agric. Sc. lett. arti e Comm. Verona, ser. 4,12:126, fig.2. 1912.

Desikachary, p.405, pl.71, fig.4. 1959; Huber-Pestalozzi, p.204, fig.108. 1962.

Trichomes single, straight or slightly bent, 1-2 mm long, 4-5 µm broad, slightly constricted at the cross-walls; cells barrel-shaped, cylindrical, 1-3 times as long as broad, with gas-vacuoles; heterocysts sub-spherical or ellipsoidal, 5.5-7 µm broad, 6-7.5 µm long; spores single or few near the heterocysts, spherical, 8-14 µm broad, with smooth colourless wall (pl.5, fig.77, photo 34, 35).

Anjum 120, May 24, 1978.

Habitat: Terrestrial.

Local distribution: Dry land, Dera Ismail Khan.

Soil depth: 1 inch.

Geographical distribution: Europe, India, Pakistan.

3. Anabaena augstumalis Schmidle, Einige Algen aus preussischen Hochmooren. Hedwigia, 38:174. 1899.

Prescott, p.513, 1951; Huber-Pestalozzi, p.217, fig. 144. 1962.

Trichomes often more or less bent; sheath diffluent; cells cylindrical or squarish, without gas-

vacuoles, 4 µm broad, 1-1½ times as long as broad; heterocysts cylindrical, 6 µm broad; spores away from the heterocyst, 6 µm broad, 25-50 µm long (pl.6, fig.82). Anjum 95, Feb. 2, 1978.

Habitat: Aquatic (Prescott, 1951); terrestrial.

Local distribution: Dry hill, Kohat.

Soil depth: 2 inch.

Geographical distribution: Africa, Europe, North America, Pakistan.

4. Anabaena circinalis Rabenh. ex Born. et Flah., Rev. des Nostocacées heterocystées, 230. 1888. Prescott, p.514, pl.116, figs.1-2. 1951; Tiffany & Britton, p.357, pl.98, figs.1129,1130. 1952; Desikachary, p.414. 1959; Huber-Pestalozzi, p.214, fig.135. 1962.

= Anabaena circinalis (Kg.) Hansg., Oest. bot. Zeitschr., 34:390, pl.1, figs.12-14. 1884.

= Anabaena flos-aquae var. circinalis Kirchn., Kryptogamenflora von Schlesien, 2(1):235. 1878.

Thallus floating, frothy; trichomes mostly circinate, seldom straight; sheath absent; cells barrel-shaped or spherical, somewhat shorter than broad, with gas-vacuoles, 8-14 µm broad; heterocysts subspherical, 8-10 µm broad; spores cylindrical, sometimes curved, ends

rounded, 16-18 µm broad, 22-34 µm long, away from the heterocyst; epispore smooth and colourless (pl.6, fig.80, photo 36).

In the present study, epispores have not been observed.

Anjum 26, April 19, 1977.

Habitat: Aquatic (Biswas, 1927c; Prescott, 1951; Huber-Pestalozzi, 1962); terrestrial.

Local distribution: Rice field Methra, District Peshawar.

Soil depth: 5 inch.

Geographical distribution: Europe, India, North America, Pakistan.

5. Anabaena cylindrica Lemm. (vide, Huber-Pestalozzi, 1962). Huber-Pestalozzi, p.209, fig.121. 1962; Kantz & Bold, p.38, figs.22,46. 1969.

Cells cylindrical or barrel-shaped, 4-6 µm broad, 3-8 µm long; heterocysts cylindric, spherical or ellipsoidal, 4-8 µm in diameter, 6-8 µm long; spores cylindric, spherical or ellipsoidal, 5-7 µm broad, 8-20 µm long (pl.6, fig. 83).

Anjum 36, June 4, 1977.

Habitat: Aquatic (Huber-Pestalozzi, 1962); terrestrial.

Local distribution: Sorghum field, Peshawar.

Soil depth: 4 inch.

Geographical distribution: Europe, North America, Pakistan.

Thallus thick, gelatinous; trichomes mostly solitary, spiral densely arranged, coiled, not screw-like, rarely straight; cells subspherical, 6-7.5 µm broad, apex acute; heterocysts spherical, 7-8 µm in diameter; spores in chain, away from the heterocyst, spherical, 14 µm in diameter (pl.18, fig.208).

Anjum 223, Feb.16, 1979; Anjum 223A, Feb. 19, 1979.

Habitat: Terrestrial.

Local distribution: Sugar-cane fields, Mardan.

Soil depth: 1, 3 inches.

Geographical distribution: India, Pakistan.

8. Anabaena orientalis Dixit, The Myxophyceae of the Bombay Presidency, I, Proc. Indian Acad., Sci., B, p.3:101, fig.3D. 1936.
Desikachary, p.405, pl.77, fig.6. 1959.

Trichomes solitary, straight or slightly curved, 2.5-4 µm broad; cells quadrate or cylindrical, rarely slightly barrel-shaped, up to 2-3 times as long as broad, 3.7-4.8 µm long; end cell conical with rounded apex; heterocysts single, intercalary, cylindrical or slightly ellipsoidal, with rounded end walls, 4.8-5.5 µm broad, 7.4-9.2 µm long; spores one on each side of a heterocyst, ellipsoidal, 7.4-9.2 µm broad, 14.8-16.6 µm long (pl.5, fig.78).

Anjum 38, June 16, 1977; Anjum 38A, Sep. 29. 1977; Anjum 38B, Sep. 4. 1978.

Habitat: Aquatic (Dixit, 1936; Gonzalves, 1947); terrestrial.

Local distribution: Dry lands, Dera Ismail Khan and Kohat; Pine forest, Parachinar.

Soil depth: 1,2 and 3 inches.

Geographical distribution: India, Pakistan.

9. Anabaena oryzae Fritsch, The genus Anabaena, J. Indian bot. Soc., 28:135, figs.1-16. 1949.

Desikachary, p.396, pl.72, fig.3. 1959.

= Anabaena gelatinosa Fritsch ex De. 1939.

Thallus soft, green, gelatinous, membranous; t trichomes short, straight, densely aggregated generally parallel; cells 2.5-3 µm broad, more or less barrel-shaped, 1½-2 times as long as broad; heterocysts terminal and intercalary, broader than the vegetative cells, 3-3.5 µm broad, terminal ones conical, and twice longer than broad, intercalary ones single, or 2-3 in series, generally barrel-shaped, sometimes spherical, single; spores rarely single, next to the terminal heterocyst, commonly away from the intercalary heterocyst, single or 2-7 in series, subspherical or short ellipsoidal, 5-6.5 µm in diameter, 5-7 µm long, exospore yellowish brown (pl.5, fig.7).

Anjum 25, April 10, 1977; Anjum 25A, May 8, 1978; Anjum 25B, May 12, 1978; Anjum 25C, June 1, 1978; Anjum 25D, June 5, 1978; Anjum 25E, June 10, 1978.

Habitat: Terrestrial (Fritsch, 1949).

Local distribution: Dry lands, Peshawar, Bannu and Dera Ismail Khan; Dry hills, Kohat, Abbottabad; Maize field, Mardan.

Soil depth: 1, 2, 3, 4, 5 and 6 inches.

Geographical distribution: India, Pakistan.

10. Anabaena sphaerica Born. et Flah., Rev. des Nostocacées heterocystées, 228. 1888.

Smith, p.287, fig.166A. 1955; Desikachary, p.393. 1959; Huber-Pestalozzi, p.206. 1962.

Thallus floccose, blue-green; trichomes moniliform, straight, arranged parallel, 5-6 µm broad, with an indistinct mucilage sheath; cells spherical to short barrel-shaped; end cell rounded; heterocysts subspherical, 6-7 µm broad; spores on one or both sides of the heterocysts, subspherical to oval, 8-12 µm broad, 12-18 µm long, one to few together; epispore smooth, yellowish brown (pl.5, fig.72).

Anjum 24, April 4, 1977.

Habitat: Aquatic (Banerji, 1938; Ganapathi, 1940; Huber-Pestalozzi, 1962); terrestrial.

Local distribution: Dry land, Dera Ismail Khan.

Soil depth: 3 inch.

Geographical distribution: Europe, India, Java, North America, Pakistan.

11. Anabaena spiroides Klebahn, Flora, 80:125, pl.4, figs.11-13. 1895.

Tilden, p.96, fig.43D. 1937; Prescott, p.518. 1951; Tiffany & Britton, p.357, pl.98, fig.1133. 1952; Desikachary, p.395, pl.71, fig.9. 1959; Huber-Pestalozzi, p.208, fig.119. 1962.

Trichomes single, free-floating, regularly spirally coiled, with thick and mucilaginous sheath, spirals 45-54 µm broad and 40-50 µm distant; cells spherical, 6.5-8 µm broad, mostly shorter than broad, with gas-vacuoles; heterocysts subspherical, 7 µm broad; spores single, at first spherical, later elongate, slightly bent, next to the heterocysts or away from it, 14 µm broad (pl.5, fig.73).

Anjum 47, July 29, 1977.

Habitat: Aquatic (Crow, 1923b; Biswas, 1942; Skuja, 1949; Huber-Pestalozzi, 1962); terrestrial.

Local distribution: Dry land, Dera Ismail Khan.

Soil depth: 1 inch.

Geographical distribution: Burma, Europe, India, Pakistan, Sri Lanka.

12. Anabaena subcylindrica Borge, Die Algenflora des Takernsees; Sjoen Tokerns Fauna och Flora. Kongl. Sv. Vet.-Akad., No:4,3-48. 1921. Prescott, p.518, pl.118, figs.6-8. 1951; Huber-Pestalozzi, p.210, fig.124. 1962; Kantz & Bold, p.39, figs.26,50. 1969.

Trichomes straight, solitary or forming a thin layer, cells short cylindric, 4-4.5 µm broad, 5.5-10 µm long; heterocysts cylindrical, 5-7.5-10 µm in diameter, 15-18 µm long; spores cylindrical, 7-8.5 µm in diameter, 54-57 µm long (pl.6, fig.81, photo 37,38).

Anjum 88, Jan. 9, 1978.

Habitat: Aquatic (Prescott, 1951); terrestrial.

Local distribution: Sorghum field, Peshawar.

Soil depth: 5 inch.

Geographical distribution: Europe, North America, Pakistan.

13. Anabaena variabilis Kg., ex Born.et Flah., Rev. des Nostocacées, heterocystées, 226. 1888. Prescott, p.519, pl.118, figs.9-10. 1951; Tiffany & Britton, p.357, pl.98, fig.1132. 1952; Desikachary, p.410, pl.71, fig.5. 1959; Huber-Pestalozzi, p.295. fig.111. 1962.

= Anabaena indica Zeller, Algae collected in Arracan etc., J. Asiatic. Soc., Bengal, 42: 1873a.

Thallus gelatinous, dark green; trichomes without sheath, flexuous, 4-6 µm broad, slightly constricted at the cross-walls, end cell conical-obtuse; cells barrel-shaped, sometimes with gas-vacuoles, 2.5-6 µm long; heterocysts spherical or oval, 6 µm broad, up to 8 µm long; spores formed centrifugally, not contiguous with the heterocysts, barrel-shaped, in series, 7-9-11 µm long; epispore smooth, or with fine needles, colourless or yellowish-brown (pl.6, fig.79).

Anjum 151, Oct. 9, 1978; Anjum 151A, Oct. 15, 1978.

Habitat: Aquatic (Banerji, 1938; Biswas, 1942; Prescott, 1951; Huber-Pestalozzi, 1962); terrestrial (Ghose, 1927b).

Local distribution: Rice field & dry land, Peshawar.

Soil depth: 2, 3 inches.

Geographical distribution: Burma, Europe, India, North America, Pakistan.

AULOSIRA Kirchner

Kryptogamenflora von Schlesien, 238. 1878.

Filaments free, sparse or in bundles, uniformly broad, without differentiation of base and apex; trichomes with sheath; heterocysts intercalary; spores cylindrical, often in chains, contiguous with the heterocysts or away from it.

Key to the species

1. Filaments 6.5-8 µm broad..... A. aenigmatica (1)

1. Filaments 9.5-14.7 µm broad..... A. pseudoramosa (2)

1. Aulosira aenigmatica Frémy, Cyanophycees de l'Inde meridionale, Blumea, Suppl. 2:37, fig.11. 1942.

Desikachary, p.428, pl.81, figs.15,17. 1959.

Thallus floating, expanded, dark blue-green, filaments more or less intricate, suberect, 6.5-8 µm broad; sheath hyaline, membranous, delicate, close to the trichome; trichomes pale blue-green, 5.5-6 µm broad, somewhat constricted at the cross-walls, attenuated towards the apices; cells subquadrate, longer or shorter than broad, contents finelly granular, end cell obtuse-conical; heterocysts single or rarely in pairs, oblong to spherical, as broad as or slightly broader than the trichomes; spores barrel-shaped or compressed spherical, commonly shorter than broad, 7 µm broad, in series; epispore colourless, somewhat thick (pl.6. fig.85).

Anjum 37, June 10, 1977; Anjum 37A, Sep.28, 1977.

Habitat: Aquatic (Frémy, 1942); terrestrial.

Local distribution: Dry lands, Dera Ismail Khan.

Soil depth: 1, 2 inches.

Geographical distribution: India, Pakistan.

2. Aulosira pseudoramosa Bharadwaja, Contributions to our

knowledge of Myxophyceae of India, Ann. Bot., Lond., 47: 137, figs.7,9. 1933.

Desikachary, p.430, pl.81, figs.7-14. 1959.

Thallus flat, compact; filaments unbranched, 9.5-14.7 µm broad, irregularly bent, densely entangled; sheath thick, firm, colourless, stratified with uneven outer surface, at maturity becoming deep yellow or golden yellow; trichomes constricted at the cross-walls; cells cylindrical, rarely barrel-shaped, slightly longer than broad, sometimes quadrate or rarely shorter than broad, 6.3-10.5 µm broad, blue green; in young trichomes heterocysts are absent while in old trichomes, intercalary, occuring single, rarely in pairs or terminal, as broad as the trichomes, 6.3-10.5 µm broad, 6.3-18.9 µm long; spores not known; fragmentation (pl.6, fig.84).

Anjum 118, May 10, 1978.

Habitat: Aerial (Bharadwaja, 1933); aquatic (Skuja, 1949); terrestrial.

Local distribution: Moist land, Dera Ismail Khan.

Soil depth: 4 inch.

Geographical distribution: Burma, India, Pakistan.

NODULARIA Martens

in Juergens, Algae aquaticae, Dec., 15 nr. 4. 1822.

Filaments free; sheath hyaline, delicate, mucilaginous, diffluent; trichomes uniform in breadth at

the vegetative stage; cells short, depressed discoid; heterocysts compressed, intercalary; spores spherical, subspherical to discoid, single or in chains, between the heterocysts, epispore smooth.

Key to the species

1. Cells 4-6 µm broad..... N. harveyana (1)

1. Cells 6-10 µm broad..... N. spumigena (2)

1. Nodularia harveyana (Thw.) Thuret, Essai de class. des Nostochinées. 1:378. 1875.

Prescott, p.527. 1951.

Filaments flexuous, solitary, more or less straight; sheath delicate, hyaline, usually close but sometimes diffluent and becoming indistinct; cells 4-6 µm in diameter, 1/3 or nearly as long as broad; apical cell obtusely conical; spores spherical or some somewhat compressed, 8 µm broad, yellowish-brown in colour (pl.19, fig, 245).

Anjum 224, Feb. 16, 1979.

Habitat: Aquatic (Prescott, 1951); terrestrial.

Local distribution: Sugar-cane field, Mardan.

Soil depth: 6 inch.

Geographical distribution: Europe, North America, Pakistan.

2. Nodularia spumigena Martens ex Born. et Flah., Rev. des Nostocacées heterocystées, 245. 1888.

Prescott, p.527, pl.122, figs.3-5. 1951;
Desikachary, p.423, pl.80, figs.13,14. 1959.

Filaments usually in bundles, entangled in a loose, gelatinous mass, rarely solitary, 8-12 µm broad, straight, bent or spirally coiled; sheath thin or thick, hyaline; cells disc-shaped, compressed, constricted at the cross-walls, 6-7.8-10 µm in diameter, 5.6 µm long; heterocysts somewhat broader than the vegetative cells; spores in series, seldom one to few, subspherical, intercalary, not necessarily near the heterocysts, 12 µm in diameter, 8-9 µm long; epispore yellowish-brown (pl.18, fig.215).

Anjum 225, Feb. 18, 1979.

Habitat: Aquatic (Bharadwaja, 1935; Randhawa, 1936; Prescott, 1951); terrestrial.

Local distribution: Sugar-cane field, Mardan.

Soil depth: 5 inch.

Geographical distribution: Europe, India, North America, Pakistan.

PLECTONEMA Thuret

Essai class Nostocacées, Ann. Sci. nat. Bot., Ser. 6, 1:375. 1875.

Trichomes variously bent, with a thin, firm sheath; false branching; branches single or in pairs; heterocysts absent; homogones present; spores unknown.

Key to the species

1. Cross-walls not granulated..... P. nostocorum (1)

1. Cross-walls granulated..... P. notatum (2)

1. Plectonema nostocorum Bornet ex Gomont, Monogr. Oscillariées, 102, pl.1, fig.11. 1892.

Prescott, p.539, pl.126, figs.4,5. 1951; Tiffany & Britton, p.368, pl.102, fig.1157. 1952; Desikachary, p.439, pl.83, fig.7. 1959.

Filaments nearly straight or flexuous; false branches sparse, single or geminate; sheath thin, hyaline, not coloured by chlor-zinc-iodide; cells cylindrical, sometimes constricted at the cross-walls, septa not granulated, 1-1.5 µm broad, 2-2.5 µm long, pale blue-green; end cell rounded (pl.19, fig.235).

Anjum 227, Feb. 20, 1979.

Habitat: Aquatic (Prescott, 1951); terrestrial (Gonzalves & Gangla, 1949).

Local distribution: Sugar-cane field, Mardan.

Soil depth: 1 inch.

Geographical distribution: Europe, India, North America, Pakistan.

2. Plectonema notatum Schmidle, in Simmer's IV, Ber, ueber d' Kryptogamenflora V. Kreuzecker, Allg. bot. Zeitschr., n. 3/4; 84, figs.8,9. 1901.

Prescott, p.540, pl.126, figs.6,7. 1951;
Desikachary, p.440, pl.83, fig.5. 1959.

Filaments variously bent, 1.7-2 µm broad, free-floating or forming a distinct thallus; false branching sparse, single or geminate; sheath thin, colourless; cells cylindrical, 1.2-2 µm broad, 2-3 times as long as broad, with two granules at the cross-walls, not constricted, pale blue-green; end cell rounded (pl.6, fig.86).
Anjum 75, Nov. 15, 1977; Anjum 75A, Nov.22, 1977.
Habitat: Epiphytic (Prescott, 1951); terrestrial.
Local distribution: Dry lands, Dera Ismail Khan.
Soil depth: 5, 6 inches.
Geographical distribution: Europe, North America, Pakistan.

SCYTONEMA Ag.

Syst. Alg., 26. 1824.

Filaments false-branched; false branches single or in pairs, formed laterally in between heterocysts; trichomes single in each sheath, straight; hormogones terminal, solitary; pseudo-hormogonia present; spores spherical or ovate, exospore thin and smooth.

Key to the species

1. Filaments 7-12 µm broad..... S. hofmanni (1)
1. Filaments 12-15 µm broad..... S. javanicum (2)
1. Filaments 15-21 µm broad..... S. millei (3)

1. Scytonema hofmanni Ag. ex Born. et Flah., Rev. des Nostocacées heterocystées 97. 1887.

Desikachary, p.476, pl.91, fig.2. 1959.

= Scytonema kurzianum Zeller, J. Asiatic Soc. Bengal, 42(2):182. 1873.

Thallus cushion-like, broadly expanded, blackish-blue-green, sometimes impregnated with calcium carbonate; filaments 7-12 µm broad, rarely up to 15 µm broad, in bundles, false branched; sheath firm, membranous; trichomes 5-10 µm broad, olive to blue-green; cells unequal in length; heterocysts oblong (pl.7, fig.88).

Anjum 168, Nov. 29, 1978.

Habitat: Aquatic (Biswas, 1924); epiphytic (Skuja, 1949); terrestrial (Gonzalves & Gangla, 1949; Mitra, 1951; Gupta, 1953).

Local distribution: Dry hill, Kohat.

Soil depth: 4 inch.

Geographical distribution: Barkuda, Burma, Europe, India, Pakistan.

2. Scytonema javanicum (Kg.) Bornet ex Born. et Flah., Rev. des Nostocacées heterocystées, 95. 1887.

Tilden, p.75, figs.25A-C. 1937; Desikachary, p.461, pl.100, fig.4. 1959.

Thallus cushion-like, deep blue-green to reddish;

filaments 12-15 µm broad, in erect fascicles; false branches long, flexuous, aggregated; sheath firm, thin, hyaline or becoming yellowish; trichomes 9-12 µm broad; cells compressed to quadrate; heterocysts subquadrate (pl7, fig.89).

Anjum 169, Nov. 29, 1978.

Habitat: Aquatic and terrestrial (Ghose, 1927e; Rao, C.B., 1937b; Frémy, 1942).

Local distribution: Dry land, Dera Ismail Khan.

Soil depth: 2 inch.

Geographical distribution: Africa, Burma, Europe, India, Indonesia, Pakistan.

3. Scytonema millei Bornet ex Born. et Flah., Rev. des Nostocacées heterocystées, 93. 1887.

Desikachary, p.460, pl.93, figs.2-3. 1959.

Thallus wooly, cushion-like, broadly expanded, dull-green or brownish; filaments 15-21 µm broad, interwoven; false branches erect; sheath firm, brownish, when old with parallel lamellations; cells 10-15 µm broad, discoid, when old becoming elongated up to as long as broad; heterocysts mostly discoid, somewhat broader than the trichomes (pl.7, fig.87).

Anjum 167, Nov. 25, 1978.

Habitat: Terrestrial.

Local distribution: Dry land, Dera Ismail Khan.

Soil depth: 5 inch.

Geographical distribution: Europe, Pakistan.

TOLYPOTHRIX Kg.

Phyc. gen., 227. 1843.

Filaments with a firm, thin or thick sheath; with a single trichome in each sheath, false-branched, mostly free, prostrate or erect; false branches single, mostly subtending a heterocyst, occasionally geminate as in Scytenema; hormogonia formed from the tips; trichome with apical growth, apices often broader with shorter cells.

Key to the species

1. Sheath lamellated..... T. tenuis (3)

1. Sheath unlamellated..... 2

2. Trichomes 9-12 µm broad..... T. distorta (1)

2. Trichomes 4-5.5 µm broad..... T. fragilis (2)

1. Tolypothrix distorta Kg. ex Born. et Flah., Rev. des Nostocacées heterocystées, 119. 1887.
Prescott, p.537, pl.125, figs.5,6. 1951;
Desikachary, p.495, pl.102, fig.1. 1959;
Fritsch, p.805, figs.308, N-P. 1959.

Thallus expanded, cushion-like, blue-green to brownish, sometimes calcium incrusted; filaments highly false-branched, 10-15 µm broad; false branches mostly

deeply or sharply erect; sheath thin, close to the trichomes, at first colourless, later brownish; trichomes 9-12 µm broad; slightly torulose, blue-green; cells as long as broad or shorter than broad; heterocysts single or 2-3; nearly spherical to cylindrical (pl.7, fig.90).

Anjum 179, Dec. 23, 1978.

Habitat: Aquatic (Ghose, 1919; Parukutty, 1939; Gonzalves & Joshi, 1946; Prescott, 1951); terrestrial.

Local distribution: Dry hill, Abbottabad.

Soil depth: 4 inch.

Geographical distribution: Europe, India, North America, Pakistan.

2. Tolypothrix fragilis (Gardner) Geitler, Kryptogamenflora, 724, fig.465. 1942.
Desikachary, p.500, pl.103, fig.1. 1959.

Filaments short, straight, 5.5-7 µm broad; sheath thin, colourless, unlamellated, sometimes gelatinized at the base of the branch; trichome 4-5.5 µm broad, unconstricted at the cross-walls, as long as broad, at the ends half as long as broad; heterocysts spherical or compressed (pl.7, fig.91).

Anjum 140, Aug. 26, 1978.

Habitat: Terrestrial (Gonzalves & Gangla, 1949).

Local distribution: Rice field Methra, District Peshawar.

Soil depth: 1 inch.

Geographical distribution: Europe, India, Pakistan.

3. Tolypothrix tenuis (Kg.) Johs. Schmidt em., Bot. Tidsskr., 22:383. 1899.

Prescott, p.538. 1951; Desikachary, p.494, pl.102, fig.4. 1959.

= T. tenuis Kg. Phyc. gen., 228. 1843.

= T. muscicola Kg., Phyc. gen., 227. 1843.

= T. lanata Wartmann in Rabenhorst, Fl. Eur. Alg., 2:227. 1865.

= T. inflata Ghose, On some Myxophyceae from Maymyo. J. Burma Res. Soc., 17:254, pl.4, fig.4, 1927.

Thallus cushion-like, blue-green or brown; filaments (4-)6-17(-18) µm broad, repeatedly branched; sheath thin, close to the trichome, at first hyaline later yellowish-brown, often lamellated; cells (4-)5-13 µm broad, quadrate or longer than broad, blue-green, slightly or unconstricted at the cross-walls; heterocysts cylindrical, spherical or discoid, 6-14 µm broad, 2.3-6 µm long, colourless or yellowish, solitary or 2-5 in a series (pl.19, fig.244).

Anjum 226, Feb.18, 1979.

Habitat: Aquatic (Turner, 1892; Crow, 1923b; Ghose, 1927d; Bharadwaja, 1934; Rao, C.B., 1937b; Parukutty, 1940; Rao, C.S., 1940; Prescott, 1951);

terrestrial (Dixit, 1936).

Local distribution: Sugar-cane field, Mardan.

Soil depth: 2 inch.

Geographical distribution: Burma, Europe, India, North America, Pakistan, Sri Lanka.

MICROCHAETE Thuret

Essai class. Nost., Ann. Sci. nat., Bot., Ser. 6, 1:378. 1875.

= Frémyella De Toni, Noterella de nomeneel. algol., 8:3. 1936.

Filaments attached, single, in bundles, or clustered; trichomes single with a distinct sheath, more or less attenuated at the apices, seldom uniform in breadth throughout the trichome; heterocyst basal, rarely intercalary; spores single, seldom in series, away from the heterocyst or near it; hormogones present. Single species was collected from N.W.F.P. soil.

1. Microchaete tenera Thuret ex Born. et Flah., Rev. des Nostocacées heterocystées, 84. 1887.

Prescott, p.542, pl.127, fig.6. 1951;

Desikachary, p.513, pl.105, figs.1-2. 1959.

= Frémyella tenera (Thuret) De Toni, J. Noterelle di nomenel. algol, 8:4. 1936.

Filaments single, or in small stellate clusters,

slightly bent, prostrate at the base, 6-7-8.5 µm in diameter; sheath thin, close to the trichome, hyaline, unlamellated; trichomes 5 µm broad, blue-green; cells at the base twice as long as broad; heterocysts basal and intercalary, nearly spherical or cylindrical, 6 µm broad, 6-8.5 µm long; spores single or in series, basal or intercalary, cylindrical, with brownish walls, 6-7.5 µm broad, 13-17 µm long (pl.7, fig.92).

Anjum 141, Aug. 28, 1978; Anjum 141A, Sep. 18, 1978.

Habitat: Aquatic (Skuja, 1949); terrestrial (Rao, C.B., 1937b).

Local distribution: Rice fields Methra, District Peshawar.

Soil depth: 1, 2 inches.

Geographical distribution: Burma, Europe, India, North America, Pakistan.

CALOTHRIX Ag.

Syst. Alg., 24. 1824.

Filaments single or in small bundles, caespitose, tomentose, pulvinate or penicillate; filaments more or less parallel, mostly erect, unbranched or rarely false-branched; sheath firm, sometimes seen only at the base; heterocysts mostly basal, rarely intercalary; spores when formed single or in series, next to the basal heterocyst.

Key to the species

1. Filaments distinctly constricted..... C. marchica (4)

1. Filaments unconstricted or slightly constricted..... 2

2. Trichomes 3.5-4 µm broad at the base..... C. epiphytica (3)

2. Trichomes 5-5.5 µm broad at the base..... C. clavata (1)

2. Trichomes 5-7 µm broad at the base.... C. elenkinii (2)

1. Calothrix clavata G.S.West, in Fuhrmann et Mayer, Voyage d' explor. Colombie, 1019, pl.21, figs.6, 7. 1914.

Desikachary, p.542, pl.114, fig.2. 1959; Frémy, p.142. pl.36, fig.1. 1972.

Filaments single or in groups, straight or slightly bent, prominently swollen at the base, 7 µm in diameter; sheath delicate, hyaline, close to the trichome; trichomes slightly constricted at the cross-walls, 5-5.5 µm broad at the base, in the middle 2-5 µm broad; cells discoid at the base, 2-3 times as long as broad above; heterocysts basal, single, hemispherical (pl.8, fig.99).

Anjum 147, Sep. 22, 1978.

Habitat: Aquatic (Skuja, 1949); terrestrial.

Local distribution: Pine forest, Parachinar.

Soil depth: 2 inch.

Geographical distribution: Africa, Burma, Columbia, Europe, Pakistan, South America.

2. Calothrix elenkinii Kossinskaja, Not. Syst. Crypt. Inst. Horti. Bot. Petropol., 3.11. 1924.

Desikachary, p.531, pl.114, figs.5,6,11. 1959.

Filaments in tufts, bent and swollen at the base, interlaced with each other, 6-9 µm broad at base, in the middle 4.5-6 µm broad; sheath close to the trichomes, thin, unlamellated, hyaline, open at the ends; trichomes blue or olive-green, at the base 5-7 µm broad, in the middle 3.5-4.5 µm broad, unconstricted at the base, apical hair not formed; cells quadrate, somewhat shorter than broad; heterocyst basal, single, 4.5-7 µm broad (pl.8, fig.98, photo 39).

Anjum 146, Sep. 12, 1978.

Habitat: Aquatic (Parukutty, 1940); terrestrial.

Local distribution: Pine forest, Parachinar.

Soil depth: 1 inch.

Geographical distribution: India, Pakistan, Russia.

3. Calothrix epiphytica West & West, J. Bot. London., 35:290. 1897.

Prescott, p.553, pl.132, figs.2,3. 1951;

Desikachary p.543. 1959.

Filaments single or in groups, at the base 5-7.5 µm broad, at the apex gradually attenuated; sheath somewhat thick, hyaline; trichomes at the base 3.5-4 µm broad, tapering to a fine hair; cells somewhat shorter than broad below and longer than broad above; heterocysts basal, single, small (pl.8, fig.96).

Anjum 175, Dec. 18, 1978.

Habitat: Aquatic (Prescott, 1951); terrestrial (Gonzalves & Gangla, 1949).

Local distribution: Dry hill, Abbottabad.

Soil depth: 5 inch.

Geographical distribution: Burma, Europe, India, North America, Pakistan.

4. Calothrix marchica Lemm. Abh. Naturh. ver. Bremen, 23(1):248, fig.1-2. 1914.

Desikachary, p.543, pl.114, fig.4. 1959.

Filaments straight or slightly bent, single, at the base 4-6 µm broad; sheath thin, close to the trichome, not coloured violet by chlor-zinc-iodide; trichomes blue-green, gradually attenuated into a hair, distinctly constricted at the cross-walls, at the base 4-5.5 µm broad, ½-¼ as long as broad; end cell conical, pointed; heterocysts single, basal, nearly spherical or hemispherical, 4-5.5 µm broad (pl.8, fig.97).

Anjum 180, Dec. 25, 1978.

Habitat: Terrestrial.

Local distribution: Dry hill, Abbottabad.

Soil depth: 3 inch.

Geographical distribution: Europe, Pakistan.

RIVULARIA (Roth) Ag.
Syst. Alg., 19. 1829.

Filaments more or less irregularly false-branched, sometimes unbranched, more or less radial or parallel in a hemispherical or spherical mucilaginous, hollow or solid colony; sheath more or less gelatinizing; trichomes ending in a hair, often with distinct trichothallic growth; heterocysts basal or intercalary; often false branching at the base; hormogonia single or in series gradually progressing towards the base from the meristematic zone; spores absent. Represented by a single species.

1. Rivularia dura Roth ex Born. et Flah., Rev. des Nostocacées heterocystées, 347. 1886.
Tilden, p.80, fig.30C. 1937; Smith, p.278, fig.161H. 1955; Desikachary, p.55, pl.115, fig.2. 1959.

Thallus hard, calcium incrusted, blackish-green; filaments densely arranged; sheath thin, hyaline, unlamellated, uniform; trichome 4-9 µm broad, blue-green, ending

in a long hair; cells at the base as long as broad, above about 1/3 as long as broad (pl.8, fig.95).

Anjum 171, Dec. 4, 1978.

Habitat: Terrestrial.

Local distribution: Dry land, Dera Ismail Khan.

Soil depth: 1 inch.

Geographical distribution: Europe, North America, Pakistan.

GLOEOTRICHIA Ag.

Alg. Maris et Adriat., 8. 1842.

Thallus spherical or hemispherical, solid, sometimes when old inflated and hollow; filaments radial, more or less parallel, often with false branches; sheath at first firm, only gelatinizing on the outside, soft to mostly diffluent; trichomes with a distinct trichothallic growth; heterocysts basal; spores at the base of the trichome, single or a few next to the heterocyst; hormogones present.

Key to the species

1. Spore 40 µm long..... G. longicauda (3)

1. Spores 44-50 µm long..... G. echinulata (1)

1. Gloeotrichia echinulata (J.E.) Smith P. Richter, Forschungsber. d. Biol. stat. Ploen, part 2, 31, figs.1-8. 1894.

Tilden, p.82, fig.31A-E. 1937; Prescott, p.557,

pl.134, figs.1-2. 1951; Desikachary, p.556, pl.116, figs. 9-10. 1959; Huber-Pestalozzi, p.176, fig.69. 1962.

Thallus solid, free-swimming, soft, spherical, later lenticular or cylindrical; filaments loosely arranged, radial, superficial ones produced outside the margins of the thallus, mucilage limits giving it a villose appearance; sheath delicate, not lamellated, more or less distinct, hyaline; trichomes with a long hair, 1-2 µm broad, at the base 8-10.4 µm broad; cells cylindrical, mostly with gas-vacudes; heterocysts spherical or ellipsoidal, 7-10 µm broad; spores cylindrical, with rounded ends, straight or bent, 6-18 µm broad, 44-50 µm long (pl.7, fig.93).

Anjum 142, Aug. 30, 1978.

Habitat: Aquatic (Crow, 1923b; Prescott, 1951); terrestrial.

Local distribution: Rice field Methra, District Peshawar.

Soil depth: 5 inch.

Geographical distribution: Europe, North America, Pakistan, Sri Lanka.

2. Gloeotrichia longicauda Schmidle, Hedwigia, 40:51, pl.3, figs.4-5. 1901.

Desikachary, p.558, pl.117, figs.1,7,8. 1959.

Thallus hemispherical; sheath somewhat diffluent, unlamellated, hyaline; trichomes gradually attenuated

into a long hair; cells as long as broad or somewhat longer than broad, 6-8 µm broad; heterocysts mostly many, of varying diameter; immature spores rounded, cylindrical or long ellipsoidal, later bent or curved, 16 µm broad, 40 µm long; epispore hyaline (pl.18, fig.214, photo 40).

Anjum 228, Feb. 21, 1978.

Habitat: Terrestrial.

Local distribution: Sugar-cane field, Mardan.

Soil depth: 1 inch.

Geographical distribution: Burma, Europe, Pakistan.

C H L O R O P H Y C E A E

Key to the genera of Chlorophyceae

1. Vegetative cells with flagella, motile..... 2

1. Vegetative cells without flagella, non motile..... 3

2. Plant unicellular..... Chlamydomonas

2. Plant colonial..... Pandorina

3. Plant filamentous..... 4

3. Otherwise..... 12

4. Filaments branched..... 5

4. Filaments unbranched..... 8

5. Cells lemon-shaped..... Physolinum

5. Otherwise..... 6

6. Cells with one pyrenoid..... Stigeoclonium

6. Cells with 4 or more pyrenoids..... 7

7. Filaments with rhizoid-like branches..... Rhizoclonium

7. Filaments with many-celled branches..... Cladophora

8. Cells medianly constricted, with isthmus..... Spondylosium

8. Cells not medianly constricted..... 9

9. Cell-wall breaking into H-pieces.. Microspora

9. Otherwise..... 10

10. Holdfast absent..... Chlorohormidium

10. Holdfast present..... 11

11. Cells with apical caps, upper end of cell broader..... Oedogonium

11. Cells without apical caps, cells uniformly broad..... Ulothrix

12. Plant colonial..... 13

12. Plant unicellular..... 23

13. Colony with wide gel..... 14

13. Colony with or without narrow gel. 17

14. Gel layered..... Gloeocystis

14. Otherwise..... 15

15. Cells rounded..... 16

15. Cells long-cylindric or fusiform. Quadrigula

16. Colony rounded..... Planktosphaeria

16. Colony shapless..... Palmella

17. Cells spherical..... 18

17. Cells elongated, curved or squarish..... 21

18. Colony a hollow sphere..... Coelastrum

18. Colony an irregular packet..... 19

19. Zoospores absent..... Protococcus

19. Zoospores present..... 20

20. Chloroplast parietal and fissured..... Tetracystis

20. Chloroplast parietal and non-fissured..... Chlorosarcinopsis

21. Colony not in one plane, old parent wall present..... Oocystis

21. Colony in one plane, old parent wall absent..... 22

22. Cells elongate, lying parallel..... Scenedesmus

22. Cells squarish, not lying parallel..... Crucigenia

23. Cells with a median constriction. Cosmarium

23. Cells without median constriction..... 24

24. Plant sessile, elongated with a stalk..... Characium

24. Otherwise..... 25

25. Cells angular..... 26

25. Otherwise..... 27

26. Chloroplast one to many parietal discs..... Tetraëdron

26. Chloroplast one, net-like or spongy..... Chlorotetraëdron

27. Cells rounded..... 28

27. Cells not rounded..... 35

28. Chloroplast asteroid..... Radiosphaera

28. Chloroplast net-like..... Spongiochloris

28. Otherwise..... 29

29. Chloroplast a hollow sphere, cells varying in size..... 30

29. Otherwise..... 31

30. Autospores present..... Neochloris

30. Autospores absent..... Chlorococcum

31. One parietal chromatophore..... Chlorella

31. Several discoid chromatophores.. 32

32. Autospores present..... 33

32. Autospores absent..... 34

33. Cells large, 20-200 µm in diameter..... Eremosphaera

33. Cells small, 7-8 µm in diameter. Palmellococcus

34. Zoospores with two equal-lengthed flagella..... Dictyococcus

34. Zoospores with two unequal-lengthed flagella..... Bracteacoccus

35. Two axial chloroplasts..... Closterium

35. One axial chloroplast..... 36

36. Chromatophore with an excentric notch at the centre. Rova

36. Chromatophore without an excentric notch..... Mesotaenium

CHLAMYDOMONAS Ehrenberg

Dritter Beitrag zur Erkenntnis grosser Organization in der Richtung des Kleinsten Raumes. Abh. d. Koenig. Akad. Wiss. 2. Berlin, 145-336. 1833.

Vegetative cells unicellular, actively motile, ovoid, ellipsoid or spherical, sometimes with one or two apical papillae, from which two equal flagella arise; often with a narrow or wide mucilaginous sheath; cells uninucleate, chloroplast of several types, dense, occupying the entire cell, or a thin parietal cup; pyrenoids one to many, basal or bilateral and scattered; pigment-spot lateral and anterior, rarely median; 2-4 apical contractile vacuoles usually present.

Key to the species

1. Cells ovoid to ellipsoid..... 2
1. Cells globose..... 3
  2. Cells 12 µm in diameter..... C. typica (4)
  2. Cells 6.5-8 µm in diameter..... C. snowii (3)
3. Cells with anterior papilla..... C. pseudopetryi (2)
3. Cells without an anterior papilla. C. globosa (1)

1. Chlamydomonas globosa Snow, Bull. U.S. Fish. Comm, 389. 1903.

Prescott, p.71, pl.1, figs.8,9. 1951; Tiffany & Britton, p.13, pl.1, fig.4. 1952; Huber-Pestalozzi, p.157, fig.132. 1962.

Cells broadly ovoid to globose; gelatinous, sheath hyaline; without an anterior papilla; chloroplast a dense parietal cup, a basal pyrenoid, one contractile vacuole in the anterior end of cell; pigment spot lens-shaped, supermedian in position, lateral; cells 5-7 µm in diameter, 10-19 µm long (pl.9, fig.101).

Anjum 89, Jan. 15, 1978.

Habitat: Aquatic (Prescott, 1951; Huber-Pestalozzi, 1962); terrestrial.

Local distribution: Dry land, Peshawar.

Soil depth: 5 inch.

Geographical distribution: Europe, North America, Pakistan.

2. Chlamydomonas pseudopetryi Pascher, Die Suesswasser-flora Deutschlands, Oesterreichs und des Schweiz. Heft. 4:1-506, figs.1-45. 1927.

Prescott, p.72, pl.1, fig.12. 1951; Huber-Pestalozzi, p.173, fig.164. 1962.

Cells globose, with a prominent hemispherical papillae; chloroplast cup-shaped, dense in the basal portion; 2 anterior contractile vacuoles; pyrenoid posterior; pigment-spot lens-shaped, anterior and lateral; cells 12-18-(27) µm in diameter (pl.9, fig.102).

Anjum 92, Jan. 25, 1978.

Habitat: Aquatic (Prescott, 1951; Huber-Pestalozzi, 1962); terrestrial.

Local distribution: Dry land, Peshawar.

Soil depth: 6 inch.

Geographical distribution: Europe, North America, Pakistan.

3. Chlamydomonas snowii Printz, Skr. Vidensk. i. Kristiania. Mat.- Nat. Kl., No:6, p.18. 1914. Prescott, p.72, pl.1, figs.13,14. 1951; Smith, p.33, fig.8. 1955; Huber-Pestalozzi, p.184, fig.183. 1962.

Cells narrowly ovoid to ellipsoidal, with an anterior papilla; chloroplast a parietal cup, dense in the posterior region; pyrenoid one, centrally located; cells 6.5-8 µm in diameter, 10-15 µm long (pl.9, fig.100).

Anjum 59, Oct. 3, 1977.

Habitat: Aquatic (Prescott, 1951); terrestrial.

Local distribution: Dry land, Peshawar.

Soil depth: 1 inch.

Geographical distribution: Europe, North America, Pakistan.

4. Chlamydomonas typica Deason & Bold, Phycological Stud., Univ. Texas, p.19, figs.18,19; 86-89. 1960.

Cells ovate-ellipsoidal, 8-12 µm in diameter, 9-18 µm long; chloroplast cup-shaped with a basal pyrenoid; 2 contractile vacuoles; stigma anteriorly placed; cell wall of moderate thickness; without

papilla; matrix distinct; endogenous bipartition of non-motile cells to form four daughter cells (pl.17, fig.195, photo 41,42).

However, in the present study, cells were 15-17 µm broad and 18-20 µm long.

Anjum 229, Feb. 21, 1979.

Habitat: Terrestrial (Deason & Bold, 1960).

Local distribution: Rice field Methra, District Peshawar.

Soil depth: 2 inch.

Geographical distribution: North America, Pakistan.

PANDORINA Bory

In Dictionnaire d'histoire naturelle-Paris, p.600. 1824.

Colony ovate or obvoid, composed of 8-16-(32) globose or pyriform cells, compactly arranged and enclosed by a common gelatinous envelope; cells with the broad anterior end directed outward; chloroplast a parietal cup with one basal pyrenoid; pigment-spot anterior and lateral; flagella two, arising from the anterior end of the cell and diverging widely after emerging from colonial envelope; the colony swimming in a rolling manner; vegetative reproduction by the simultaneous division of each cell in the colony to form as many colonies; sexual reproduction by the isogametes formed in groups of 8 or 16 by the partition of some or all of the cells of the colony. Represented by a solitary species.

1. Pandorina morum (Meull.) Bory, In Dictionnaire d' historire naturelle-Paris, p.600. 1824. Collins, p.132, pl.2, fig.17. 1909; Tilden, p.438, fig.227C-D. 1937; Prescott, p.75, pl.1, fig.23. 1951; p.48, pl.1, fig.10. 1969; Tiffany & Britton, p.16, pl.1, fig.13. 1952.

Colony distinctly ovate, as much as 220 µm in diameter; cells pyriform, crowded, usually 16 in number, 10-15 µm broad, 12-17 µm long (pl.9, fig.103, photo 43).

Anjum 154, Oct. 22, 1978; Anjum 154A, Oct. 28, 1978.

Habitat: Aquatic (Prescott, 1951); terrestrial.

Local distribution: Wheat fields, Peshawar.

Soil depth: 1, 3 inches.

Geographical distribution: Asia, Europe, New Zealand, Pakistan, South and North America.

PALMELLA Lyngbye

Tentanen Hydrophytologiae Danicae. Kjobenhavn, p.203. 1819.

Thallus amorphous, gelatinous, containing many spherical cells without any order of arrangement; individual cell sheaths usually distinct at first becoming confluent with the clonial mucilage; chloroplast cup-shaped or bell-shaped, with pyrenoid; vegetative

division by biflagellate zoospores, with or without eye spot; akinetes present; sexual reproduction by isogametes.

Key to the species

1. Cells 3-40 µm broad..... P. miniata (1)

1. Cells 5-14 µm broad..... P. texensis (2)

1. Palmella miniata Leibl., Algologische Benerkungen. Flora, Vol. XIII, p.337. 1830.

Collins, p.137, pl.3, fig.23. 1909; Lemmermann, p.33, fig.6a-g. 1915; Tiffany & Britton, p.21, pl.3, figs. 28,29. 1952.

Cells 3-40 µm in diameter, solitary or in groups of 2-8 in irregular gelatinous masses; sheath thick, hyaline, more or less distinctly lamellate, diffluent; zoosporangium producing 4-8 zoospores is 10-12 µm in diameter or a single cell developing a single zoospores; sexual reproduction by isogametes (pl.9, fig.5).

Anjum 155, Oct. 26, 1978; Anjum 155A, Oct. 28, 1978.

Habitat: Terrestrial (Collins, 1909; Tiffany & Britton, 1952).

Local distribution: Pine forests, Parachinar.

Soil depth: 5, 6 inches.

Geographical distribution: Europe, North America, Pakistan.

2. Palmella texensis Groover & Bold, Phycological studies,

p.48, figs.35, 143-149, 159-30. 1969.

Thallus amorphous; vegetative cells spherical, uninucleate 5-14 µm broad, solitary or in groups of 2-4 or 8; individual gelatinous matrix lamellated, groups of cells also within a common matrix; chloroplast parietal, massive; pyrenoids 1-2; in stationary phase of growth, cells spherical, 16-20 µm broad, with the walls up to 2 µm thick with an individual matrix; multiplication in the non-motile stage by cell-division, usually in three planes; zoospores ovoid, 3.5-7.5 µm broad, 7.5-12.5 µm long, with 2 flagella of equal length, an anterior linear stigma, two contractile vacuoles, a posterior nucleus, a medial pyrenoid and a parietal band-like chloroplast; akinetes with red orange droplets; sexual reproduction not observed (pl.9, fig.104).

Anjum 121, May 26, 1978; Anjum 121A, May 30, 1978; Anjum 121B, June 9, 1978; Anjum 121C, June 11, 1978; Anjum 121D, June 16, 1978.

Habitat: Terrestrial (Groover & Bold, 1969).

Local distribution: Pine forests, Parachinar; Dry hills, Abbottabad.

Soil depth: 1,2,3,4 and 5 inches.

Geographical distribution: North America, Pakistan.

GLOEOCYSTIS Naeg.

Gatt. einzell. Algen, 65. 1849.

Cells spherical, sometimes solitary, usually grouped into colourless gelatinous envelope, envelope may be spherical or amorphous, lamellated or rarely homogenous; chloroplast parietal,cup-shaped, often covering the entire cell, obscured by numerous starch grains or oil bodies; pyrenoid one.

Key to the species

1. Cells ovoid or oblong..... G. ampla (1)

1. Cells spherical..... G. vesiculosa (2)

1. Gloeocystis ampla (Kg.) Lagerheim, Bidrag till Sveriges algflora. Oef. Kgl. Vet. Akad. Foerh. Stockholm, 40(2):63, pl.1, 1883.

Heering, p.35, fig.4a,b. 1914; Prescott, p.84, pl.3, fig.17. 1951; Tiffany & Britton, p.21, pl.3, fig.23. 1952.

Colonies spherical or amorphous; gelatinous envelope unlamellated; individual sheaths and colonial sheaths not confluent but distinct and angular due to the mutual compression of cells; cells 9-11 µm broad, 10-14 µm long (pl.9, fig.106).

Anjum 3, Dec. 8, 1976; Anjum 3A, Oct. 4, 1977; Anjum 3B, Oct. 6, 1977; Anjum 3C, Sep. 5, 1978; Anjum 3D, Sep.9,1978; Anjum 3E, Oct. 1, 1978.

Habitat: Aquatic (Prescott, 1951); terrestrial.

Local distribution: Dry lands, Peshawar.

Soil depth: 1, 2, 3, 4, 5 and 6 inches.

Geographical distribution: Europe, North America, Pakistan.

2. Gloeocystis vesiculosa Naeg., Gatt. einzell. Algen, 66. 1849.

Heering, p.35, fig.10. 1914; Prescott, p.85, pl.3, fig.15. 1951.

Colony large, amorphous, usually attached; colonial envelope mucilaginous, lamellated; cells spherical, 4.5-12 µm in diameter (pl.9, fig.107).

Anjum 10, Jan. 7, 1977; Anjum 10A, May 11, 1977; Anjum 10B, May 2, 1977; Anjum 10C, Sep. 9, 1978; Anjum 10D, Sep. 16, 1978; Anjum 10E, Sep. 28, 1978.

Habitat: Aquatic (Prescott, 1951); terrestrial.

Local distribution: Garden soil, Peshawar; Pine forests, Parachinar; Dry hills, Abbottabad.

Soil depth: 1,2,3,4,5 and 6 inches.

Geographical distribution: North America, Pakistan.

ULOTHRIX Kg.

Flora 16, p.517. 1833.

Filaments unbranched, not apically attenuated, frequently attached basally; vegetative cells uninucleate, cylindric or sometimes barrel-shaped; chromatophores band-shaped, partially or wholly covering the cell circumference, with one or more pyrenoids; zoospores

quadriflagellate, or biflagellate; akinetes present; sexual reproduction by isogametes formed 8-16-64 in a cell, smaller than zoospores.

Key to the species

1.Cells 8-10 µm in diameter..... U. idiospora (1)

1.Cells 5-7 µm in diameter..... U. variabilis (2)

1. Ulothrix idiospora G.S.West, J. Linn. Soc. (Bot.) 39:47, pl.2, figs. 12-14. 1908.

Ramanathan, p.40, pl.10, figs. M-O. 1969.

Filaments subflexuous, 8-10 µm broad, 3/4-2¼ times as long as broad; chloroplast a parietal lobe; pyrenoid one; akinetes single or in chains up to 20, formed by enlargment of vegetative cells, ellipsoidal or doliform and enclosed in a thick scrobiculated wall, 10-13 µm broad and 18-36 µm long (pl.10, fig.113, photo 44).

Anjum 18, March 5, 1977.

Habitat: Terrestrial.

Local distribution: Dry land, Dera Ismail Khan.

Soil depth: 2 inch.

Geographical distribution: Australia, Pakistan.

2. Ulothrix variabilis Kg., Sp. Alg., p.346. 1849.

Heering, p.32, fig.27. 1914; Prescott, p.97, pl.9, fig.13. 1951; Tiffany & Britton, p.26, pl.4, fig.37. 1952; Ramanathan, p.39, pl.10,

figs. D-F. 1962.

= Hormidium variabilis Kg. 1849.

= U. subtilis var. variabilis Kirchner, (vide, Ramanathan, 1962).

Filaments sometimes with a pointed basal cell; cells 5-7 µm broad, ½ - 1½ times as long as broad, cylindrical, with a thin cell wall; chloroplast usually not filling more than half the circumference of the cell, appearing as a plate covering one side of the cell; pyrenoid one (pl.10, fig.112, photo 45).

Anjum 166, Nov.24, 1978; Anjum 166A, Dec. 12, 1978.

Habitat: Cosmopolitan.

Local distribution: Dry land, Peshawar; Dry hill, Kohat.

Soil depth: 1, 2 inches.

Geographical distribution: Worldwide.

CHLOROHORMIDIUM Fott

Taxonomische Uebertragungar und Namensanderungar Unter du Algase. Preslia 32:142-154. 1960.

= Hormidium Kg., 1896.

Filaments simple; cells cylindrical; chloroplast a parietal plate extending around the cell for ½ or less of the circumference; one elongated or oval pyrenoid; fragmentation common.

Key to the species

1. Filaments 5-14 µm broad..... C. flaccidum (1)

1. Filaments 6 µm broad..... C. sterile (2)

1. Chlorohormidium flaccidum (Kg.) Fott, Preslia 32:149. 1960.

Heering, p.45. 1914; Ramanathan, p.81, pl.21, A-F; 22, A-E. 1962; Farooqui, p.3, pl.1-6. 1969.

= Ulothrix flaccida Kg., 1849.

= Ulothrix flaccida Kg., 1852.

= Hormiscia flaccida (Kg.) Lagerh., Flora. 71:63. 1888.

= Stichococcus flaccidus (Kg.) Gay, Recherches Alg. Vert., p.79, pl.2, fig.106. 1891.

= Hormidium flaccidum (Kg.) A Braun in Klebs. Die Bedingugen der Fortpflanzung bei einigen Algen und Pilzen, 341. 1896.

= Hormococcus flaccidus & flaccida Chodat, Beitr. Krypt. Flora Schweiz, 1:269. 1902.

Filaments long, unbranched, fragmenting into short lengths; cells cylindrical, thin-walled, 5-14 µm broad, 1-3 times as long as broad, with a single chloroplast, covering half the cell; pyrenoid one; reproduction by aplanospores and zoospores (pl.18, fig.198).

Anjum 230, Feb. 23, 1979.

Habitat: Terrestrial (Peterson, 1935; Randhawa, 1959); aquatic and epiphytic (Heering, 1914); on coastal ice (Fritsch, 1935).

Local distribution: Sugar-cane field, Mardan.

Soil depth: 1 inch.

Geographical distribution: America, Asia, Europe.

2. Chlorohormidium sterile (Deason & Bold) Com. Nov.

= Hormidium sterile Deason & Bold. Expl. Studies of Texas soil Algae, Phycological studies, p.36, figs.54-55, 112. 1960.

Single uninucleate cells with rounded poles or 2-10-25 celled unbranched filament, chloroplast laminate, encircling slightly more than one-half the circumference of the cell; one pyrenoid; cells 6 µm broad, 15 µm long; cross-walls not constricted (pl.9, fig.108, photo 46,47).

Anjum 108, March 26, 1978; Anjum 108A, March 27, 1978.

Habitat: Terrestrial (Deason & Bold, 1960).

Local distribution: Moist land, Dera Ismail Khan, Garden soil, Peshawar.

Soil depth: 1, 2 inches.

Geographical distribution: North America, Pakistan.

MICROSPORA Thuret

Recherches sur less zoospores des algues et les antheridies des cryptogams. Ann. Sci. Nat. Bot., 14(3):221. 1850.

Filaments unbranched, unattached; cells uniseriately arranged, cylindrical or slightly swollen; cell-walls thin in some species, in others thick and lamellate, composed of 2 sections overlapping in the mid region; filaments fragmenting readily after maturation by the separation of the walls at their point of junction, so that H-shaped sections and fragments are formed; chloroplast either a dense and irregularly padded parietal plate, or not; pyrenoids lacking, cells frequently forming aplanospores or akinetes, the later globose, with much thickened walls. Only one species is recorded for the genus.

1. Microspora tumidula Hazen, Hazen, The Ulothricaceae & Chaetophoraceae of the United States. 11:177. 1902.

Collins, p.194, pl.7, fig.68. 1909; Heering, p.151, fig.211. 1914; Prescott, p.108, pl.8, fig.9. 1951; Tiffany & Britton, p.29, pl.5, fig.53. 1952; Ramanathan, p.122. 1962.

Filaments unbranched, slightly constricted at

the cross-walls; cells cylindrical, 7.4 µm in diameter, 10-14.8 µm long; chloroplast densely granulated; cell walls relatively thick, lamellated, the sections of the walls very evident in the mid-region of the cell (pl.9, fig. 109).

Anjum 143, Sep.6, 1978; Anjum 143A, Oct. 15, 1978.

Habitat: Aquatic (Prescott, 1951); terrestrial.

Local distribution: Rice fields Methra, District Peshawar.

Soil depth: 1, 2 inches.

Geographical distribution: Africa, Europe, India, North and South America, Pakistan.

STIGEOCLONIUM Kg.

Phyc. gen. 253. 1843.

Filaments branched, arising from a prostrate position of a thallus which may be reduced to a pseudo-parenchymatous mass of cells; in some species major portion of the plant spreading in loosely branched horizontal filaments; plants covered by a thin, scarcely evident, film of mucilage; branches of first and second order either alternate or opposite, composed of cells scarcely smaller than those of main axis, ending in bluntly pointed or setiferous cells; chloroplast a parietal plate covering most of the cell circumference especially in the cells of branches; one to several pyrenoids.

Key to the species

1. Filaments 19.5-21 µm broad..... S. pachydermum (1)

1. Filaments 4-10 µm broad..... S. polymorphum (2)

1. Stigeoclonium pachydermum Prescott, New species & varietes of algae, Farlowia, 1.350. 1944.

Prescott, p.116, pl.12, figs. 1-4,9,10. 1951.

Filaments much branched, erect, with mumerous basal, downward-projecting rhizoidal branches; branches in the upper portion irregularly disposed and extremely varied in form, mostly alternate, but with one branch arising immediately above another on the opposite side of the filament, or in a plane at right angles to it; branches often developing from short, barrel-shaped cells, many thorn-like and irregular, downward projecting branches developing from upper part of the main axis, branchlets tapering to a blunt point and frequently ending in somewhat enlarged quadrangular-globose sporangial cells, which may be intercalary, near the ends of short branches also; cells in the main axis 19.5-21 µm in diameter, in the branches 15-16 µm in diameter, cylindrical, somewhat longer than wide (pl.10, fig.111).

Anjum 107, March 20, 1978.

Habitat: Aquatic (Prescott, 1951); terrestrial.

Local distribution: Moist land, Dera Ismail Khan.

Soil depth: 3 inch.

Geographical distribution: North America, Pakistan.

2. Stigeoclonium polymorphum (Franke) Heer., in Pascher, 6:3, p.87, fig.126. 1914.

Prescott, p.116, pl.9, fig.9. 1951.

= Endoclonium polymorphum Franke (vide, Pascher, 1914).

Filaments short, sparsely branched, arising from an extensive prostrate, pseudo-parenchymatous or monostromatic and radiating portion; upright branches ending in long tapering setae; cells quadrangular in the basal portion, cylindrical in the vertical branches, 4-10 µm in diameter, 6-12 µm long (pl.9, fig.110, photo 48).

Anjum 156, Oct. 29, 1978.

Habitat: Aquatic (Prescott, 1951); terrestrial.

Local distribution: Rice field Methra, District Peshawar.

Soil depth: 2 inch.

Geographical distribution: Europe, North America, Pakistan.

PROTOCOCCUS Ag.

Syst. Algarum, p.13. 1824.

Unicellular or in indefinite clusters; cells globose or angular from mutual compression; sometimes

organized to form simple filaments, branches of filaments vestigial; chloroplast dense, lobed, parietal plate, covering most of the cell wall; one pyrenoid. One species has been recorded for the genus.

1. Protococcus viridis Ag., Syst. Algarum, p.13. 1824. Pascher, p.224, fig.31,32. 1915; Prescott, p.127, pl.10, figs.5-7. 1951; Tiffany & Britton, p.42, pl.6, fig.58. 1952.
= Pleurococcus vulgaris Naegeli.
= Pleurococcus naegeli Chodat.

Cells spherical, 8-12 µm in diameter, unicellular or grouped; chloroplast parietal covering most of the cell circumference (pl.10, fig.115).

Anjum 4, Jan. 2, 1977; Anjum 4A, Jan. 4, 1977; Anjum 4B, Feb. 8, 1978.

Habitat: Aquatic, epiphytic and subaerial (Prescott, 1951); terrestrial.

Local distribution: Dry land, Peshawar; Maize and Sugar-cane fields, Mardan.

Soil depth: 1, 2 and 3 inches.

Geographical distribution: Europe, North America, Pakistan.

PHYSOLINUM Printz.

subaerial algae from South Africa, mat. Nat. Kl. 1:1-41, pl.14. 1921.

Thallus an irregularly branched filament, not differentiated into prostrate and erect portions; cells moniliform; cell division distinctive; cell division by a papillate outgrowth; chloroplast parietal, laminate, with or without band-shaped projections; at times chloroplast fragmenting into several disc-shaped chromatophores; pyrenoids absent; reproduction by several, small, spherical, aplanospores with certain intercalary cells; aplanospores liberation takes place by a rupture of the parent cell wall; fragmentation common. The genus was represented by a solitary species.

1. Physolinum monilia (de Wilden) Printz, Vorarbeiten zu einter Monographie der Trentopohliaceae. Nyt. Mag. Naturbidensk. 80:137-210, pl.32. 1939. Smith, p.181, fig.111. 1950.

Filaments irregularly branched, no differentiation into prostrate and erect branches; cells moniliform; chloroplast parietal, laminate, fragmented into several disc shaped chromatophores; pyrenoids absent; cells 15 µm in diameter; reproduction by aplanospores; fragmentation of filaments common (pl.17, fig.194).

Anjum 103, Feb. 28, 1978.

Habitat: Terrestrial.

Local distribution: Moist land, Dera Ismail Khan.

Soil depth: 1 inch.

Geographical distribution: North America, Pakistan, South Africa.

CLADOPHORA Kg.

Phyc. gen. 262. 1843.

Repeatedly branched filamentous thallus with basal-distal differentiation; attached when young but in some species becoming free-floating; branches alternate, opposite or sometimes di- or trichotomous; branches smaller than the main axis, or at least tapering slightly towards the apices; cells cylindrical or swollen; cell walls thick and lamellate in most species, sometimes thin and firm; chloroplast a parietal reticulum sometimes becoming fragmented and appearing as numerous discs; pyrenoids many; asexual reproduction by zoospores; sexual reproduction by isogametes produced in apical or sub-apical, unspecialized cells.

Key to the species

1. Cells irregularly swollen..... C. fracta (1)

1. Cells not swollen but cylindrical... C. glomerata (2)

1. Cladophora fracta (Dillw.) Kg., Phyc. gen. 263. 1843. Prescott, p.137, pl.20, figs.1-6. 1951; Faridi, p.46, figs.32-37. 1961.

= C. crispata (Roth). Kg. gen., p.264. 1843.

Thallus free-floating, forming coarse light-green masses of irregularly branched filaments, the branches often curving; cells irregularly swollen or clavate, 60-120 µm in diameter in the main axis, 1-3 times their diameter in length; 20-40 µm in diameter in the ultimate branches, 3-6 times their diameter in length (pl.18, fig.197).

Anjum 231, Feb. 25, 1979.

Habitat: Aquatic (Prescott, 1951); terrestrial.

Local distribution: Sugar-cane field, Mardan.

Soil depth: 2 inch.

Geographical distribution: Europe, North America, Pakistan.

2. Cladophora glomerata (L.) Kg., Phyc. germ. 212. 1845.

Collins, p.350, pl.XIII, fig.124. 1909; Prescott, p.138, pl.20, figs.8,9; pl.21, figs. 1,2. 1951; Tiffany & Britton, p.45, pl.13, fig.93. 1952; Faridi, p.57, figs.28-31. 1961.

Thallus attached, dark green, fluffy; filaments successively and regularly branched; the branches usually crowded in the upper limits; cells very slightly attenuated towards the apices of the branches; apices bluntly pointed; main axis 75-100 µm in diameter, 6-7 times the diameter in length; cells in the branches 35-50 µm in

diameter, 3-6 times the diameter in length (pl.10, fig.114, photo 49).

Anjum 158, Nov. 8, 1978; Anjum 158A, Nov. 16, 1978.

Habitat: Aquatic (Prescott, 1951); terrestrial.

Local distribution: Rice field Methra, District Peshawar.

Soil depth: 1, 2, 4 inch[es].

Geographical distribution: Europe, North America, Pakistan.

RHIZOCLONIUM Kg.

Phyc. gen., 261. 1843.

Filaments coarse, wiry, forming tangled, floating mass; either branched or with short rhizoidal branches, occasionally with long, multicellular branches; without distinct basal-distal differentiation in the plane of branching; cells stout, short or long-cylindric, rarely with slightly inflated lateral walls; cell walls in most species thick and lamellate; chloroplast a parietal reticulum, often dense, sometimes loose and appearing as if composed of many irregularly shaped ovate chloroplasts; one pyrenoid. Single species was cultivated for the genus.

1. Rhizoclonium hieroglyphicum (Ag.) Kg., Phyc. germ., 206. 1845.

Collins, p.329, pl.12, fig.119. 1909; Prescott, p.142, pl.23, fig.3. 1951; Tiffany & Britton,

p.46, pl.13, fig.91. 1952; Faridi, p.79, fig.16. 1961.

Filaments long, wiry, unbranched; cell walls of variable thickness, usually thin in typical form; cells 10-53 µm in diameter, 2½ to 10 times as long as broad; chloroplast varying with the age of plant, sometimes a close net and very dense, or an open reticulum (pl.10, fig.116, photo 50).

Anjum 159, Nov. 1, 1978; Anjum 159A, Nov. 5, 1978; Anjum 159B, Nov. 15, 1978.

Habitat: Aquatic (Prescott, 1951); terrestrial.

Local distribution: Rice fields Methra, District Peshawar.

Soil depth: 2,3 and 4 inches.

Geographical distribution: Europe, North America, Pakistan.

OEDOGONIUM Link

Epistola de algis aquaticis in genera disponendis. Nees, Horae Physicae, p.1. 1820.

Filaments solitary, unbranched; cells uninucleate, cylindrical or sometimes capitellate, nodulose or undulate; chloroplast reticulate; numerous pyrenoids at larger intersections or reticulum; basal cell with holdfast; terminal cell obtuse, apiculate or hyaline; vegetative cells except the basal one capable of division; oogonia and antheridia produced by direct

division of vegetative cells; reproduction by multiflagellate zoospores, oogonia and eggs, antheridia and multiflagellate antherozoids, oospore, dwarf males, androsporangia and androspores.

Key to the species

1. Filaments monoecious, oogonia 32-37 µm broad..... O. hirnii (1)
1. Filaments dioecious, oogonia 19.5-27 µm broad..... O. porrectum (2)

1. Oedogonium hirnii Gutwinski, De nonnulis algis novris vel minus Cognitis. Akad. Umiei. Krakowie, Rozor. Wydz. Mat. Pryyr. 33:34. 1896. Heering, p.207, fig.300. 1914; Tiffany, p.73, pl.XIV, figs.136-137. 1930; Prescott, p.178, pl.31, fig.4. 1951.

Plant macrandrous, monoecious; vegetative cells cylindric or slightly capitellate, 8-11-13 µm in diameter, 28-61-80 µm long; oogonia solitary, subglobose or subovate, opening by a superior pore, 32-37 µm in diameter, 32-39 µm long; oospore globose, wall thick, smooth, 28-31 µm in diameter; antheridial cells 8-10.8-11 µm in diameter, 5-7-2 µm long (pl.10, fig.117, photo 51).

Habitat: Aquatic (Prescott, 1951); terrestrial.

Local distribution: Rice field Methra, District Peshawar.

Soil depth: 6 inch.

Geographical distribution: Australia, Europe, Ireland, North America, Pakistan.

2. Oedogonium porrectum Nord. & Hirn., Monographie und iconographie der Oedogoniaceae. Acta. Soc. Sci. Fenn., 27:186; In Hirn, p.186, pl.29, fig.183. 1900.

Tiffany, p.109, pl.85, figs.361,362. 1930;

Prescott, p.186, pl.36, figs.6,7. 1951.

Macrandrous, dioecious; vegetative cells cylindric, 5.8-8-10 µm in diameter, 23-29-(-55) µm long; oogonia solitary, ellipsoidal or oblong-ellipsoidal, operculate; division superior, 19.5-22-27 µm in diameter, 27.3-39-44 µm long; oospore ellipsoid, not filling the oogonia, wall smooth, 17.5-24 µm in diameter, 6-8 µm long (pl.10, fig.118).

Anjum 161, Nov. 12, 1978; Anjum 161A, Nov. 21, 1978; Anjum 161B, Nov. 26, 1978.

Habitat: Aquatic (Prescott, 1951); terrestrial.

Local distribution: Rice fields Methra, District Peshawar.

Soil depth: 1,2 and 3 inches.

Geographical distribution: Brazil, Europe, North America, Pakistan.

BRACTEACOCCUS Tereg

Einige nene Gruenalgen. Beih, 2. Bot. Centralbt. 39:179-195. 1923.

Vegetative cells with several to many separate polygonal, plate-like chloroplasts; wall thickness varies from species to species; pyrenoids absent; zoospores of various sizes, flattened to various degrees dorsoventrally, becoming spherical at quiescence, each zoospore has 2 flagella, slightly unequal in length, emerging from anterior pole of the cell.

Key to the species

1. Mature cells upto 35 µm in diameter.. B. grandis (1)
1. Mature cells less in diameter..... 2
  2. Mature cells 5-20 µm broad..... B. minor (3)
  2. Mature cells 20-25 µm broad..... 3
3. Plant mass coherent, irregular..... B. pseudominor (4)
3. Plant mass otherwise..... B. medinucleatus (2)

1. Bracteacoccus grandis Bischoff & Bold, Phycological studies, IV. p.48,57, figs.76-79, 139. 1963.

Cells spherical at all ages, up to 35 µm broad; cell wall smooth, thin, not thickening with age, may be with the bubble-like protrusion at one pole of the cell; chloroplast plate-like, small; contractile vacuoles absent; mature cells multinucleate; asexual reproduction

by zoospores and aplanospores; zoospores fusiform, 2-3 µm broad, 8.5-10 µm long, with 2-3 parietal and disected chloroplasts, 2 anterior contractile vacuoles, anterior nucleus, small equatorial stigma, 2 flagella of unequal length, the longer one as long as the cell body; sexual reproduction not observed (pl.11, fig.120, photo 87).

Anjum 64, Oct. 15, 1977; Anjum 64A, Oct. 22, 1977.

Habitat: Terrestrial (Bischoff & Bold, 1963).

Local distribution: Wheat fields, Peshawar.

Soil depth: 1, 2 inches.

Geographical distribution: North America, Pakistan.

2. Bracteacoccus medinucleatus Bischoff & Bold, Phycological studies IV, p.57, figs.73-75, 137-138. 1963.

Vegetative cells spherical to subspherical, depending on age; mature cells spherical with a maximum diameter of 25 µm; cell wall smooth and thin, not thickening with age; chloroplast plate like, parietal; no contractile vacuoles; stationary cells multinucleate, with nuclei clustered near the centre of the cell; asexual reproduction by zoospores and aplanospores; zoospores elongate, with acute anterior and rounded posterior poles, 3.5-5.0 µm long, with 2 parietal

chloroplast, anterior nucleus, small equatorial stigma, 2 equal lengthed flagella which are slightly longer than the cell body; sexual reproduction not observed (pl.11, fig.121).

Anjum 2 , Dec. 2, 1976; Anjum 2A, Dec. 5, 1976.

Habitat: Terrestrial (Bischoff & Bold, 1963).

Local distribution: Dry lands Peshawar and Dera Ismail Khan.

Soil depth: 1 and 3 inches.

Geographical distribution: North America, Pakistan.

3. Bracteacoccus minor (Chodat) Petrova, Die Vermeintliche Heterokonte "Botrydiopsis" minor - eine chlorophyceae. Beih. 2. Bot. Centralbl. 48:221-228. 1931.

Starr, p.63, figs.143-153. 1955. Bischoff & Bold, p.56, 1963.

Vegetative cells spherical at all stages; at stationary phase 5-20 µm in diameter; cell wall smooth, not thickening with age; zoospores spindle-shaped, some having blunt posterior poles, 5-7 µm long, 1-3 parietal chloroplasts, stigma very small and slightly posterior to the equator of cell (pl.11, fig.119).

Anjum 12, Jan. 18, 1977.

Habitat: Terrestrial (Bischoff & Bold, 1963).

Local distribution: Dry land, Peshawar.

Soil depth: 4 inch

Geographical distribution: North America, Pakistan.

4. Bracteacoccus pseudominor Bischoff & Bold, Phycological studies IV, p.52, 57, figs.82-84, 143. 1963.

Vegetative cells spherical to subspherical, depending on age; mature cells spherical, with a maximum diameter of 25 µm; sometimes vegetative cells coherent, forming amorphous masses; cell wall smooth thin, not thickening with age; chloroplast plate-like, large and parietal; contractile vacuoles absent; mature cells multinucleate; asexual reproduction by zoospores and aplanospores; zoospores 2.2-2.8 µm broad, 6.5-7.5 µm long, ovoid, with 2 parietal chloroplasts, 2 anterior contractile vacuoles, anterior nucleus, posterior stigma, 2 flagella of unequal length; sexual reproduction not observed (pl.11, fig.122).

Anjum 105, March 12, 1978.

Habitat: Terrestrial (Bischoff & Bold, 1963).

Local distribution: Moist land, Dera Ismail Khan.

Soil depth: 3 inch.

Geographical distribution: North America, Pakistan.

CHLOROSARCINOPSIS Herndon

Studies on Chlorosphaeracean algae from soil. Amer. J. Bot., 45:298-308. 1958.

Cells unicellular, capable of vegetative cell division, unrestricted in direction; cells with parietal chloroplast; one or more pyrenoids; zoospores with two flagella of equal length, becoming spherical at quiscence.

Key to the species

1. Cell packets very large..... C. pseudominor (4)
1. Cell packets small..... 2
2. Mature cells 10 µm broad..... 3
2. Mature cells 16 µm broad..... 4
3. Cell packets readily dissociating. C. deficiens (3)
3. Cell packets not readily dissociating..... C. arenicola (1)
4. Cell packets 2-4 celled..... C. auxotropica (2)
4. Cell packets 4-16 celled..... C. sempervirens (5)

1. Chlorosarcinopsis arenicola Groover & Bold, Phycological studies VIII, p.31, figs.21-22, 102-106, 159-19, 159-20. 1969.

Vegetative cells spherical when solitary, 3-10 µm in diameter, chloroplast parietal, pyrenoid one, uninucleate, walls not thickening with age; mature

cells spherical, with numerous orange-red oil droplets; cell packets formed by successive vegetative divisions; packets 8-celled, three dimensional, irregular in shape, surrounded by a colloidal matrix, not readily dissociating; asexual reproduction by biflagellate zoospores produced by repeated biparitions, elongate to ovoid, anterior and often tapered slightly, 2-4 µm broad, 6-14 µm long, wall-less, with an anterior nucleus, two contractile vacuoles, a small linear, anterior stigma, a medial sometimes posterior pyrenoid, parietal plastid; sexual reproduction not observed (pl.11, fig.126).
Anjum 109, April 4, 1978.

Habitat: Terrestrial (Groover & Bold, 1969).
Local distribution: Moist land, Dera Ismail Khan.
Soil depth: 1 inch.

Geographical distribution: North America, Pakistan.

2. Chlorosarcinopsis auxotropica Groover & Bold,
Phycological Studies VIII, p.24, figs.14-15, 81-87, 159-13. 1969.

Vegetative cells spherical when solitary, 4-16 µm broad, uninucleate, cell wall not thickening with age, chloroplast parietal, 1-2 pyrenoids; cell packets formed by successive vegetative divisions, 2-4 celled; small, irregular, three dimensional packets occasionally observed; packets devoid of a gelatinous matrix, readily dissociating;

asexual reproduction by biflagellate zoospores, ovoid to slightly elongate, 3-4 µm broad, 6 µm long, with an anterior linear stigma, a median sometimes posterior pyrenoid, a parietal plastid; sexual reproduction not observed (pl.11, fig.124).

Anjum 113, April 17, 1978.

Habitat: Terrestrial (Groover & Bold, 1969).

Local distribution: Garden soil, Peshawar.

Soil depth: 5 inch.

Geographical distribution: North America, Pakistan.

3. Chlorosarcinopsis deficiens Groover & Bold, Phycological Studies VIII, p.37, figs.26-27, 121-126, 159-23. 1969.

Vegetative cells spherical when solitary, 4-10 µm broad, chloroplast parietal, pyrenoid one, uninucleate, wall not thickening with age, devoid of gelatinous matrices; cell packets formed by successive vegetative divisions, small, 2-4 celled, in one plane, 8-celled cuboidal packets not infrequent, devoid of gelatinous matrix, readily dissociating; asexual reproduction by biflagellate zoospores, produced by repeated bipartitions, ovoid, 3-4 µm in diameter, 6-8 µm long, with a small anterior stigma, two anterior contractile vacuoles, a posterior nucleus, a medial to slightly

anterior pyrenoid, a parietal plastid; sexual reproduction not observed (pl.11, fig.127).

Anjum 110, April 6, 1978.

Habitat: Terrestrial (Groover & Bold, 1969).

Local distribution: Moist land, Dera Ismail Khan.

Soil depth: 5 inch.

Geographical distribution: North America, Pakistan.

4. Chlorosarcinopsis pseudominor Groover & Bold, Phycological Studies VIII, p.29, figs.17-20, 94-101, 159, 15,16,17,18. 1969.

Vegetative cells spherical when solitary, 4-10.4 µm in diameter, chloroplast parietal, cup-shaped, pyrenoids, 1-2, uninucleate, cell walls thin; mature cells forming hormotile-like stages; cell packets three-dimensional, large, cuboidal, devoid of gelatinous matrix, not readily dissociating; asexual reproduction by biflagellate zoospores, produced by repeated bipartitions, elongate to ovoid, not pointed at the anterior end, 2-5 µm in diameter, 4-12 µm long, wall-less, with an anterior stigma, two contractile vacuoles, a posterior nucleus, sometimes slightly posterior pyrenoid, a parietal plastid; sexual reproduction not observed (pl.11, fig.125, photo 52).

Anjum 111, April 10, 1978; Anjum 111A, April 16, 1978;

Anjum 111B, April 21, 1978; Anjum 111C, April 26, 1978; Anjum 111D, April 27, 1978; Anjum 111E, April 29, 1978.

Habitat: Terrestrial (Groover & Bold, 1969).

Local distribution: Dry lands, Peshawar.

Soil depth: 1,2,3,4,5 and 6 inches.

Geographical distribution: North America, Pakistan.

5. Chlorosarcinopsis sempervirens Groover & Bold, Phycological Studies VIII, p.22, figs.12-13, 70-80, 159. 1969.

Solitary vegetative cells spherical, 6-12 µm broad, chloroplast parietal, pyrenoid one, uninucleate, walls not thickening with age; mature cells with an individual gelatinous matrix; cell packets formed by successive vegetative divisions, 2-16 celled, cubiodal, with a common colloidal matrix, not readily dissociating; vegetative reproduction by the occasional dissociation of packets; asexual reproduction by ovoid biflagellate zoospores produced by repeated bipartitions, 3 µm in diameter, 6 µm long, with an anterior linear stigma, two contractile vacuoles, a median sometimes posterior pyrenoid, a parietal plastid; sexual reproduction not observed (pl.11, fig.123, photo 53).

Anjum 20, March 14, 1977; Anjum 20A, Nov. 10, 1977.

Habitat: Terrestrial (Groover & Bold, 1969).

Local distribution: Wheat field, Peshawar; Moist land, Dera Ismail Khan.

Soil depth: 1, 2 inches.

Geographical distribution: North America, Pakistan.

TETRACYSTIS Brown & Bold

Phycological studies, V. Comparative Studies of the algal general Tetracystis and Chlorococcum. Univ. Texas, 1964.

Vegetative cells isolated or in groups of 2,4, 8 or in multiple of 2 or 4; daughter cells of the groups associated at first, sometimes secondarily dissociating; cells with a hollow, more or less massive, parietal chloroplast, often traversed by fissures, with one pyrenoid; asexual reproduction by division into 2-8 vegetative cells which lack the potentiality of direct motility, thus differing from aplanospores which arise from motile or potentially motile precursors; asexual reproduction also by zoospores formed of cells of all ages including the daughter vegetative cells of the tetrads; zoospores not becoming spherical immediately upon quiescence.

Key to the species

1. Tetrads forming complexes..... 2.
1. Tetrads not forming complexes..... T. excentrica (1)
2. Tetrads isobilateral..... T. isobilateralis (3)

2. Tetrads otherwise..... 3

3. Cells up to 20 µm broad..... T. intermedium (2)

3. Cells smaller.....4

4. Pyrenoids with two starch grains.....T. texensis (6)

4. Pyrenoids with many starch grains..... 5

5. Cells 14 µm broad..... T. pampae (4)

5. Cells 15-18 µm broad..... T. tetrasporium (5)

1. Tetracystis excentrica Brown & Bold, Phycological Studies. V. p.18, figs.1-12, 101-102. 1964.

Young vegetative cells ellipsoidal, rapidly maturing into spherical vegetative cells, 16 µm in diameter, chloroplast parietal, sometimes massive, punctate, large clear internal cytoplasmic area in mature vegetative cells, one excentric, ellipsoidal pyrenoid with two hemispherical starch grains; mature cells yellow-orange in colour, with two to many contractile vacuoles, uninucleate; asexual reproduction by cell-division giving rise directly to tetrads, rarely to diads of vegetative cells which soon dissociate from parent cell wall at maturity; tetrads not forming complexes; asexual reproduction also by zoospores and aplanospores; zoospores cylindrical, 3 µm in diameter,

up to 10 µm long, somewhat pointed anteriorly and broadened posteriorly with a posterior nucleus, two anterior contractile vacuoles, a parietal chloroplast, single equatorial pyrenoid, minute anteriorly placed, linear stigma, two flagella of equal length, slightly shorter than the cell body length; sexual reproduction unknown (pl.12, fig.128, photo 54,55).

However in the present investigation, diads were frequent and tetrads forming complexes were also observed occasionally.

Anjum 162, Nov. 12, 1978.

Habitat: Terrestrial (Brown & Bold, 1964).

Local distribution: Rice field Methra, District Peshawar.

Soil depth: 3 inch.

Geographical distribution: North America, Pakistan.

2. Tetracystis intermedium Brown & Bold, Phycological Studies, V. p.27, figs.73-78, 89-100. 1964.

= Chlorococcum intermedium Deason & Bold, p.25. 1960.

Young vegetative cells ellipsoidal; mature vegetative cells spherical, 12-20 µm broad, cell wall not thickening with age; chloroplast thin, parietal, with a few shallow fissures, one ellipsoidal pyrenoid which is excentric, 2 µm in diameter, surrounded by two starch grains; cells becoming bright-orange in stationary

phase of growth; uninucleate vegetative cells containing two contractile vacuoles; asexual reproduction by cell division giving rise to diads and mostly to tetrads of vegetative cells, at maturity strongly adherent to the parent cell-wall; several tetrads aggregating to form complexes; asexual reproduction also by zoospores and aplanospores formed by rapid successive bipartitions, zoospores 2.5 µm in diameter, 9.5 µm long, with posterior pyrenoid, an anterior stigma, two equal lengthed flagella which are slightly longer than the cell body length; sexual reproduction not observed (pl.12, fig.132, photo 56).

Anjum 71, Nov. 3, 1977.

Habitat: Terrestrial.

Local distribution: Dry hill , Kohat.

Soil depth: 5 inch.

Geographical distribution: North America, Pakistan.

3. Tetracystis isobilateralis Brown & Bold, Phycological Studies V. p.21, figs. 41-48, 81-82. 1964.

Mature vegetative cells spherical to sub-spherical, 18-19 µm in diameter, uninucleate, contractile vacuoles absent; cell walls thickening insignificantly; chloroplast massive, filling the entire cell circumference except for the perinuclear area; deep fissures absent; one large, central pyrenoid, 5-7 µm in diameter, irregularly

shaped and surrounded by many starch plates; cells become green in stationary phase of growth; asexual reproduction by cell division giving rise directly to diads and tetrads of vegetative cells which are intimately associated with the parent wall at maturity; composed of one to several tetrads; zoospores and aplanospores formed by successive bipartition of a multinucleate protoplast; zoospores ovoid, 4-6 µm broad, 8-10 µm long, with a posterior nucleus, 2 anterior contractile vacuoles, a parietal chloroplast, 1 to several equatorial pyrenoids, equatorial to slightly anterior stigma, 2 equal-lengthed flagella 1½ times the body length; sexual reproduction unknown (pl.2, fig.129, photo 57).

Anjum 91, Jan. 21, 1978.

Habitat: Terrestrial (Brown & Bold, 1964).

Local distribution: Maize field, Mardan.

Soil depth: 4 inch.

Geographical distribution: North America, Pakistan.

4. Tetracystis pampae Brown & Bold, Phycological Studies. V. p.23, figs. 57-64, 105-106. 1964.

Young vegetative cells ellipsoidal; mature cells spherical to subspherical, 14 µm in diameter; cell wall thickening insignificant; chloroplast massive, starchy, with few shallow fissures; one slightly excentric

to central, irregularly shaped pyrenoid, 4 µm in diameter, surrounded by many starch-plates; cells remaining bright-green in stationary phase of growth; uninucleate vegetative cells containing 2 contractile vacuoles; asexual reproduction by cell division into diads and mostly tetrads in delayed growth; at maturity, diads and tetrads of daughter cells strongly adherent to parent cell wall; tetrads often forming complexes; zoospores and aplanospores produced by repeated bipartitions of vegetative cells; zoospores cylindrical, 4 µm in diameter, 8 µm long, with a posterior nucleus, 2 contractile vacuoles, parietal chloroplast, single equatorial pyrenoid, an anterior stigma, 2 equal-lengthed flagella, about equal to the cell body length; sexual reproduction not observed (pl.12, fig.130, photo 58).

Anjum 72, Nov. 7, 1977.

Habitat: Terrestrial (Brown & Bold, 1964).

Local distribution: Maize field, Mardan.

Soil depth: 2 inch.

Geographical distribution: North America, Pakistan.

5. Tetracystis tetrasporum Brown & Bold, Phycological Studies, V. p.28, figs.79-80, 93-94. 1964.

= Chlorococcum tetrasporum Arce & Bold, p.493, figs.9-15. 1958.

Young vegetative cells ellipsoidal, mature

cells spherical to subspherical, 15-18 µm in diameter; cell wall thickening insignificant; chloroplast massive, with few shallow fissures; single central to slightly excentric, spherical pyrenoid, 4-5 µm in diameter, surrounded by many closely packed starch-grains; cells remaining green in stationary phase of growth; uninucleate vegetative cells containing 2 contractile vacuoles; asexual reproduction by cell division giving rise to tetrads of daughter vegetative cells; tetrads strongly adherent at maturity to form cellular complexes; zoospores and aplanospore frequently formed; zoospores 4 µm broad, 10 µm long, with a posterior nucleus, 2 anterior contractile vacuoles, a parietal plastid, single equatorial pyrenoid, a large anterior stigma, 2 equal lengthed, slightly shorter than the cell body length flagella; sexual reproduction unknown (pl.12, fig.133, photo 59). Anjum 117, May 6, 1978; Anjum 117A, May 21, 1978.

Habitat: Terrestrial.

Local distribution: Moist lands, Dera Ismail Khan.

Soil depth: 1,2 inches.

Geographical distribution: North America, Pakistan.

6. Tetracystis texensis Brown & Bold, Phycological Studies. V., p.25, figs. 19-24, 95-96. 1964.

Young vegetative cells ellipsoidal, mature

cells spherical, 14-15 µm in diameter; cell wall thickening upto 3-4 µm, thickening increasing in old cells; chloroplast parietal, thin, often striate and deeply lobed; one excentric, ellipsoidal pyrenoid, with two hemispherical starch grains; cells becoming yellow brown in stationary phase of growth; contractile vacuoles absent in the uninucleate vegetative cells; asexual reproduction by cell division giving rise directly to tetrads or octads; tetrads aggregates intimately associated with parent cell walls; octads less intimately associated; octads and most frequently tetrads cohering to form complexes of many cells; zoospores and aplanospores present; zoospores 3 µm broad, 10 µm long, with a posterior nucleus, 2 anterior contractile vacuoles, a parietal chloroplast, single slightly anterior pyrenoid, an anterior stigma, 2 flagella of equal length, slightly shorter than or equal to the cell body length; sexual reproduction not observed (pl.12, fig.131, photo 60,61).

Anjum 104, March 2, 1978.

Habitat: Terrestrial (Mattox, 1961).

Local distribution: Moist land, Dera Ismail Khan.

Soil depth: 3 inch.

Geographical distribution: North America, Pakistan.

CHLOROCOCCUM Menegh.

Monographia Nostochinearum Italicarum, Mem. Reale

Acad. Sci. Torino II. 5:1-143. 1842.

Cells spherical, solitary or more often gregarious in amorphous gelatinous clumps or forming films on moist or submerged substrates; cell wall thin; chloroplast a thin parietal plate, covering the wall or nearly so; pyrenoid one, rarely more than one; reproduction by 8-16 zoospores.

Key to the species

1. Young cells 4-16 µm broad..... C. minutum (11)
1. Young cells broader..... 2
2. Young cells 20-39 µm broad..... C. macrostigmatum (9)
2. Young cells narrower..... 3
3. Pyrenoids 2-3..... C. refringens (15)
3. Pyrenoid one..... 4
4. Cells coherent..... 5
4. Cells not coherent..... 6
5. Cells cohere though lacking matrices..... C. lacustre (8)
5. Cells cohere by their individual matrices..... C. gelatinosum (5)
6. Pyrenoid angular..... C. reticulatum (16)
6. Pyrenoid smooth..... 7
7. Hypnospores present..... C. hypnosporum (6)
7. Hypnospores absent..... 8
8. Cell walls of mature cells

5-7 µm thick..... 9

8. Cells walls of mature cells thin..... 11

9. Mature cells 35-40 µm in diameter. C. microstigmatum (10)

9. Mature cells small..... 10

10. Young cells 5-10 µm in diameter.. C. echinozygotum (3)

10. Young cells 10-15 µm in diameter..... C. aureum (2)

11. Chloroplast fissured..... 12

11. Chloroplast otherwise..... 13

12. Mature cells 25-30 µm in diameter..... C. elkhartiense (4)

12. Mature cells 15-20 µm in diameter..... C. pulchrum (14)

13. Cells egg shaped..... C. oviforme (13)

13. Cells otherwise..... 14

14. Zoospores 10-15 µm long..... C. novae angliae (12)

14. Zoospores shorter..... 15

15. Cell wall of mature cells 3 µm thick..... C. acidum (1)

15. Cell wall of mature cells 2 µm thick..... C. salsugineum (17)

15. Cell wall of mature cells 1 µm thick..... 16

15. Cell wall of mature cells 0.3 µm thick..... C. isabeliens (7)

16. Young cells 10-15 µm in diameter..... C. sphacosum (18)

16. Young cells 15-25 µm in diameter..... C. typicum (19)

1. Chlorococcum acidum Archibald & Bold, Phycological Studies, XI. p.21, figs.9,38,39. 1970.

Young vegetative cells spherical, 15-20 µm in diameter, cell wall 1 µm thick; mature cells up to 25 µm in diameter, cell wall 3 µm thick; chloroplast thin, pyrenoid single, surrounded by an apparently continuous starch sheath; cells uninucleate; reproduction by zoospores and aplanospores; zoospores ellipsoidal, 4 µm broad and 7 µm long, with a posterior nucleus, and an anterior minute stigma (pl.12, fig.134, photo 62). Anjum 11, Jan. 10, 1977; Anjum 11A, Jan. 15, 1977.

Habitat: Terrestrial (Archibald & Bold, 1970).

Local distribution: Wheat field and dry land, Peshawar.

Soil depth: 1 - 3 inches.

Geographical distribution: North America, Pakistan.

2. Chlorococcum aureum Archibald & Bold, Phycological Studies, XI. p.23, figs.11,42,43. 1970.

Young cells spherical, 10-15 µm in diameter, cell wall 1 µm thick; mature cells up to 25 µm in

diameter, with an individual matrix 5-7 µm thick; chloroplast thin, delicate; pyrenoid single surrounded by an apparently continuous starch sheath; contractile vacuoles often present; cells uninucleate; zoospores and aplanospores present; zoospores ovoid, 4 µm broad and 8 µm long, with a posterior nucleus and a minute anterior stigma (pl.12, fig.135, photo 63).

Anjum 78, Nov. 24, 1977; Anjum 78A, Feb. 5, 1978.

Habitat: Terrestrial (Archibald & Bold, 1970).

Local distribution: Maize fields, Mardan.

Soil depth: 4 & 5 inches.

Geographical distribution: North America, Pakistan.

3. Chlorococcum echinozygotum Starr. Ind. Univ. p.18, figs.22-57. 1955.
Archibald & Bold, p.27, figs.16,52. 1970.

Young cells ovoid to subspherical, 5-10 µm in diameter, cell walls thin; in stationary phase of cultures cells spherical, 20-30 µm in diameter, cell walls 5-6 µm thick; chloroplast thin; pyrenoid single, smooth with continuous starch sheath; zoospores and aplanospores present, zoospores 4 µm broad, 6 µm long, with a medial anterior nucleus, and an anterior stigma (pl.12, fig.136, photo 64).

Anjum 7, Dec. 29, 1976.

Habitat: Terrestrial (Bold, 1955).

Local distribution: Dry land, Peshawar.

Soil depth: 6 inch.

Geographical distribution: North America, Pakistan.

4. Chlorococcum elkhartiense Archibald & Bold,
Phycological Studies, XI. p.28, figs.17,53. 1970.

Young cells spherical, 10-15 µm in diameter, cell walls thin; mature cells 25-30 µm in diameter, cell walls 2 µm thick; chloroplast massive, fissured; pyrenoid single surrounded by continuous starch sheath; contractile vacuoles often present; cells uninucleate; zoospores ovoid, 4 µm wide, 8 µm long, with a median posterior nucleus, an anterior stigma; empty zoosporangia persistant for long periods; zoospores usually few in number (pl.13, fig.137, photo 65).

Anjum 53, Sep. 2, 1977.

Habitat: Terrestrial (Archibald & Bold, 1970).

Local distribution: Sorghum field, Peshawar.

Soil depth: 1 inch.

Geographical distribution: North America, Pakistan.

5. Chlorococcum gelatinosum Archibald & Bold,
Phycological studies XI. p.29, figs.19,55. 1970.

Young vegetative cells spherical or ellipsoidal,

10-15 µm in diameter, cell walls thin, 0.5 µm thick; mature cells 30-35 µm in diameter, cell walls 1 µm thick; cytoplasm frothy; pyrenoid one, surrounded by continuous starch sheath; cells coherent by their individual matrices; zoospores and aplanospores present; zoospores 4 µm broad, 8 µm long, with a posterior nucleus and an anterior stigma (pl.13, fig.138, photo 66). Anjum 63, Oct. 12, 1977.

Habitat: Terrestrial (Archibald & Bold, 1970).

Local distribution: Maize field, Mardan.

Soil depth: 2 inch.

Geographical distribution: North America, Pakistan.

6. Chlorococcum hypnosporum Starr, Indiana Univ. p.26, figs.58-80. 1955.

Brown & Bold, p.95, fig.234,240. 1964;

Archibald & Bold, p.30, figs.3,56-57. 1970.

Cells spherical, 11-16 µm in diameter, cell walls thin; mature cells 25-30 µm in diameter with 5-6 µm thick cell walls; pyrenoid single, surrounded by a discontinuous starch sheath, starch grains 4-5 in number; zoospores and aplanospores present; zoospores ellipsoidal, 2.5-5.5 µm broad, 7.5-13 µm long, with a median posterior nucleus, an anterior stigma; echinate hypnospores common, 20-100 µm in diameter with stratified

wall, up to 10 µm thick; sexual reproduction by isogametes; zygote smooth-walled (pl.13, fig.139, photo 67,68,69). Anjum 43, July 12, 1977; Anjum 43A, Oct. 8, 1978; Anjum 43B, Oct. 5, 1978; Anjum 43C, Feb. 15, 1979.

Habitat: Terrestrial (Archibald & Bold, 1970).

Local distribution: Garden soil, Peshawar.

Soil depth: 1,2,3 and 4 inches.

Geographical distribution: North America, Pakistan.

7. Chlorococcum isabeliense Archibald & Bold, Phycological Studies, XI. p.31, figs.20,58,59. 1970.

Young cells spherical, 12-15 µm in diameter; cell walls thin, 0.3 µm thick, cells not increasing markedly in size at mature stage; chloroplast massive; pyrenoid one, surrounded by continuous starch sheath; cells uninucleate; zoospores and aplanospores present; zoospores 3.5 µm broad, 10 µm long, a posterior-median nucleus, an anterior stigma (pl.13, fig.140, photo 70). Anjum 45, July 21, 1977.

Habitat: Terrestrial (Archibald & Bold, 1970).

Local distribution: Garden soil, Peshawar.

Soil depth: 6 inch.

Geographical distribution: North America, Pakistan.

8. Chlorococcum lacustre Archibald & Bold, Phycological Studies, XI. p.32, figs.21,60. 1970.

Young cells spherical, 10-15 µm in diameter, with thin cell walls; mature cells 20-25 µm in diameter with cell walls 1-5 µm thick; cells tending to cohere, though lacking matrices; one angular pyrenoid surrounded by continuous starch sheath; chloroplast thin; contractile vacuoles often present; cells uninucleate; zoospores and aplanospores present; zoospores 3 µm broad, 11 µm long with an anterior nucleus, an anterior stigma and median-posterior pyrenoid (pl.13, fig.141, photo 71).

Anjum 17, Feb. 28, 1977.

Habitat: Terrestrial (Archibald & Bold, 1970).

Local distribution: Dry land, Dera Ismail Khan.

Soil depth: 1 inch.

Geographical distribution: North America, Pakistan.

9. Chlorococcum macrostigmatum Starr, Further Studies in the genus Chlorococcum, Menegh. Lloydia 16: 142-148. 1954.

Archibald & Bold, p.33-34, figs.23,26. 1970.

Young cells spherical, 20-30 µm in diameter, cell wall 1 µm thick; mature cells spherical, increasing to 60 µm with cell walls up to 9 µm thick; pyrenoid single, smooth, surrounded by a continuous starch sheath; reproduction by aplanospores and zoospores; zoospores 4 µm

broad, 8 µm long, with a posterior nucleus and large anterior stigma (pl.13, fig.142, photo 72,73).

Anjum 41, June 30, 1977.

Habitat: Terrestrial (Archibald & Bold, 1970).

Local distribution: Wheat field, Peshawar.

Soil depth: 1 inch.

Geographical distribution: North America, Pakistan.

10. Chlorococcum microstigmatum Archibald & Bold, Phycological Studies, XI. p.34, figs.24,63. 1970.

Young cells spherical, 10-15 µm in diameter, cell wall thin, 0.5 µm thick; mature cells up to 35-40 µm in diameter; cell wall 6 µm thick; chloroplast with a small superficial opening; contractile vacuoles often present; pyrenoid one, surrounded by a continuous starch sheath; cells uninucleate; zoospores and aplanospores present; zoospores spindle-shaped, 4 µm wide, 10 µm long, with a median-posterior nucleus, and an anterior stigma (pl.14, fig.150, photo 75).

Anjum 48, Aug. 4, 1977.

Habitat: Terrestrial (Archibald & Bold, 1970).

Local distribution: Dry land, Dera Ismail Khan.

Soil depth: 4 inch.

Geographical distribution: North America, Pakistan.

11. Chlorococcum minutum Starr, A comparative study of Chlorococcum Menegh. and other spherical zoospore-producing genera of the Chlorococcales, Ind. Univ. p.30, figs.81-103. 1955.

Archibald & Bold, p.35, figs.25,64. 1970.

Young cells ovoid, subspherical or spherical, 4-6 µm in diameter, cell wall thin; mature cells 20 µm in diameter, cell wall 5-6 µm thick; pyrenoid one, surrounded by a continuous starch sheath; reproduction by zoospores and aplanospores; zoospores 3-5 µm broad, 6-7 µm long, with a posterior nucleus, and an anterior stigma; sexual reproduction by isogametes (pl.14, fig.151, photo 74).

Anjum 8, Dec. 31, 1977.

Habitat: Terrestrial (Archibald & Bold, 1970).

Local distribution: Dry land, Dera Ismail khan.

Soil depth: 2 inch.

Geographical distribution: North America, Pakistan.

12. Chlorococcum novae angliae Archibald & Bold, Phycological Studies, XI. p.35, figs.2,65. 1970.

Young cells spherical, 10-15 µm in diam., with cell walls 1 µm thick; cells not increasing in size with age, also cell walls not thickening with age; pyrenoid one, surrounded by discontinuous starch grains; cells

uninucleate, reproduction by zoospores and aplanospores; zoospores 5.5-6 µm wide, 10-12 µm long, an anterior nucleus, stigma anterior to almost equatorial; 2-4 zoospores per zoosporangium; zoospores resembling Chlamydomonas. (pl.14, fig.152, photo 76). However, in the present study, the zoospores were 6-8 µm broad and 10-15 µm long.

Anjum 232, Feb. 25, 1978.

Habitat: Terrestrial (Archibald & Bold, 1970).

Local distribution: Moist land, Dera Ismail Khan.

Soil depth: 1 inch.

Geographical distribution: North America, Pakistan.

13. Chlorococcum oviforme Archibald & Bold, Phycological Studies, XI. p.37, figs.31,75-76. 1970.

Young cells egg-shaped or spherical, 15 µm in diameter, cell wall 1 µm thick; cells not increasing in size with age, cell walls 2-3 µm thick in mature cells; chloroplast massive; pyrenoid single, peripheral, surrounded by a continuous starch sheath; cells uninucleate; zoospores and aplanospores present; zoospores ovoid, 5 µm broad, 10 µm long, with a posterior nucleus and an anterior stigma (pl.13, fig.143, photo 77).

Anjum 5, Dec. 15, 1976; Anjum 5A, Oct. 19, 1977.

Habitat: Terrestrial (Archibald & Bold, 1970).

Local distribution: Dry lands, Peshawar.

Soil depth: 3, 4 inches.

Geographical distribution: North America, Pakistan.

14. Chlorococcum pulchrum Archibald & Bold, Phycological Studies, XI. p.40, figs.4,73-74. 1970.

Young cells spherical, 10-15 µm in diameter, cell walls thin, 0.3 µm thick; mature cells 15-20 µm in diameter, cell wall 1 µm thick; chloroplast massive, with a superficial opening, delicate fissures; pyrenoid one; cells uninucleate; reproduction by zoospores and aplanospores; zoospores ovoid, 3 µm wide, 7 µm long, with a posterior nucleus and an anterior stigma (pl.13, fig.144, photo 79).

Anjum 87, Jan. 7, 1978.

Habitat: Terrestrial (Archibald & Bold, 1970).

Local distribution: Wheat field, Peshawar.

Soil depth: 5 inch.

Geographical distribution: North America, Pakistan

15. Chlorococcum refringens Archibald & Bold, Phycological Studies, XI. p.41, figs.32,77. 1970.

Young cells spherical, 10-15 µm in diameter, cell wall thin, 0.3 µm thick; mature cells 30-35 µm in diameter, cell wall 2 µm thick; pyrenoids 2-3, each

pyrenoid surrounded by discrete starch grains; cells uninucleate; zoospores and aplanospores present; zoospores spindle-shaped, 3 µm wide, 7 µm long, with an anterior nucleus and an anterior stigma (pl.13, fig.145, photo 80).

Anjum 6, Dec. 20, 1976; Anjum 6A, Sep. 10, 1977; Anjum 6B, Sep. 14, 1977.

Habitat: Terrestrial (Archibald & Bold, 1970).

Local distribution: Dry lands and Garden soil, Peshawar.

Soil depth: 1, 2 and 3 inches.

Geographical distribution: North America, Pakistan.

16. Chlorococcum reticulatum Archibald & Bold, Phycological Studies, XI. p.42, figs.7,78-79. 1979.

Plant mass rough and reticulate unlike other species; young cells spherical, 15-20 µm in diameter, cell wall 2 µm thick; mature cells 25 µm in diameter; cell wall not thickening with age; chloroplast with a superficial opening; one hexagonal, angular pyrenoid, surrounded by continuous starch sheath; cells uninucleate; reproduction by zoospores and aplanospores; zoospores ellipsoidal, 3 µm broad and 11 µm long, with an anterior-median nucleus and an anterior stigma (pl.14, fig.146, photo 81).

Anjum 51, Aug. 22, 1977.

Habitat: Terrestrial (Archibald & Bold, 1970).

Local distribution: Wheat field, Peshawar.

Soil depth: 6 inch.

Geographical distribution: North America, Pakistan.

17. Chlorococcum salsugineum Archibald & Bold, Phycological Studies, XI. p.44, figs.5,81-82. 1970.

Young cells spherical to ellipsoidal, 15-20 µm in diameter, cell wall 1 µm thick; mature cells 30 µm in diameter, cell wall 2 µm thick; chloroplast massive; one pyrenoid surrounded by a continuous starch sheath; cells uninucleate; reproduction by zoospores and aplanospores; zoospores 5 µm broad and 10 µm long, spindle-shaped, with a posterior nucleus, and an anterior stigma (pl.14, fig.147, photo 82).

Anjum 61, Oct. 6, 1977; Anjum 61A, Oct. 9, 1977.

Habitat: Terrestrial (Archibald & Bold, 1970).

Local distribution: Moist lands, Dera Ismail Khan.

Soil depth: 3, 4 inches.

Geographical distribution: North America, Pakistan.

18. Chlorococcum sphacosum Archibald & Bold, Phycological Studies, XI. p.45, figs.34,84-85. 1970.

Young cells ellipsoidal or spherical, 15-25 µm in diameter, cell wall thin, 0.5 µm thick; cells not increasing in size with age; however, cell walls becoming 1 µm thick; chloroplast massive; single pyrenoid surrounded by a continuous starch sheath; cells uninucleate; reproduction by zoospores and aplanospores; zoospores ovoid, 3.5 µm broad and 10 µm long, with a posterior nucleus and an anterior stigma (pl.14, fig.148, photo 83).

Anjum 157, Nov. 1, 1978; Anjum 157A, Nov. 12, 1978.

Habitat: Terrestrial (Archibald & Bold, 1970).

Local distribution: Wheat fields, Peshawar.

Soil depth: 1, 2 inches.

Geographical distribution: North America, Pakistan.

19. Chlorococcum typicum Archibald & Bold, Phycological Studies, XI. p.46, figs.36,89-91. 1970.

Young cells spherical, 10-15 µm in diameter, with cell walls 0.3 µm thick; mature cells 20 µm diameter, cell wall 1 µm thick; chloroplast thin; one pyrenoid surrounded by a continuous starch sheath; cells uninucleate; reproduction by zoospores and aplanospores; zoospores ovoid 4 µm broad, 10 µm long with a posterior nucleus and an anterior stigma (pl.14,fig.149, photo 78,84).

Anjum 40, June 23, 1977.

Habitat: Terrestrial (Archibald & Bold, 1970).

Local distribution: Garden soil, Peshawar.

Soil depth: 6 inch.

Geographical distribution: North America, Pakistan.

EREMOSPHAERA De Bary

Untersuchungen ueber die Familie der Conjugaten. 1858.

Cells large, 20-200 µm in diameter, spherical, subspherical or ellipsoidal; usually solitary, occasionally in groups of 2-4; cell wall with or without polar thickenings; usually with a gelatinous sheath which may be broad or narrow, regular or irregular in outline, pectinaceous or non-pectinaceous; cells uninucleate, nucleus massive, central; cytoplasm dissected into three sharply-defined regions, viz: an avacuolate, granular perinuclear layer; a multistranded radial system; and a peripheral reticulate system.

Cytoplasm highly vacuolated; chloroplasts numerous, variously shaped, parietal or radial, pyrenoid one to many; reproduction by autospores.

Key to the species

1. Cells 20-40 µm in diameter..... E. eremosphaeria (1)

1. Cells 80-200 µm in diameter.... E. viridis (2)

1. Eremosphaera eremosphaeria Smith & Bold, Phycological

Studies, VI. p.87, figs.35-41. 1966.

= Oocystis eremosphaeria Smith, 1918.

Cells broadly to narrowly ellipsoidal, small, 20-40 µm in diameter, mostly 25-30 µm; cell wall relatively thin, 0.5-1 µm, ornamented with polar nodules, surrounded by a firm, regular, non-pectinaceous sheath; nucleus central; chloroplast polygonal to elongate, peripheral, sometimes radial, each with a single pyrenoid; reproduction by 2-4 compact autospores, released from localized gelatinizations of the mother cell wall aided by daughter cell expansion; resting cells not observed (pl.15, fig.158).

Anjum 34, May 27, 1977.

Habitat: Aquatic (Smith & Bold, 1966).

Local distribution: Dry land, Peshawar.

Soil depth: 1 inch.

Geographical distribution: North America, Pakistan.

2. Eremosphaera viridis De Bary, Untersuchungen Uber die Familie des Conjugaten 1858;

Collins, p.154, pl.5, fig.39. 1909; Heering, p.109, fig.70. 1914; Prescott, p.240, pl.53, fig.22. 1951; p.66, pl.3, fig.47. 1969; Siddiqui & Faridi, p.67, fig.70. 1964.

= Chlorosphaera oliver Henfry. 1859.

= Eremosphaera viridis Var. ovalis Play fair. 1916.

= Eremosphaera viridis var. nodosa Play fair. 1916.

Cells subspherical or spherical, relatively large, 80-200 µm in diameter, mostly 120-170 µm in diameter, cell solitary; cell wall smooth, thin, 0.5-1 µm thick; cells occasionally with many concentric wall layers; usually with a broad or narrow irregular pectinaceous sheath; nucleus with 2-5 nucleoli; chloroplast lens-shaped; parietal or radial, occasionally perinuclear, each with one or two pyrenoids; autospore formation effected by one or rarely two cell divisions; daughter cell existance within nondistended mother cell wall usually ephemeral, terminated by breakage of the wall resulting from daughter cell expansions; resting spores brick-red; zoospores 3-3.5 µm wide, 11 µm long, biflagellate, flagella unequal in length (pl.15, fig.157, photo 85).

Anjum 69, Oct. 28, 1977; Anjum 69A, Nov. 8, 1977.

Habitat: Cosmopolitan.

Local distribution: Dry land, Dera Ismail Khan; Wheat field, Peshawar.

Soil depth: 2 & 3 inches.

Geographical distribution: Worldwide.

PLANKTOSPHAERIA G.M.Smith

A second list of algae found in Wisconsin lakes. Trans. Wisconsin Geol. and Nat. Hist. Surv. 57: 1-243. 1918.

Cells spherical, chloroplast with many separate discs each containing a pyrenoid; zoospores without wall, with two equal lengthed flagella. Represented by a single species.

1. Planktosphaeria texensis Bischoff & Bold, Phycological Studies, IV. p.36, figs.50-60, 119-121. 1963.

Vegetative cells solitary or colonial, enveloped by an individual and common matrices; cells spherical at all ages; mature cells 50 µm in diameter; cell wall smooth, thin, not thickening with age; chloroplast parietal, prismatic; each chloroplast with one pyrenoid; starch abundant; oil droplets absent; cytoplasm vacuolated; contractile vacuoles absent; mature cells multinucleate; reproduction by zoospores and aplanospores; zoospores elongate, becoming ovoidal, 2.5-3.5 µm broad, 8.3-11.6 µm long, one parietal disected chloroplast, a large anterior nucleus, linear equatorial to posterior stigma, 2 equal-lengthed flagella; sexual reproduction unknown (pl.15, fig.159).

Anjum 73, Nov. 10, 1977.

Habitat: Terrestrial (Bischoff & Bold, 1963).

Local distribution: Dry land, Peshawar.

Soil depth: 1 inch.

Geographical distribution: North America, Pakistan.

DICTYOCOCCUS Gerneck emend. Starr

A comparative study of Chlorococcum Menegh. & other spherical zoospore producing genera of the chlorococcales, Ind. Univ. Sci. Ser. 1955.

Cells solitary, spherical, of varying sizes; cell wall smooth; protoplast of varying number of units separated by plasma membranes; number of units increasing with cell size; divisions of protoplast appear in fresh specimens as separate chromotophores, each unit with one polygonal chromatophore whose inner surface bears a variable number of centripetally projecting processes; chromatophores of young cells parietal, in mature cells both parietal and internal; pyrenoids absent; starch present; asexual reproduction by zoospores and aplanospores; zoospores with two equal-lengthed flagella, without walls; sexual reproduction unknown. One species was observed for this genus.

1. Dictyococcus varians Gerneck emend. Starr, A comparative study of Chlorococcum Menegh. and other spherical zoospore producing genera of the

Chlorococcales, Ind. Univ. Sci. Ser. 1955. Brunnthaler, p.66, fig.4. 1915; Starr, p.57, figs.128-142. 1955.

Cells solitary, spherical, with a maximum diameter of 60 µm; cell wall smooth, thickening with age to 3-4 µm; protoplast of varying number of units separated by plasma membranes only; number of units increase with cell size; divisions of protoplast in living cells as separate chromatophores, each unit with one polygonal chromatophore whose inner surface is composed of a variable number of centripetally projecting processes; chromatophores of young cells parietal only, in old cells both parietal and internal; protoplast multinucleate in all but youngest cells; units of protoplast multinucleate also; pyrenoids absent, starch present; little or no oil present; zoospores and aplanospores frequent; zoospores ovoid, 3 µm wide, 7.5 µm long, with a linear anterior stigma, 2 flagella of equal length, without walls, becoming spherical at quiscence; sexual reproduction not observed (pl.15, fig.162).

Anjum 181, Dec. 19, 1978; Anjum 181A, Dec. 20, 1978.

Habitat: Aquatic (Starr, 1955); terrestrial.

Local distribution: Dry hills, Abbottabad.

Soil depth: 3 & 4 inches.

Geographical distribution: Pakistan, Scotland.

NEOCHLORIS Starr

A comparative study of Chlorococcum Menegh. and other spherical, zoospore-producing genera of the Chlorococcales, Ind. Univ. Sci. Ser. No.20, 1955.

Cells nonmotile, solitary, spherical at all ages; cell wall smooth; chromatophore a parietal, hollow sphere, with an opening at one side; pyrenoid present; zoospores & aplanospores present; zoospores with two equal lengthed flagella, without a body wall; sexual reproduction unknown. The genus is represented by a single species.

1. Neochloris cohaerens Groover & Bold, Phycological Studies, VIII. p.45, figs.34,134-142, 159-29. 1969.

Vegetative cells spherical when solitary, young cells 3-12 µm in diameter; mature cells up to 20 µm in diameter; cell walls not thickening with age; chloroplast parietal, cup-like; pyrenoid one spherical, curved with a mass of minute starch grains; cells uninucleate; contractile vacuoles not observed; asexual reproduction by zoospores, aplanospores and autospores; zoospores biflagellate, produced by repeated bipartition, ovoid to elongate, 2-3 µm wide, 6-8 µm long, wall-less, a small anterior to medial stigma, two anterior contractile

vacuoles, an anterior nucleus, a minute medial to posterior pyrenoid, and a parietal plastid, autospores spherical, 4-8 in number; aplanospores 16-32 in number; autospores and aplanospores usually not liberated but coherent after disintegration of parent wall; sexual reproduction not observed (pl.15, fig.163, photo 86). Anjum 19, March 5, 1977; Anjum 19A, March 10, 1977; Anjum 19B, March 29, 1978.

Habitat: Terrestrial (Groover & Bold, 1967).

Local distribution: Garden soil, Peshawar; Moist land, Dera Ismail Khan.

Soil depth: 1,2 and 3 inches.

Geographical distribution: North America, Pakistan.

SPONGIOCHLORIS Starr

A comparative study of Chlorococcum Menegh. and other spherical, zoospore-producing genera of the Chlorococcales. Ind. Univ. Sci. Ser. No: 20. p.66. 1955.

Cells spherical to subspherical, of varying sizes, cell wall smooth, sometimes thickening with age; chromatophore a network of anastomosing strands, both parietal and internal, of varying degrees of coarseness; pyrenoid single or many, centrally or parietally located; mature cells multinucleate; zoospores and aplanospores

present; zoospores formed by the progressive cleavage of the protoplast; zoospores with 2 equal flagella, wall-less, becoming spherical upon quiscence; sexual reproduction not observed.

Key to the species

1. Mature cells up to 54 µm in diameter..... S. incrassata (1)

1. Mature cells up to 100 µm in diameter..... S. spongiosa (2)

1. Spongiochloris incrassata Chantanchat & Bold, Phycological Studies, II. p.27, figs.29-35, 93-96. 1962.

Vegetative cells spherical, varying in size; cells with a maximum diameter of 54 µm; cell wall thick, stratified; chloroplast parietal, in mature cells net-like; pyrenoid in young cells when the plastid is entirely parietal, pyrenoid is also parietal, but as the chloroplast becomes more complex and net-like, the pyrenoid becomes central, one; young cells uninucleate, old cells multinucleate; asexual reproduction is by zoospores and aplanospores, zoospores formed by progressive cleavage of the protoplast, ovoid, 2-4 µm broad 8-9 µm long, with 2 equal lengthed flagella, 2 contractile vacuoles, an anterior stigma, a single

anterior nucleus, a parietal chloroplast and a posterior pyrenoid; sexual reproduction not observed (pl.16, fig.171, photo 88).

Anjum 81, Dec. 2, 1977; Anjum 81A, Dec. 18, 1977.

Habitat: Terrestrial (Chantanchat & Bold, 1962).

Local distribution: Maize fields, Mardan.

Soil depth: 1, 2 inches.

Geographical distribution: North America, Pakistan.

2. Spongiochloris spongiosa Starr, A comparative study of Chlorococcum Menegh. and other spherical, zoospore-producing genera of the Chlorococcales, Ind. Univ. Sci. Ser. 20: p. 70-71, figs.154-164. 1955.
= Asterococcus spongiosus Vischer. 1945.

Cells spherical to subspherical; mature cells 100 µm in diameter; cell wall smooth, not thickening with age; chromatophores a fine net-work of interlacing strands, pyrenoid single in young cell, fragmenting in old ones, occupying a central to nearly central position; starch produced; with orange oil droplets in old cells; asexual reproduction by zoospores and aplanospores; zoospores formed by progressive cleavage of the protoplast, elongate to spindle-shaped, 2 µm broad and 15 µm long, an anterior stigma, two anterior contractile vacuoles,

2 flagella of equal length; zoospores metabolic, wall-less, becoming spherical at quiescence, sexual reproduction not observed (pl.16, fig.170).

Anjum 58, Oct. 1, 1977; Anjum 58A, Oct. 11, 1977.

Habitat: Terrestrial (Starr, 1955).

Local distribution: Dry lands, Peshawar.

Soil depth: 3 & 4 inches.

Geographical distribution: Pakistan, Switzerland.

RADIOSHPAERA Snow

The fresh-water algae, in Ward and Whipple, Fresh-water biology, p.115-177. 1918.

Cells spherical; chromatophore asteroid; pyrenoid present; reproduction by zoospores, with two equal flagella; zoospores walled, Chlamydomonas type. One species was recorded for this genus.

1. Radiosphaera dissecta Starr, A comparative study of Chlorococcum Menegh. and other spherical, zoospore producing genera of the Chlorococcales, Ind..Univ. Sci. Ser. 20: p.50, figs.117-127. 1955.

= Macrochloris dissecta Korschikoff. 1926.

Cells nonmotile, spherical; young cells ellipsoidal; cell wall 2 µm thick; mature cells up to 150 µm in diameter, cell wall up to 6 µm thick;

chromatophore asteroid, with a central portion from which lobes radiate; young cells with chromatophores parietal and with simple lobes; pyrenoid central; young cells uninucleate, mature cells multinucleate; contractile vacuoles present; asexual reproduction by aplanospores and zoospores, later Chlamydomonas - like 5 µm wide, 12 µm long, with 2 equal lengthed flagella which are equal to the body length, stigma linear, anterior; chromatophore a parietal plate or asteriod with radiating lobes, walls thin; sexual reproduction unknown (pl.16, fig.172).

Anjum 102, Feb. 20, 1978.

Habitat: Terrestrial (Starr, 1955).

Local distribution: Pine forest, Parachinar.

Soil depth: 5 inch.

Geographical distribution: North America, Pakistan.

CHLORELLA Beijerinek

Kulturversuche mit Zoochlorellen, Lichenegonidien und anderen niederen Algen. Bot. Zeit., 48:758. 1890.

Unicellular, solitary or aggregated in irregular clumps; rounded or ellipsoid; variable in size in the same habitat; chloroplast a parietal cup or merely a plate; with or without pyrenoids; reproduction by 4 or 8 daughter cells (non-motile) produced from the protoplast

of the mother cell.

1. Chlorella ellipsoidea Gerneck, Zur Kenntnis niederen Chlorophyceen Beih. Bot. Centralbl., 21(Abt.2): 250. 1907.

Brunnthaler, p.113, fig.74. 1915; Prescott, p.236, pl.53, figs.11-12. 1951.

= Protococcus monas Ag.

Cells ellipsoidal, sometimes asymmetrical, chloroplast a folded plate covering part of the cell wall; cells 7-8 µm in diameter, 9-9.5 µm long; reproduction by autospores, as many as 32 autospores, (pl.16, fig.164).

Anjum 122, March 30, 1978; Anjum 122A, May 16, 1978; Anjum 122B, May 21, 1978.

Habitat: Aquatic (Prescott, 1951); terrestrial.

Local distribution: Pine forests, Parachinar.

Soil depth: 1,2 and 3 inches.

Geographical distribution: Europe, North America, Pakistan.

OOCYSTIS Naeg.

In: Braun, A. Algarum unicellularum genera nova vel minus cognita. 1855.

Cells relatively small, generally ellipsoidal; mostly with polar nodules at one or both ends of thin ellipsoidal wall; usually lacking gelatinous sheath;

uninucleate; cytoplasm homogeneous, not highly dissected; 1-5 to many chloroplasts, parietal; pyrenoid single in some without pyrenoid in other species; reproduction by 2-16 autospores, loosely entangled within a greatly distended mother cell wall.

Key to the species

1. Cells ellipsoid or fusiform..... O. parva (2)
1. Cells pyriform..... O. pyriformis (3)
1. Cells ovate..... 2
   2. Cells 3-9 µm broad..... O. solitaria (4)
   2. Cells 14-26 µm broad..... O. crassa (1)

1. Oocystis crassa Witrock in Wittrock & Nordstedt Algae aquae dulcis exsiccatae Nos. 201-298, 1879. Collins, p.160, 1909; Brunnthaler, p.125, fig.99. 1915; Prescott, p.243, pl.51, fig.9. 1951; Tiffany & Britton, p.117, pl.101, fig. 318. 1952; Smith, p.259, fig.173D. 1955; Siddiqi & Faridi, p.68, fig.41. 1964.

Unicellular, or in colonies of 2-8, enclosed by a much swollen and gelatinized mother cell wall; cells ovate; poles broadly rounded, with a nodular thickening; chloroplast several, as many as 10, large parietal discs, with pyrenoids; cells 10-20 µm broad, 14-26 µm long (pl.16, fig.168).

Anjum 82, Dec. 10, 1977.

Habitat: Aquatic (Prescott, 1951; Siddiqui & Faridi, 1964); terrestrial.

Local distribution: Maize field, Mardan.

Soil depth: 5 inch.

Geographical distribution: Europe, North America, Pakistan.

2. Oocystis parva West & West, in Jour. Bot. 36; p.335. 1898.

Brunnthaler, p.125, fig.198. 1915; Prescott, p.246, pl.54, fig.3. 1951; p.65, pl.3. fig.45. 1969; Smith, p.99, fig.51F. 1955.

Cells solitary, or in colonies of 2-8, enclosed by the enlarged mother cell wall of the previous generation; 2-4 generations sometimes involved; cells ellipsoid or fusiform with pointed poles, without definite polar nodules; chloroplast 1-3 parietal discs; pyrenoid sometimes present; cells 4-7.5 µm broad, 6-15 µm long; colony up to 43.9 µm in diameter (pl.16, fig.167).

Anjum 178, Dec. 12, 1978; Anjum 178A, Dec. 30, 1978.

Habitat: Aquatic (Prescott, 1951); terrestrial.

Local distribution: Dry lands, Kohat & Peshawar.

Soil depth: 3 & 4 inches.

Geographical distribution: Europe, North America, Pakistan.

3. Oocystis pyriformis Prescott, New species and varieties of Wisconsin algae. Falowia, 1:347-385. 1944.

Prescott, p.246, pl.54, figs.8-9. 1954; Siddiqui & Faridi, p.69, fig.37. 1964.

Cells broadly pyriform-ovoid, with a prominent apiculation at one pole, other end broadly rounded; united in colonies of 2 or 4, chloroplast massive, parietal; pyrenoid one; cells 14-18 µm in diameter, 16-19 µm long; colony of 4 cells up to 36 µm broad and 48.8 µm long (pl.16, fig.166).

Anjum 83. Dec. 15, 1977.

Habitat: Aquatic (Prescott, 1951; Siddiqui & Faridi, 1964); terrestrial.

Local distribution: Maize field, Mardan.

Soil depth: 1 inch.

Geographical distribution: North America, Pakistan.

4. Oocystis solitaria Wittrock, in Wittrock & Nordstedt Algae aquae dulcis exsiccatae, 20-27. 1879.

Collins, p.160, pl.5, fig.44. 1909; Brunnthaler, p.124, fig.94. 1915; Prescott, p.247, pl.54, fig.10. 1951; Tiffany & Britton, p.116, pl.101, fig.319. 1952.

Cells solitary or in colonies of 2-8 cells,

enclosed by the old mother cell wall; cells ovate, or ellipsoidal; poles with nodular thickenings; chloroplasts numerous, parietal plates, each with one pyrenoid; cells 3-9 µm broad, 7-20 µm long (pl.16, fig.165).

Anjum 77, Nov. 20, 1977.

Habitat: Aquatic (Prescott, 1951); terrestrial.

Local distribution: Wheat field, Peshawar.

Soil depth: 2 inch.

Geographical distribution: Europe, North America, Pakistan.

CRUCIGENIA Morren

Me. Sur un végétale microscopique d'un nouveau genre, proposé sous le nomme Microsder, ou conservateur des petites choses. Ann. Sci. Nat. Bot., 20(1): 404-415. 1830.

Colony free-floating, consisting of a plate of 4-16 trapezoid or rhomboid cells, in one plane about a small or large central space; chloroplast parietal; pyrenoid one in each cell; colony enclosed by a thin, inconspicuous gelatinous envelope; colonies adhere to form complexes. Represented by one species.

1. Crucigenia irregularis Wille, Beschreibung einiger Planktonalgen aus norwegischen Suesswasserseen, Centralbl. Biol., 18:302. 1898.

Prescott, p.284, pl.65, fig.6. 1951; Tiffany &

Britton, p.121. 1952; Siddiqui & Faridi, p.82, fig.108. 1964.

Colony free-floating; 4 or multiple of 4 ovate cells not definitely arranged about a central space, not in quadrangular formation, with both lateral and apical walls in contact; chloroplast a parietal plate or discoid, 4 discs in a cell; pyrenoid absent; cells 5-9 µm in diameter, 8-14 µm long (pl.14, fig.154).
Anjum 96, Feb. 6, 1978.
Habitat: Aquatic (Prescott, 1951); terrestrial.
Local distribution: Maize field, Mardan.
Soil depth: 1 inch.
Geographical distribution: Europe, North America, Pakistan.

PALMELLOCOCCUS Chodat

Matériaux pour servir & l'histoire des Protococcoidées. Bull. Herb. Boiss. 2:429. 1894.

Cells unicellular, minute, microscopic, free-floating, cells smooth, spherical or subcylindrical, without setae and gelatinous sheath; chloroplasts 2-4, parietal; reproduction by autospores. One species was cultivated for this genus.

1. Palmellococcus protothecoides Chodat, Etude critique et expérimentale sur le polymorphisme des algues.

Geneva, pl.165, pl.23. 1909.

Thompson, p.136, fig.6, 132. 1959.

Unicellular, subspherical, 7.5-8.5 µm in diameter; cells without a gelatinous sheath; chloroplast 3-4, discoid; autospores in multiples of two, 3.5-5 µm in diameter; sheath around the autospores (pl.14, fig.153).

Anjum 145, Sep. 15, 1978.

Habitat: Terrestrial.

Local distribution: Dry land, Peshawar.

Soil depth: 6 inch.

Geographical distribution: Europe, Pakistan.

SCENEDESMUS Meyen

Beobachtungen ueber einige niedere Algenformen.

Nova Acta Acad. Caes. Leop.-Carol., 14:774, 1829.

Colony of 2-4-8-32 ovoid, fusiform, cresent-shaped, or oblong cells lying side by side in a single series, or in a double row with the cells alternating; cell wall smooth or with spines, teeth, and ridges; chloroplast a parietal plate, covering most of the cell wall, often with a median lateral notch; pyrenoid one.

Key to the species

1. Cell wall with nodular thickenings..... S. incrassatulus (3)

1. Cell wall smooth..... 2

2. Poles of cells rounded..... S. arcuatus (1)

2. Poles of cell narrowed, sometimes pointed..... 3

3. Cells fusiform, all of the same shape in the colony, 4.2-9 µm broad..... S. obliquus (4)

3. Cells fusiform & cresent-shaped in the same colony, 3-6 µm broad..... S. dimorphus (3)

1. Scenedesmus arcuatus Lemm., Das Phytoplankton, Saechsischer Teiche. Forsch. Biol. Stat. z. Ploen, 7:112, pls. 1,2. 1899. Brunnthaler, p.167, fig.232. 1915; Prescott, p.275, pl.62, fig.8. 1951.

Cells arranged forming single or double series of 4-16 oblong-ovate individuals with lateral walls in contact along 1/3 to ½ their length; cell wall without spines or teeth; poles of cells broadly rounded; cells 4-8 µm in diameter, 10-15 µm long (pl.17, fig.189).

Anjum 233, Feb. 27, 1979.

Habitat: Aquatic (Prescott, 1951); terrestrial.

Local distribution: Sugar-cane field, Mardan.

Soil depth: 2 inch.

Geographical distribution: Europe, North America, Pakistan.

2. Scenedesmus dimorphus (Turp.) Kg., Algologische Mittheilungen. I. ueber Gloionema Agh. II. Ueber eine neue Gattung der Confervaceen. Flora, 16:513-528. 1833.

Prescott, p.277, pl.63, figs.8,9. 1951; Siddiqui & Faridi p.77, figs.93,94. 1964.

Colony composed of 4 or 8 fusiform cells arranged in a single or alternating series; inner cells with straight, sharp apices; the outer cells lunate, strongly curved, with acute apices; cells 3-6 µm in diameter, 16-22 µm long (pl.17, fig.188).

Anjum 234, Feb. 27, 1979.

Habitat: Aquatic (Prescott, 1951: Siddiqui & Faridi, 1964); terrestrial.

Local distribution: Sugar-cane field, Mardan.

Soil depth: 6 inch.

Geographical distribution: Europe, North America, Pakistan.

3. Scenedesmus incrassatulus Bohlin, Die Algen der ersten Regnell'schen Expedition. I. Protococcoideen Bih. Kongl. Sv. Vet.-Akad. Handl., 23, Afd. 3, 7:24, pls.1,2. 1897.

Brunnthaler, p.163, fig.210. 1915; Prescott, p.278, pl.63, fig.14. 1951; Siddiqui & Faridi, p.78, fig.96. 1964.

Colony composed of 2-4-8 fusiform subacute cells arranged in either 1 or 2 series (alternating); median cells slightly curved; outer cells definitely curved; with the free walls strongly concave; apices of the cells with a nodular thickening; cells 5-8 µm in diameter, 17-24 µm long (pl.15, fig.160, photo 89).

Anjum 124, June 10, 1978.

Habitat: Aquatic (Siddiqui & Faridi 1964); terrestrial.

Local distribution: Maize field, Mardan.

Soil depth: 1 inch.

Geographical distribution: Europe, North America, Pakistan.

4. Scenedesmus obliquus (Turp.) Kg., Synoposis Diatomacearum oder Versuch einer systematischen Zusammenstellung der Diatomeen, Linnaea, 8:609. 1833.

Brunnthaler, p.163, fig.208. 1915; Prescott, p.279, pl.63, fig.17. 1971; Siddiqui & Faridi, p.78, figs.97,98,99. 1964.

= Scenedesmus acutus Meyen inkl. f. parvus and magnus Bemard.

Colony composed of 2-8 (usually 4 or 8) fusiform cells arranged in a single series; apices of cells apiculate; wall smooth; cells 4.2-9 µm in diameter, 14-21 µm long (pl.17, fig.190).

Anjum 235, Feb. 27, 1979.

Habitat: Aquatic (Prescott, 1951; Siddiqui & Faridi, 1964); terrestrial.

Local distribution: Sugar-cane field, Mardan.

Soil depth: 5 inch.

Geographical distribution: Europe, North America, Pakistan.

QUADRIGULA Printz

Beiträge zur Kenntnis des Chlorophyceen und ihrer verbreitung in Norwegen. Kgl. Norske Vidensk. Selskabs Skrifter , 2:49. 1915.

Colony free-floating, ellipsoidal, of 2-4-8 long-cylindrical or fusiform cells with long axis parallel with that of the gelatinous sheath in which they are enclosed; poles of cells subacute or sharply rounded; chloroplast a parietal plate covering most of the cell wall or sometimes located along one side; pyrenoid sometimes present. Represented by one species.

1. Quadrigula closterioides (Bohlin) Printz, Beiträge zur Kenntnis des Chlorophyceen und ihrer verbreitung in Norwegen. Kgl. Norske Vidensk. Selskabs Skrifter , 2:49. 1915.

Prescott, p.260, pl.58, figs.9,10. 1951.

Cells long, straight, but with one margin

slightly curved, cylindrical in the mid-region, tapering to sharply rounded apices, arranged in longitudinal bundles of 4 within a fusiform colonial envelope; chloroplast parietal, covering almost the entire cell wall, with a median notch; pyrenoid one, cells 4-6 µm in diameter, 22-35-(45) µm long (pl.17, fig.191).

Anjum 236, Feb. 28, 1979.

Habitat: Aquatic (Prescott, 1951); terrestrial.

Local distribution: Sugar-cane field, Mardan.

Soil depth: 4 inch.

Geographical distribution: Europe, North America, Pakistan.

TETRAËDRON Kg.

Phyc. germ, p.129. 1845.

Cells solitary, unattached, of various shapes, triangular and flat, pyramidal, polyhedric; the angles entire, with or without spines or variously lobed to form dichotomous or trichotomous spine-tipped processes; chloroplast one to many parietal discs or plates; pyrenoids usually present.

Key to the species.

1. Cells triangular..... T. muticum (3)
1. Cells quadrangular..... T. constrictum (1)
1. Cells irregularly 5 or 6 angled... T. gigas (2)

1. Tetraëdron constrictum G.M.Smith, Phytoplankton of inland lakes of Wisconsin. Part.I. Wis. Geol. and Nat. Hist. Surv., Bull. 57:122; pls. 1-51. 1920.

Prescott, p.264, pl.59, fig.28. 1951.

Cells quadrangular in outline, tetrangonal, 2 sides subparallel, the other 2 deeply concave; the angles extended into slightly tapering processes which are dichotomously branched and tipped with a short spine; in side view fusiform, the processes at the superimposed poles of cell not quite in the same plane but slightly turned at different angles; cells 5-8 µm in diameter, without processes, 8 µm thick, 18-25 µm long (pl.17, fig.182).

Anjum 238, March 3, 1979.

Habitat: Aquatic (Prescott, 1951); terrestrial.

Local distribution: Sugar-cane field, Mardan.

Soil depth: 1 inch.

Geographical distribution: North America, Pakistan.

2. Tetraëdron gigas (Wittr.) Hansgirg, Ueber die Suesswasser-Gattungen Trochiscia Kg. (Acanthococcus Lagerh., Glochiococcus De-Toni) und Tetraëdron Kg. (Astericium Corda, Polyedrium Naeg., Cerasterias Reinsch).

Hedwigia, 27:131. 1833.

Brunnthaler, p.148, fig.159. 1915; Prescott, p.265. 1951.

= Polyedrium gigas Wittrock.

Cells relatively large, irregularly 5 or 6 angled, the processes broadly rounded, with the margins between the angles broadly concave cells 35-45 µm in short diameter, 65-75 µm long (pl.17, fig.183).

Anjum 237, March 1, 1979.

Habitat: Terrestrial.

Local distribution: Sugar-cane field, Mardan.

Soil depth: 4 inch.

Geographical distribution: Europe, Pakistan.

3. Tetraëdron muticum (A. Braun) Hansgirg, Ueber, die Suesswasser-gattungen Trochiscia Kg. (Acanthococcus Lagerh., Glochiococcus De Toni) und Tetraëdron Kg. (Astericium Corda, Polyedrium Naeg., Cerasterias Reinsch). Hedwigia, 27:131. 1888.

Brunnthaler, p.146, fig.153. 1915; Prescott, p.267, pl.60, figs.16,17. 1951; Siddiqui & Faridi, p.73, fig.53. 1964.

= Polydrium muticum A. Braun.

Cells small, flat, triangular, the angles without spines or furcations; sides of the cell emerginate or slightly convex; cells 6-18 µm in diameter

(pl.17, fig.184).

Anjum 240, March 6, 1979.

Habitat: Aquatic (Prescott, 1951); terrestrial.

Local distribution: Sugar-cane field, Mardan.

Soil depth: 6 inch.

Geographical distribution: Europe, North America, Pakistan.

CHLOROTETRAËDRON MacEntee, Bold & Archibald, Correction of the name Pseudotetraëdron polymorphum (Chlorophyceae):(in press).

= Pseudotetraëdron MacEntee, Bold & Archibald, 1977.

Cells spherical, saccate or tetrahedral; tetrahedral form occasionally persistent in adult cells or represented by four minute, vestigial processes; with a net-like or spongy chloroplast containing usually one central or slightly excentric pyrenoid, sometimes with more pyrenoids in stationary-phase cells; cells multinucleate; reproduction by biflagellate zoospores which become tetrahedral upon quiescence, and by aplanospores. Single species was collected.

1. Chlorotetraëdron polymorphum MacEntee, Bold & Archibald, p.162, figs.1-8, photo 1-13. 1977.

Cells spherical, tetrahedral, or saccate,

attaining a max. diameter of 90 µm, with their walls thickening to 10 µm; chloroplast net-like or spongy with a single central to slightly excentric pyrenoid; zoospores biflagellate, at first pointed both anteriorly and posteriorly, soon becoming rounded posteriorly and later spherical as they become quiescent after a short period of motility; with two anterior contractile vascuoles, and an anterior nucleus, stigma absent; sexual reproduction not observed (pl.17, fig.180, photo 90).

Anjum 239, March 6, 1979.

Habitat: Terrestrial (MacEntee et al., 1977).

Local distribution: Wheat field, Peshawar.

Soil depth: 1 inch.

Geographical distribution: Australia, Pakistan.

COELASTRUM Naeg.

Gutt. einzell. Algen, 137. 1849.

Colony hollow, spherical; cells as many as 128, globose, ovoid or pyramidal; cells either closely adjoined, compressed or interconnected by narrow processes to form a fenestration; daughter colonies present within the parent cell; walls of the parent cells may persist about the new colonies interconnecting them, forming complexes. Represented by single species.

1. Coelastrum microporum Naeg., in A. Braun, Algarum unicellularum genera nova vel minus congnita. p.70. 1855.

Brunnthaler, p.195, fig.307. 1915; Prescott, p.230, pl.53, fig.3. 1951; Tiffany & Britton, p.113, pl.31, fig.312. 1952; Smith, p.248, fig.159A. 1955; Siddiqui & Faridi, p.163, fig.66. 1964.

= Coelastrum robustum Häntzsch

= Coelastrum sphaericum var. compactum Moebius

= Coelastrum indicum Turner.

Coenobium spherical containing 8-64 globose sheathed cells; cells interconnected by very short scarcely discernable gelatinous processes, leaving small intercellular spaces; cells with sheath 8-20 µm in diameter (pl.15, fig.161).

Anjum 80, Nov. 28, 1977.

Habitat: Aquatic (Prescott, 1951; Siddiqui & Faridi, 1964); terrestrial.

Local distribution: Maize field, Mardan.

Soil depth: 2 inch.

Geographical distribution: Europe, North America, Pakistan.

CHARACIUM A. Braun

In: Kg. Sp. Alg. p.208. 1849.

Cells solitary or aggregate, generally stipitate or sometimes nearly sessile; pyriform, ovoid, subspherical, cylindric or fusiform; chromatophore one or several, parietal and laminate to cup-shaped; pyrenoid one or more; cells uninucleate or multinucleate; formation of zoospores and gametes.

Key to the species

1. Apex rounded..... C. naegeli (3)
1. Apex acute..... 2
  2. Cells 15-20 µm broad..... C. acuminatum (1)
  2. Cells smaller..... 3
3. Cells 20-25 µm long..... C. pringsheimii (4)
3. Cells 25-30 µm long..... C. ambiguum (2)

1. Characium acuminatum A. Braun in Kg., Sp. Alg. p.892. 1849.

Brunnthaler, p.79, fig.18. 1915; Prescott, p.216, pl.46, fig.7. 1951; Siddiqui & Faridi, p.57, fig.10. 1964.

Cells oblong or narrowly ovate, narrowed anteriorly to form a short apiculation, acuminate; stipe short; cells 15-20 µm in diameter, 35-40 µm long (pl.17, fig.179).

Anjum 241, March 9, 1979.

Habitat: Aquatic (Prescott, 1951; Siddiqui & Faridi 1964); terrestrial.

Local distribution: Sugar-cane field, Mardan.

Soil depth: 2 inch.

Geographical distribution: Europe, North America, Pakistan.

2. Characium ambiguum Hermann, Ueber die bei Neudamm aufgefundenen Arten der Genus Characium p.26. 1863.

Brunnthaler, p.79, fig.17. 1915; Prescott, p.216, pl.45, fig.11. 1951.

Cells solitary, lance-shaped, fusiform or ensiform, narrowed to a sharp point anteriorly, tapering posteriorly to a fine hair-like stipe, without an attached disc; chloroplast 1-3; cells 4-8 µm in diameter, 25-30 µm long (pl.17, fig.178, photo 91).

However, in the present collection, cells have a small attaching disc.

Anjum 242, March 9, 1979.

Habitat: Aquatic (Prescott, 1951); terrestrial.

Local distribution: Garden soil, Peshawar.

Soil depth: 4 inch.

Geographical distribution: Europe, North America, Pakistan.

3. Characium naegeli A. Braun, in Kg., Sp. Alg. 1849.

Brunnthaler, p.82, fig.29. 1915; Tiffany & Britton, p.108, pl.29, fig.284. 1952; Siddiqui & Faridi, p.58, fig.13. 1964.

Cells 7-18 µm in diameter, 20-42 µm long; cells ellipsoid, lanceolate, pyriform or ovoid, with rounded apex, short stipe, without basal thickenings (pl.17, fig.177, photo 92).

Anjum 114, April 20, 1978.

Habitat: Terrestrial.

Local distribution: Rice field Methra, District Peshawar.

Soil depth: 3 inch.

Geographical distribution: Europe, North America, Pakistan.

4. Characium pringsheimii A. Braun, Alg. Unicell. genera Nova vel minus cognita. 1855.

Brunnthaler, p.80. 1915; Prescott, p.218, pl.45, fig.21. 1951; Tiffany & Britton, p.108, pl.29, fig.285. 1952; Siddiqui & Faridi, p.59, fig.4. 1964.

Cells narrowly elongate-ovoid to fusiform, erect but with a short oblique tip; stipe short; chloroplast a laciniate plate; pyrenoid one; cells 6-10 µm broad, 20-25 µm long (pl.17, fig.176).

Anjum 32, May 18, 1976.

Habitat: Terrestrial.

Local distribution: Rice field Methra, District Peshawar.

Soil depth: 1 inch.

Geographical distribution: Europe, North America, Pakistan.

MESOTAENIUM Naeg.

Gatt. einzell. Algen, p.137, pl.8. 1849.

Cells cylindrical or subcylindrical, solitary or embeded in layers within a common watery gelatinous matrix; cells with broadly rounded poles; cell wall without pores; chloroplast axial, laminate; pyrenoids one to few; cells uninucleate; often contains oil droplets; some species purple or violet due to phycoparaphyrin; asexual reproduction by cell division or lid-like abscission of the wall at one pole and escape of protoplast followed by its development into a spherical aplanospore of a reddish-brown colour; sexual reproduction by conjugation with a tube; thick-walled zygotes produce 2 or 4 new cells; parthenospores common. Represented by a single species.

1. Mesotaenium purpureum West & West, A monograph of the British Desmidiaceae, vol. 1:55, pl.3, figs. 25-26. 1904.

Cells cylindrical, slightly curved; cells

9.4 broad, 30-40 µm long, 3½ to 4½ times longer than their diameter, apices rounded, chloroplast plate-like, rather thick; cell sap purple or violet in colour (pl.15, fig.156).

Anjum 163, Nov. 15, 1978.

Habitat: Terrestrial.

Local distribution: Rice field Methra, District Peshawar.

Soil depth: 1 inch.

Geographical distribution: Europe, Pakistan.

ROYA West & West

On some North American Desmidiaceae. Tr. Linnean Soc. Bot. 2d. Ser., 5:229-74. 1896.

Cells very slightly arcuate, almost cylindric slightly attenuated toward the extremities, apices subtruncate or obtusely rounded, wall smooth and colourless; one chromatophore in each cell, generally with a small excavation in the middle of the concave side, the extremities convex and extending almost to the extreme ends of the cell; pyrenoids 2-14 in a single series, lacking apical vacuoles and moving granuules; zygote formed by the union of gametes midway between gametangial protuberance. The genus was represented by a single species.

1. Roya obtusa (Bréb.) West & West, A monograph of the British Desmidiaceae, vol.1. p.107, pl.10,

fig.27, 1904.

Tiffany & Britton, p.167, pl.51, fig.533. 1952.

Cells cylindric, 6-15 µm broad, 1.5-8.0 times longer than the diameter, 22-148 µm long, very slightly curved, apices obtusely rounded; chromatophore with an excentric notch at the centre; pyrenoids 2-8; zygote spherical, smooth (pl.17, fig.181).

Anjum 244, March 12, 1979.

Habitat: Terrestrial.

Local distribution: Sugar-cane field, Mardan.

Soil depth: 2 inch.

Geographical distribution: Europe, North America, Pakistan.

CLOSTERIUM Nitzsch ex Ralfs

Brit. Desm. p.159. 1848.

Cells elongate, markedly attenuated, rarely straight, mostly curved, often strongly arcuate or lunate; without a median constriction, poles obtuse, truncate, rostrate, or attenuate to fine needle-like points; cell wall smooth, costate, or striate, colourless or yellow to brown in colour, often with one or more transverse lines either at middle of cell or at different points along the cell; chloroplast entire or with a variable number of longitudinal ridges, one in each semicell; pyrenoids few to many, usually in a single

axial row or more rarely scattered throughout chloroplast; with a terminal vacuole between cell apex and end of the chloroplast, containing one or more crystals of gypsum which exhibit a constant Brownian movement; conjugation between recently divided cells or mature cells. One species was collected.

1. Closterium porrectum Nordst. De Algis Aquae Dulcis, Lund. 1878.
West & West, p.116, pl.11, fig.11. 1904.

Cells of mediam size, about 12 times longer than their diameter, very strongly arcuate; distance between the apices varying from 225-270 µm; outer margin about 160° of arc., inner margin not tumid, gradually and uniformly attenuated to the apices, which are tapering and obtusely rounded; cell wall pale yellow-brown, strongly striate, about 6 stride visible accross the cell; zygospore unknown (pl.17, fig.173).

Anjum 164, Nov. 20, 1978.

Habitat: Terrestrial.

Local distribution: Rice field Methra, District Peshawar.

Soil depth: 3 inch.

Geographical distribution: Europe, Pakistan.

COSMARIUM Corda ex Ralfs

Brit. Desm. p.91. 1848.

Cells variable in size, little longer than wide, few species wider than long, gradually compressed, symmetrical in 3 planes at right angles to each other; constricted in the middle to variable depths; semicells elliptic, subcircular, subquadrate or truncate-pyramidale; apex rounded, truncate or subtruncate, without an apical incision, centre sometimes protuberant; vertical view elliptic, subelliptic, oblong or rarely circular, often having one or more central protuberances on either side; chromatophores usually axial, one in each semicell, with 4 curved longitudinal plates; 1-2 large pyrenoids, parietal with one or more pyrenoids in each; cell wall smooth, punctate, scrobiculate, granulate, verrucose or papillate, with the markings arranged in a definite pattern; zygotes variable in shape, smooth or variously ornamented, sometimes bearing furcate or rarely simple spines; parthenospores.

Key to the species

1. Cell up to 40 µm broad..... C. laeve (3)

1. Cells narrower..... 2

2. Isthmus 7.5 µm broad..... C. granatum (1)

2. Isthmus 6-10 µm broad..... C. granatum var. granatum (2)

1. Cosmarium granatum Bréb., in Ralfs, Brit. Desm. 96, pl.32, figs.6A-6B. 1848.

Smith, p.31, pl.57, fig.18. 1924; Croasdale, p.34, pl.6, figs.11,12. 1956.

Cells fairly small, 30 µm broad, at the apex 9 µm broad, 41 µm long, isthmus 7.5 µm broad; deeply constricted, sinus linear, with apex slightly inflated and outer margin open, isthmus narrow; semicells pyramidale and with apices truncate, basis of lateral margins subparallel for a short distance and then converging or broadly rounded, apical angles obtuse; vertical view elliptic; lateral view ovate; cell wall smooth to minutely punctate; chloroplast axial with a single pyrenoid (pl.17, fig.185).

Anjum 174, Dec. 7, 1978.

Habitat: Aquatic (Croasdale, 1956); terrestrial.

Local distribution: Dry hill, Abbottabad.

Soil depth: 3 inch.

Geographical distribution: North America, Pakistan.

2. Cosmarium granatum Bréb. var. granatum Croasdale, Freshwater algae of Elesmere island, N.W.T. Ottawa. 3:89. pl.XII, figs.16-20. 1973.

Cells 18-27 µm broad, 25-43 µm long, (1.3-1.6x), isthmus 6-10 µm, thickness 12-18 µm, wall punctate, semicells truncate-pyremidale with rounded angles and closed linear sinus, one chloroplast (pl.17, fig.186, photo 93).

Anjum 243, March 10, 1979.
Habitat: Aquatic (Croasdale, 1973); terrestrial.
Local distribution: Rice field Methra, District Peshawar.
Soil depth: 1 inch.
Geographical distribution: Europe, North America, Pakistan.

3. Cosmarium laeve Rabenh. morpha 2, Croasdale, Freshwater algae of Elleswere island, N.W.T., p.93, pl.XIV, figs.28-29. 1973.

Cells 20-40 µm broad, 28-30 µm long (1.45-1.5x); isthmus 6-7.5 µm, thickness 12-13 µm, wall smooth or or widely punctate; cells large, outline slightly irregular (pl.17, fig.187, photo 94).
Anjum 200, Jan. 20, 1979.
Habitat: Aquatic (Croasdale, 1973); terrestrial.
Local distribution: Rice field Methra, District Peshawar.
Soil depth: 2 inch.
Geographical distribution: North America, Pakistan.

SPONDYLOSIUM Bréb.

In Kg. Sp. Alg. p.189. 1849.

Cells small or medium size, flattened, moderately to deeply constricted; sinus linear to open; apex acute or rounded; cells united in long sometimes twisted filaments; with or without gelatinous sheath; semicells usually compressed, rarely radially symetrical, elliptic

to oblong or triangular, often with concave or broadly truncate apices; cell wall smooth or punctate, rarely granulate; chromatophores axial; pyrenoid one; zygote usually spherical, smooth or bearing simple spines; aplanospores. Represented by a single species.

1. Spondylosium pygmaeum (Cooke) West, freshwater algae West Ireland, Linn. Soc. Jour. Bot. 29,116. Tiffany & Britton, p.202, pl.56, fig.626. 1952.

Cells 5-8 µm broad and 5-8 µm long; isthmus 2.5-3.2 µm thick, semicells elliptic, united by relatively small surfaces of their apices into long filaments frequently embedded in a gelatinous sheath; vertical view subelliptic; cell wall smooth, about as long as wide or slightly wider; deeply constricted; sinus acute, almost linear for part of its length (pl.17, fig.193). Anjum 1, Nov. 29, 1976.

Habitat: Terrestrial.

Local distribution: Dry land, Peshawar.

Soil depth: 5 inch.

Geographical distribution: Europe, Pakistan.

X A N T H O P H Y C E A E

Key to the genera of Xanthophyceae

1. Plants colonial..... Gloeobotrys
1. Plants solitary..... Monallantus
1. Plants filamentous..... 2
  2. Filaments branched..... Heterococcus
  2. Filaments unbranched..... Tribonema

GLOEOBOTRYS Pascher

Zur Kenntnis der heterokonten Algen. Arch. f. Protist, 69:438. 1930.

Thallus free-floating or sedentary, gelatinous, with a definite or indefinite shape; cells spherical or slightly ovate, many; sheath very weakly stratified; chromatophores 2-4 parietal plates, or discs; reproduction by aplanospores and zoospores. The genus was represented by a solitary species.

1. Gloeobotrys limneticus (G.M.Smith) Pascher, Heterkonten. In L. Rabenhorst, Kryptogamenflora von Deutschland, Oesterreich und der Schweiz. XO:637. 1937-1939.

Prescott, p.356, pl.93, figs.35,36. 1951.

Colony ovate; 10-30 ovate cells in clusters within a wide, gelatinous envelope; chromatophores 3-4,

yellow-green, parietal discs; cells 5-6 µm in diameter, 6-8 µm long; colonies up to 200 µm in diameter (pl.15, fig.155).

Anjum 144, Sep. 10, 1978.

Habitat: Aquatic (Prescott, 1951); terrestrial.

Local distribution: Dry land, Peshawar.

Soil depth: 1 inch.

Geographical distribution: Europe, North America, Pakistan.

MONALLANTUS Pascher

Heterokonten, In L. Rabenhorst, Kryptogamenflora von Deutschland, Oesterrich und der Schweiz XI. 420. 1939.

Cells solitary or in unjoined clusters of 2-4 cells; sometimes arranged in a series, enclosed by an inconspicuous film of mucilage; oblong with parallel margins, broadly rounded poles; sometimes short cylinders with slightly convex margins; cell wall smooth, sometimes reddish; chromatophores 2-10, band-like or plate-like, parietal; with or without pyrenoid, leucosin granules and red oil globules usually present; reproduction by heterokont zoospores and autospores. Single species was cultured for the genus.

1. Monallantus brevicylindrus Pascher, Heterokonten. In. Rabenhorst, Kryptogamenflora von Deutschland,

Oesterrich und des Schweiz. XI. 422. 1939. Prescott, p.352, pl.95, fig.24. 1951; Smith, p.383, fig.290. 1950.

Cells cylindric, 1/3 to ½ longer than broad; 6-8 µm in diameter, 9-12 µm long; chromatophores 1-2-4; zoospores with 2 flagella, amoeboid, ellipsoid, with one or two chromatophores (p.16, fig.169). Anjum 99, Feb. 11, 1978.

Habitat: Aquatic (Prescott, 1951); terrestrial.

Local distribution: Dry land, Peshawar.

Soil depth: 2 inch.

Geographical distribution: Europe, North America, Pakistan.

TRIBONEMA Derbes & Solier

Memoire sur quelques points de la physiologie des algues. Paris, p.1. 1856.

Filaments composed of cylindrical cells; walls with two sections overlaping in the mid-region of the cell; cells forming H-shaped pieces where fragmentation of the filaments occurs; chromatophores disc-shaped, light yellow-green, 2 to several in a cell; pyrenoid absent.

Key to the species

1. Cell walls thin, many chromatophores. T. bombycium var. tenue (1)

1. Cell walls thick, 2-4 chromatophore.. T. minus (2)

1. Tribonema bombycinum var. tenue Hazen. The Ulotricaceae and Chaetophoraceae of the United States Mem. Torrey Bot. Club, 11:185. 1902.

Prescott, p.367, pl.96, fig.10. 1951.

Filaments much entangled, forming a greyish-yellow cloudy mass; cells with thin walls, cylindrical or slightly constricted at the cross-walls; 3-6 µm in diameter, 10-36 µm long; chromatophores numerous, small, parietal, pale yellow-green discs, sometimes in contact, giving the appearance of 1 or 2 large, irregularly shaped plates (pl.17, fig.175, photo 95).

Anjum 165, Nov. 22, 1978.

Habitat: Aquatic (Prescott, 1951); terrestrial.

Local distribution: Sorghum field, Peshawar.

Soil depth: 3 inch.

Geographical distribution: Europe, North America, Pakistan.

2. Tribonema minus (Wille) Hazen, the Ulotricaceae and Chaetophoraceae of the United States. Mem. Torrey Bot. Club, 11:185. 1902.

Prescott, p.368, pl.96, figs.12-13. 1951;

Tiffany & Britton, p.210, pl.209, fig.647. 1952.

Filaments slender, cells cylindrical, 5-6 µm wide, 23-27 µm long; chromatophores 2-4, relatively large,

parietal, disc-like plates, symmetrically arranged about the wall (pl.17, fig.174, photo 96).

Anjum 44, July 15, 1977.

Habitat: Aquatic (Prescott, 1951); terrestrial.

Local distribution: Garden soil, Peshawar.

Soil depth: 1 inch.

Geographical distribution: North America, Pakistan.

HETEROCOCCUS Chodat

Bull. de l Herb. Boiss. 1908.

Thallus filamentous; filaments freely branched, without differentiation into base and apex; cells uninucleate; chromatophores several, discoid; reproduction by the formation of biflagellate zoospores; aplanospore formation also frequent. Represented by a solitary species.

1. Heterococcus longicellularis Pitschmann, Vorarbeiten zu einer Monographie der Gattung, Heterococcus, Nova Hedwigia, 5: p.516, pl.19, fig.1-4. 1963.

Thallus highly branched; filaments 450 µm long, lateral branches up to 140 µm long; mature cells cylindrical, 22 µm broad; filaments closely entangled; chromatophores disc-like, ellipticle, several; reproduction by aplanospores & akinetes which are at first cylindrical, later become rounded, up to 30 µm broad,

with elliptic chloroplast (pl.17, fig.192, photo 97,98, 99).

Anjum 67, Oct. 24, 1977; Anjum 67A, Oct. 25, 1977; Anjum 67B, Oct. 28, 1977; Anjum 67C, Oct. 30, 1978; Anjum 67D, Nov. 1, 1978; Anjum 67E, Nov. 5, 1978.

Habitat: Terrestrial.

Local distribution: Dry lands, & Wheat fields, Peshawar; Maize field, Mardan; Moist land, Dera Ismail Khan.

Soil depth: 1,2,3,4,5 and 6 inches.

Geographical distribution: Europe, Pakistan.

E U G L E N O P H Y C E A E

EUGLENA Ehrenberg

Ueber die Entewicklung und Lebensdauer der Infusionsthiere; nebst fernere Beitrage zur einer Vergleichung ihrer organischen Systeme. Phys. Abh. Koenigl. Akad. Wiss. z. Berlin, 1831.104. 1833.

Cells mostly free-swimming, rarely creeping; fusiform, cylindrical or ovate; the posterior end either rounded or extending into a fine point or caudus, the anterior end usually narrowed, sometimes conspicuously bilipped; periplast either firm, giving the cell a rigid shape, or soft and pliable; cell metabolic, constantly changing shape in its movements; when firm, periplast decorated with fine spirals, striations or rows of granules; a gullet and a reservoir in the anterior end from which arises a single flagellum of variable length; chloroplasts variable, either numerous ovoid discs, a few ribbon-like bands or rarely star-shaped plates; sometimes with pyrenoids, embedded in the chloroplast protrude from either side. One species was observed for the genus.

1. Euglena proxima var. minima Szabados, A Feher to Volvocales es Flagellate vegetacioja. Hidrol. Koezloeny, 1949(7-8): 1-8. pl.1. Kable. 1949.

Gojdics, p.90, pl.7, fig.10. 1953.

Cells 4-5 µm broad, 10-17 µm long, spindle-shaped, narrow in front, attenuated posteriorly; chromatophores numerous, discoid; flagellum approximately body length (pl.17, fig.196).

Anjum 170, Dec. 2, 1978.

Habitat: Terrestrial.

Local distribution: Rice field Methra, District Peshawar.

Soil depth: 3 inch.

Geographical distribution: Europe, North America, Pakistan.

RESULTS

A total of 245 species with 74 genera belonging to Cyanophyceae, Chlorophyceae, Xanthophyceae and Euglenophyceae were recorded from soils sampled at a depth of 0-6" from various localities of N.W.F.P. Cyanophyceae with 31 genera having 146 species, followed by 38 genera with 93 species of Chlorophyceae, were well-represented groups. Xanthophyceae having 5 species in 4 genera was intermediate in position; while Euglenophyceae with a single species was least-represented group (Table 1).

The density of various recorded species was more at the top layers and it gradually decreased with increasing depth. Some of the species occupying, different vertical niches, were repeatedly found at various depths. Such species were not confined to a particular depth. In dry soils, the total observed species were 110; while in sorghum fields, the only 8 recorded species suggested low frequenty in this case. Sugar-cane fields, having 75 species, followed by 53 species in rice fields were intermediate in position (Table 2).

The presence of 158 species in Peshawar District and 100 species in Mardan District suggested ecologically favourable soil conditions for the growth

of edaphic algae. Soils from Dera Ismail Khan District supporting 62 species were next to Peshawar valley in favouring algal growth. The 6 recorded species from soils of Bannu District pointed out the least suitability for the growth of algae. The reduced number of species observed in Kohat, Abbottabad and Parachinar soils could be due to unfavourable soil conditions for the algal-growth during the period of investigation (Table 3).

Table 1: Algae isolated from soils of N.W.F.P. sampled at 0-6" depth.

S.No	Culture No.	Plants	Soil Depth (") 1	2	3	4	5	6	Source: Habitat	Source: Locality
		CYANOPHYCEAE								
1.	123	Chroococcus cohaerens	-	-	-	-	-	+	Dry land	D.I.Khan.
2.	28, 28A	C. dispersus	-	-	-	-	+	+	Dry lands	D.I.Khan.
3.	106, 106A	C. limneticus var. subsalsus	-	-	+	+	-	-	Dry land, Maize field	D.I.Khan, Mardan.
4.	27, 27A, 27B	C. minor	-	-	-	+	+	+	Dry lands	D.I.Khan
5.	126	C. minutus	-	-	-	+	-	-	Rice field	Methra, Distt. Peshawar.
6.	182	C. turgidus	+	-	-	-	-	-	Rice field	Methra, Distt. Peshawar.
7.	125	C. varius	-	+	-	-	-	-	Rice field	Methra, Distt. Peshawar.
8.	9, 9A, 9B, 9C	Microcystis aeruginosa	+	+	+	+	-	-	Dry lands	D.I.Khan.
9.	35	M. flos-aquae	-	+	-	-	-	-	Dry land	D.I.Khan.

Table 1: continued

S.No.	Culture No.	Plants	Soil Depth (")						Source	
			1	2	3	4	5	6	Habitat	Locality
10.	93	Microcystis marginata	-	-	+	-	-	-	Dry hill	Kohat.
11.	182	M. pseudofilamentosa	-	+	-	-	-	-	Sugar-cane field	Mardan.
12.	74	M. pulverea	-	-	-	-	+	-	Dry land	D.I.Khan.
13.	130	Coelosphaerium dubium	-	-	-	-	-	+	Rice field	Methra, Distt. Peshawar.
14.	98	Chlorogloea microcystoides	-	-	-	-	-	+	Dry land	D.I.Khan.
15.	90	Gloeocapsa crepidinum	-	-	-	+	-	-	Dry land	D.I.Khan.
16.	184, 184A	Gloethece rupestris	+	-	+	-	-	-	Sugar cane fields	Mardan.
17.	50	Aphanothece castagnei	-	-	-	-	-	+	Wheat field	Peshawar.
18.	55	A. gelatinosa	-	-	-	-	-	+	Dry land	Peshawar.
19.	54	A. microscopica	-	+	-	-	-	-	Dry land	Peshawar.

Table 1: continued

S.No	Culture No.	Plants	Soil Depth (")						Source	
			1	2	3	4	5	6	Habitat	Locality
20.	177	Aphanothece saxicola	-	+	-	-	-	-	Dry land	Kohat.
21.	185	Aphanocapsa banaresensis	+	-	-	-	-	-	Sugar cane field	Mardan.
22.	127	A. littoralis	-	-	+	-	-	-	Rice field	Methra, Distt. Peshawar.
23.	128	A. montana	-	-	-	-	+	-	Rice field	Methra, Distt. Peshawar.
24.	129, 129A	Merismopedia glauca	+	+	-	-	-	-	Rice fields	Methra, Distt. Peshawar.
25.	42, 42A, 42B, 42C	M. punctata	+	+	+	+	-	-	Wheat fields	Peshawar.
26.	85	M. tenuissima	-	-	-	-	-	+	Dry land	D.I.Khan.
27.	191	Stichosiphon sansibaricus	-	+	-	-	-	-	Sugar cane field	Mardan.
28.	190	Synechococcus aeruginosus	-	-	+	-	-	-	Sugar cane field	Mardan.

Table 1: continued

S.No	Culture No.	Plants	Soil Depth (") 1	2	3	4	5	6	Source: Habitat	Source: Locality
29.	176	Spirulina gomontiana	-	-	-	-	-	+	Dry hill	Abbottabad.
30.	187	S. laxissima	+	-	-	-	-	-	Sugar cane field	Mardan.
31.	49	S. massartii	-	+	-	-	-	-	Dry land	Peshawar.
32.	189, 189A, 189B	S. meneghiniana	+	+	+	-	-	-	Sugar cane fields	Mardan.
33.	188, 188A	S. platensis	-	-	-	+	+	-	Sugar cane fields	Mardan.
34.	186, 186A	Oscillatoria acutissima	+	+	-	-	-	-	Sugar cane fields	Mardan.
35.	149	O. agardhii	-	-	+	-	-	-	Dry land	Peshawar.
36.	192	O. amoena	+	-	-	-	-	-	Sugar cane field	Mardan
37.	134	O. amphibia	-	-	-	-	-	+	Rice field	Methra, Distt. Peshawar.
38.	70	O. anguina	-	-	-	-	-	+	Dry hill	Kohat.

Table 1: continued

S.No.	Culture No.	Plants	Soil Depth (")						Source	
			1	2	3	4	5	6	Habitat	Locality
39.	15	Oscillatoria animalis	-	-	-	+	-	-	Dry land	Peshawar.
40.	193	O. articulata	+	-	-	-	-	-	Sugar cane field	Mardan.
41.	194, 194A	O. cortiana	-	+	+	-	-	-	Sugar cane fields	Mardan.
42.	132, 132A	O. curviceps	+	+	-	-	-	-	Rice fields	Methra, Distt. Peshawar.
43.	97	O. foreaui	-	-	+	-	-	-	Dry land	D.I.Khan.
44.	60	O. formosa	-	-	-	+	-	-	Dry land	Peshawar.
45.	195	O. laete-virens	+	-	-	-	-	-	Sugar cane field	Mardan.
46.	196	O. lacustris	-	+	-	-	-	-	Sugar cane field	Mardan.
47.	133	O. limosa	-	-	-	-	+	-	Rice field	Methra, Distt. Peshawar.
48.	46	O. lutea	+	-	-	-	-	-	Dry land	D.I.Khan.

Table 1: continued

S.No	Culture No	Plants	Soil Depth (")						Source	
			1	2	3	4	5	6	Habitat	Locality
49.	131, 131A	Oscillatoria princeps	+	+	-	-	-	-	Rice fields	Methra, Distt. Peshawar.
50.	198, 198A	O. prolifica	+	+	-	-	-	-	Sugar cane fields	Mardan.
51.	197	O. quadripunctulata	-	-	+	-	-	-	Sugar cane field	Mardan.
52.	14	O. rubescens	+	-	-	-	-	-	Dry land	Peshawar.
53.	199	O. splendida	-	-	-	+	-	-	Sugar cane field	Mardan.
54.	135, 135A, 135B	O. subbrevis	-	-	-	+	+	+	Dry land, Rice field	Bannu; Methra, Distt. Peshawar.
55.	202, 202A	O. tenuis	+	-	+	-	-	-	Sugar cane fields	Mardan.
56.	13, 13A, 13B, 13C.	O. terebriformis	+	+	+	+	-	-	Dry lands Maize fields	Bannu; Peshawar, Mardan.
57.	76	Phormidium abronema	-	-	-	-	-	+	Dry land	D.I.Khan.

Table 1: continued

S.No	Culture No	Plants	Soil Depth (") 1	2	3	4	5	6	Source: Habitat	Source: Locality
58.	84	Phormidium ambiguum	-	-	+	-	-	-	Sorghum field	Peshawar.
59.	201	P. autumnale	+	-	-	-	-	-	Wheat field	Peshawar.
60.	245	P. bohneri	-	+	-	-	-	-	Dry land	Peshawar.
61.	68	P. corium	+	-	-	-	-	-	Dry land	D.I.Khan.
62.	16, 16A	P. foveolarum	+	+	-	-	-	-	Dry land, Wheat field	Peshawar
63.	31, 31A, 31B, 31C 31D, 31E	P. fragile	+	+	+	+	+	+	Wheat fields	Peshawar,
									Rice fields, Dry land, pine forest	Kohat, Bannu, D.I.Khan, Parachinar.
64.	203	P. incrustatum	+	-	-	-	-	-	Sugar cane field	Mardan.
65.	86	P. jadinianum	-	-	-	-	-	+	Dry land	D.I.Khan.
66.	79, 79A	P. jenkelianum	+	+	-	-	-	-	Dry lands	Bannu, D.I. Khan.

Table 1: continued

S.No	Culture No.	Plants	Soil Depth (")						Source	
			1	2	3	4	5	6	Habitat	Locality
67.	204	Phormidium mucicola	+	-	-	-	-	-	Sugar cane field	Mardan.
68.	205	P. muscorum	-	+	-	-	-	-	Sugar cane field	Mardan.
69.	112, 112A	P. papyraceum	-	+	+	-	-	-	Dry lands	Peshawar.
70.	56, 56A	P. purpurascens	+	+	-	-	-	-	Dry land, Wheat field	D.I.Khan, Peshawar.
71.	62	P. retzii	-	-	-	+	-	-	Maize field	Mardan.
72.	173	P. subincrustatum	-	+	-	-	-	-	Pine forest	Parachinar.
73.	30, 30A	P. tenue	+	+	-	-	-	-	Dry lands, Sugar cane field	D.I.Khan, Mardan.
74.	206, 206A	P. truncicola	+	-	+	-	-	-	Sugar cane fields	Mardan.
75.	208, 208A	P. uncinatum	-	-	-	+	+	-	Sugar cane fields	Mardan.
76.	207	P. valderianum	-	-	-	-	+	-	Sugar cane field	Mardan.

Table 1: continued

S.No	Culture No.	Plants	Soil Depth (") 1	2	3	4	5	6	Source: Habitat	Source: Locality
77.	152, 152A	Lyngbya aeruginco-caerulea	+	-	+	-	-	-	Sugar cane & Wheat field	Mardan, Peshawar.
78.	209	L. allorgei	-	-	-	-	+	-	Sugar cane field	Mardan.
79.	148	L. contorta	+	-	-	-	-	-	Sugar cane field	Mardan.
80.	212, 212A	L. gardneri	-	+	+	-	-	-	Sugar cane & Rice field	Mardan; Methra, Distt. Peshawar.
81.	210, 210A 210B	L. kuetzingii	-	-	-	+	+	+	Sugar cane & Sorghum field	Mardan, Peshawar.
82.	172, 172A	L. lagerheimii	-	+	+	-	-	-	Maize fields	Mardan.
83.	100	L. martensiana	-	+	-	-	-	-	Sorghum field	Peshawar.
84.	211	L. nordgardii	+	-	-	-	-	-	Sugar cane field	Mardan.
85.	23	L. polysiphonae	+	-	-	-	-	-	Dry land	D.I.Khan.
86.	213	L. putealis	-	+	-	-	-	-	Sugar cane field	Mardan.

Table 1: continued

S.No	Culture No.	Plants	Soil Depth (") 1 2 3 4 5 6	Source: Habitat	Source: Locality
87.	136	Lyngbya spirulinoides	- - - + - -	Rice field	Methra, Distt. Peshawar.
88.	215	L. taylorii	- - + - - -	Sugar cane field	Mardan.
89.	137	L. truncicola	- - + - - -	Rice field	Methra, Distt. Peshawar.
90.	101, 101A, 101B	Symploca cartilaginea	- + + + - -	Sorghum fields	Peshawar.
91.	214	S. muscorum	+ - - - - -	Sugar cane field	Mardan.
92.	216	Microcoleus chthonoplastes	+ - - - - -	Sugar cane field	Mardan.
93.	57	M. lacustris	- - - - + -	Dry land	Peshawar.
94.	138, 139A	Hydrocoleum oligotrichum	- + + - - -	Dry land, Rice field	Bannu; Methra, Distt. Peshawar.
95.	219	Schizothrix friesii	+ - - - - -	Sugar cane field	Mardan.

Table 1: continued

S.No	Culture No.	Plants	Soil Depth (") 1	2	3	4	5	6	Source: Habitat	Source: Locality
96.	217	Schizothrix tinctoria	+	-	-	-	-	-	Sugar cane field	Mardan.
97.	218, 218A, 218B	S. vaginata	-	-	+	+	+	-	Sugar cane fields	Mardan.
98.	153	Cylindrospermum minimum	-	+	-	-	-	-	Wheat field	Peshawar.
99.	29	C. stagnale	-	-	-	-	+	-	Garden	Peshawar.
100.	139, 139A	Nostoc calcicola	+	+	-	-	-	-	Rice fields	Methra, Distt. Peshawar.
101.	115	N. carneum	-	-	-	+	-	-	Dry hill	Kohat.
102.	119	N. commune	-	-	-	+	-	-	Rice field	Methra, Distt. Peshawar.
103.	220	N. comminutum	+	-	-	-	-	-	Sugar cane field	Mardan.
104.	222	N. ellipósporum	-	-	+	-	-	-	Sugar cane field	Mardan.
105.	94	N. hatei	+	-	-	-	-	-	Dry hill	Kohat.

Table 1: continued

S.No	Culture No.	Plants	Soil Depth (") 1	2	3	4	5	6	Source: Habitat	Source: Locality
106.	33	Nostoc linckia	-	+	-	-	-	-	Pine forest	Parachinar.
107.	221, 221A	N. microscopicum	-	-	-	-	+	+	Sugar cane fields	Mardan.
108.	21	N. paludosum	+	-	-	-	-	-	Dry land	Peshawar.
109.	65	N. piscinale	-	-	-	-	+	-	Garden	Peshawar.
110.	22, 22A, 22B, 22C, 22D, 22E	N. punctiforme	+	+	+	+	+	+	Dry lands, Maize fields	Peshawar, Mardan.
111.	66	N. sphaericum	-	-	-	-	+	-	Dry land	D.I.Khan.
112.	52	N. spongiaeforme	-	-	-	+	-	-	Dry land	D.I.Khan.
113.	116	N. verrucosum	-	-	+	-	-	-	Dry hill	Kohat.
114.	150	Anabaena anomala	+	-	-	-	-	-	Rice field	Methra, Distt. Peshawar.
115.	120	A. aphanizomenoides	+	-	-	-	-	-	Dry land	D.I.Khan.
116.	95	A. augstumalis	-	+	-	-	-	-	Dry hill	Kohat.
117.	26	A. circinalis	-	-	-	-	+	-	Rice field	Methra, Distt. Peshawar.

Table 1: continued

S.No	Culture No.	Plants	Soil Depth (") 1	2	3	4	5	6	Source Habitat	Locality
118.	36	Anabaena cylindrica	-	-	-	+	-	-	Sorghum field	Peshawar.
119.	39	A. fertilissima	-	+	-	-	-	-	Dry land	D.I.Khan.
120.	223, 223A	A. gelatinicola	+	-	+	-	-	-	Sugar cane fields	Mardan.
121.	38, 38A, 38B	A. orientalis	+	+	+	-	-	-	Dry lands, Pine forest	D.I.Khan, Kohat, Parachinar.
122.	25, 25A, 25B, 25C, 25D, 25E	A. oryzae	+	+	+	+	+	+	Dry lands, Dry hills, Maize field	Peshawar, Bannu, D.I.Khan, Kohat, Abbottabad, Mardan.
123.	24	A. sphaerica	-	-	+	-	-	-	Dry land	D.I.Khan.
124.	47	A. spiroides	+	-	-	-	-	-	Dry land	D.I.Khan.
125.	88	A. subcylindrica	-	-	-	-	+	-	Sorghum field	Peshawar.
126.	151, 151A	A. variabilis	-	+	+	-	-	-	Dry land, Rice field	Peshawar
127.	37, 37A	Aulosira aenigmatica	+	+	-	-	-	-	Dry lands	D.I.Khan.

Table 1: continued

S.No	Culture No.	Plants	Soil Depth (")						Source	
			1	2	3	4	5	6	Habitat	Locality
128.	118	Aulosira pseudoramosa	-	-	-	+	-	-	Moist land	D.I.Khan.
129.	224	Nodularia harveyana	-	-	-	-	-	+	Sugar cane field	Mardan.
130.	225	N. spumigena	-	-	-	-	+	-	Sugar cane field	Mardan.
131.	227	Plectonema nostocorum	+	-	-	-	-	-	Sugar cane field	Mardan.
132.	75, 75A	P. notatum	-	-	-	-	+	+	Dry lands	D.I.Khan.
133.	168	Scytonema hofmanni	-	-	-	+	-	-	Dry hill	Kohat.
134.	169	S. javanicum	-	+	-	-	-	-	Dry land	D.I.Khan.
135.	167	S. millei	-	-	-	-	+	-	Dry land	D.I.Khan.
136.	179	Tolypothrix distorta	-	-	-	+	-	-	Dry hill	Abbottabad
137.	140	T. fragilis	+	-	-	-	-	-	Rice field	Methra, Distt. Peshawar.

Table 1: continued

S.No	Culture No.	Plants	Soil Depth (") 1	2	3	4	5	6	Source: Habitat	Source: Locality
138.	226	Tolypothrix tenuis	-	+	-	-	-	-	Sugar cane field	Mardan
139.	141, 141A	Microchaete tenera	+	+	-	-	-	-	Rice fields	Methra, Distt. Peshawar.
140.	147	Calothrix clavata	-	+	-	-	-	-	Pine forest	Parachinar.
141.	146	C. elenkinii	+	-	-	-	-	-	Pine forest	Parachinar.
142.	175	C. epiphytica	-	-	-	-	+	-	Dry hill	Abbottabad.
143.	180	C. marchica	-	-	+	-	-	-	Dry hill	Abbottabad.
144.	171	Rivularia dura	+	-	-	-	-	-	Dry land	D.I.Khan.
145.	142	Gloeotrichia echinulata	-	-	-	-	+	-	Rice field	Methra, Distt. Peshawar.
146.	228	G. longicauda	+	-	-	-	-	-	Sugar cane field	Mardan.

Table 1: continued

S.No	Culture No.	Plants	Soil Depth (") 1	2	3	4	5	6	Source: Habitat	Source: Locality
		CHLOROPHYCEAE								
147.	89	Chlamydomonas globosa	-	-	-	-	+	-	Dry land	Peshawar.
148.	92	C. pseudopetryi	-	-	-	-	-	+	Dry land	Peshawar.
149.	59	C. snowii	+	-	-	-	-	-	Dry land	Peshawar.
150.	229	C. typica	-	+	-	-	-	-	Rice field	Methra, Distt. Peshawar.
151.	154, 154A	Pandorina morum	+	-	+	-	-	-	Wheat fields	Peshawar.
152.	155, 155A	Palmella miniata	-	-	-	-	+	+	Pine forest	Parachinar.
153.	121, 121A, 121B, 121C, 121D	P. texensis	+	+	+	+	+	-	Pine forests, Dry hills	Parachinar, Abbottabad.
154.	3, 3A, 3B, 3C, 3D, 3E	Gloeocystis ampla	+	+	+	+	+	+	Dry lands	Peshawar.
155.	10, 10A, 10B, 10C, 10D, 10E	G. vesiculosa	+	+	+	+	+	+	Gardens, Pine forests, Dry hills	Peshawar, Parachinar, Abbottabad.

Table 1: continued

S.No	Culture No.	Plants	Soil Depth (") 1	2	3	4	5	6	Source: Habitat	Source: Locality
156.	18	Ulothrix idiospora	-	+	-	-	-	-	Dry land	D.I.Khan.
157.	166, 166A	U. variabilis	+	+	-	-	-	-	Dry land, Dry hill	Peshawar, Kohat.
158.	230	Chlorohormidium flaccidum	+	-	-	-	-	-	Sugar cane field	Mardan.
159.	108, 108A	C. sterile	+	+	-	-	-	-	Moist land, Garden	D.I.Khan, Peshawar.
160.	143, 143A	Microspora tumidula	+	+	-	-	-	-	Rice fields	Methra, Distt. Peshawar.
161.	107	Stigeoclonium pachydermum	-	-	+	-	-	-	Moist land	D.I.Khan.
162.	156	S. polymorphum	-	+	-	-	-	-	Rice field	Methra, Distt. Peshawar.
163.	4,4A,4B	Protococcus viridis	+	+	+	-	-	-	Dry land, Maize field Sugar cane field	Peshawar, Mardan.
164.	103	Physolinum monilia	+	-	-	-	-	-	Moist land	D.I.Khan.

Table 1: continued

S.No.	Culture No.	Plants	Soil Depth (") 1	2	3	4	5	6	Source: Habitat	Source: Locality
165.	231	Cladophora fracta	-	+	-	-	-	-	Sugar cane field	Mardan
166.	158, 158A, 158B	C. glomerata	+	+	-	+	-	-	Rice fields	Methra, Distt. Peshawar.
167.	159, 159A, 159B	Rhizoclonium hieroglyphicum	-	+	+	+	-	-	Rice fields	Methra, Distt. Peshawar.
168.	160	Oedogonium hirnii	-	-	-	-	-	+	Rice field	Methra, Distt. Peshawar.
169.	161, 161A, 161B	O. porrectum	+	+	+	-	-	-	Rice fields	Methra, Distt. Peshawar.
170.	64, 64A	Bracteacoccus grandis	+	+	-	-	-	-	Wheat fields	Peshawar.
171.	2, 2A	B. medinucleatus	+	-	+	-	-	-	Dry lands	Peshawar, D.I.Khan.
172.	12	B. minor	-	-	-	+	-	-	Dry land	Peshawar.
173.	105	B. pseudominor	-	-	+	-	-	-	Moist land	D.I.Khan.
174.	109	Chlorosarcinopsis arenicola	+	-	-	-	-	-	Moist land	D.I.Khan.

Table 1: continued

S.No	Culture No.	Plants	Soil Depth (") 1	2	3	4	5	6	Source: Habitat	Source: Locality
175.	113	Chlorosarcinopsis auxotropica	-	-	-	-	+	-	Garden	Peshawar.
176.	110	C. deficiens	-	-	-	-	+	-	Moist land	D.I.Khan.
177.	111, 111A, 111B, 111C, 111D, 111E.	C. pseudominor	+	+	+	+	+	+	Dry lands	Peshawar.
178.	20, 20A	C. sempervirens	+	+	-	-	-	-	Wheat field, Moist land	Peshawar, D.I.Khan.
179.	162	Tetracystis excentrica	-	-	+	-	-	-	Rice field	Methra, Distt. Peshawar.
180.	71	T. intermedium	-	-	-	-	+	-	Dry hill	Kohat.
181.	91	T. isobilateralis	-	-	-	+	-	-	Maize field	Mardan.
182.	72	T. pampae	-	+	-	-	-	-	Maize field	Mardan.
183.	117, 117A	T. tetrasporum	+	+	-	-	-	-	Moist lands	D.I.Khan.
184.	104	T. texensis	-	-	+	-	-	-	Moist land	D.I.Khan.
185.	11, 11A	Chlorococcum acidum	+	-	+	-	-	-	Wheat field, Dry land	Peshawar.

Table 1: continued

S.No	Culture No.	Plants	Soil Depth (")						Source	
			1	2	3	4	5	6	Habitat	Locality
186.	78, 78A	Chlorococcum aureum	-	-	-	+	+	-	Maize fields	Mardan.
187.	7	C. echinozygotum	-	-	-	-	-	+	Dry land	Peshawar.
188.	53	C. elkhartiense	+	-	-	-	-	-	Sorghum field	Peshawar.
189.	63	C. gelatinosum	-	+	-	-	-	-	Maize field	Mardan.
190.	43, 43A, 43B, 43C	C. hypnosporum	+	+	+	+	-	-	Gardens	Peshawar.
191.	45	C. isabeliense	-	-	-	-	-	+	Garden	Peshawar.
192.	17	C. lacustre	+	-	-	-	-	-	Dry land	D.I.Khan.
193.	41	C. macrostigmatum	+	-	-	-	-	-	Wheat field	Peshawar.
194.	48	C. microstigmatum	-	-	-	+	-	-	Dry land	D.I.Khan.
195.	8	C. minutum	-	+	-	-	-	-	Dry land	D.I.Khan.
196.	232	C. nova angliae	+	-	-	-	-	-	Moist land	D.I.Khan.
197.	5, 5A	C. oviforme	-	-	+	+	-	-	Dry lands	Peshawar.

Table 1: continued

S.No	Culture No.	Plants	Soil Depth (")						Source	
			1	2	3	4	5	6	Habitat	Locality
198.	87	Chlorococcum pulchrum	-	-	-	-	+	-	Wheat field	Peshawar.
199.	6, 6A, 6B	C. refringens	+	+	+	-	-	-	Dry lands, Garden	Peshawar.
200.	51	C. reticulatum	-	-	-	-	-	+	Wheat field	Peshawar.
201.	61, 61A	C. salsugineum	-	-	+	+	-	-	Moist lands	D.I.Khan.
202.	157, 157A	C. sphacosum	+	+	-	-	-	-	Wheat fields	Peshawar.
203.	40	C. typicum	-	-	-	-	-	+	Garden	Peshawar.
204.	34	Eremosphaera eremosphaeria	+	-	-	-	-	-	Dry land	Peshawar.
205.	69, 69A	E. viridis	-	+	+	-	-	-	Dry land, Wheat field	D.I.Khan, Peshawar.
206.	73	Planktosphaeria texensis	+	-	-	-	-	-	Dry land	Peshawar.
207.	181, 181A	Dictyococcus varians	-	-	+	+	-	-	Dry hills	Abbottabad.

Table 1: continued

S.No	Culture No.	Plants	Soil Depth (") 1	2	3	4	5	6	Source: Habitat	Source: Locality
208.	19, 19A, 19B	Neochloris cohaerens	+	+	+	-	-	-	Gardens, Moist land	Peshawar, D.I.Khan.
209.	81, 81A	Spongiochloris incrassata	+	+	-	-	-	-	Maize fields	Mardan.
210.	58, 58A	S. spongiosa	-	-	+	+	-	-	Dry lands	Peshawar.
211.	102	Radiosphaera dissecta	-	-	-	-	+	-	Pine forest	Parachinar.
212.	122, 122A, 122B	Chlorella ellipsoidea	+	+	+	-	-	-	Pine forests	Parachinar.
213.	82	Oocystis crassa	-	-	-	-	+	-	Maize field	Mardan.
214.	178, 178A	O. parva	-	-	+	+	-	-	Dry lands	Kohat, Peshawar.
215.	83	O. pyriformis	+	-	-	-	-	-	Maize field	Mardan.
216.	77	O. solitaria	-	+	-	-	-	-	Wheat field	Peshawar.
217.	96	Crucigenia irregularis	+	-	-	-	-	-	Maize field	Mardan.

Table 1: continued

S.No	Culture No.	Plants	Soil Depth (")						Source	
			1	2	3	4	5	6	Habitat	Locality
218.	145	Palmellococcus protothecoides	-	-	-	-	-	+	Dry land	Peshawar.
219.	233	Scenedesmus arcuatus	-	+	-	-	-	-	Sugar cane field	Mardan.
220.	234	S. dimorphus	-	-	-	-	-	+	Sugar cane field	Mardan.
221.	124	S. incrassatulus	+	-	-	-	-	-	Maize field	Mardan.
222.	235	S. obliquus	-	-	-	-	+	-	Sugar cane field	Mardan.
223.	236	Quadricula closterioides	-	-	-	+	-	-	Sugar cane field	Mardan.
224.	238	Tetraëdron constrictum	+	-	-	-	-	-	Sugar cane field	Mardan.
225.	237	T. gigas	-	-	-	+	-	-	Sugar cane field	Mardan.
226.	240	T. muticum	-	-	-	-	-	+	Sugar cane field	Mardan.

Table 1: continued

S.No	Culture No.	Plants	Soil Depth (")						Source	
			1	2	3	4	5	6	Habitat	Locality
227.	239	Chlorotetraëdron polymorphum	+	-	-	-	-	-	Wheat field	Peshawar.
228.	80	Coelastrum microporum	-	+	-	-	-	-	Maize field	Mardan.
229.	241	Characium acuminatum	-	+	-	-	-	-	Sugar cane field	Mardan.
230.	242	C. ambiguum	-	-	-	+	-	-	Garden	Peshawar.
231.	114	C. naegeli	-	-	+	-	-	-	Rice field	Methra, Distt. Peshawar.
232.	32	C. pringsheimii	+	-	-	-	-	-	Rice field	Methra, Distt. Peshawar.
233.	163	Mesotaenium purpureum	+	-	-	-	-	-	Rice field	Methra, Distt. Peshawar.
234.	244	Roya obtusa	-	+	-	-	-	-	Sugar cane field	Mardan.
235.	164	Closterium porrectum	-	-	+	-	-	-	Rice field	Methra, Distt. Peshawar.

Table 1: continued

S.No	Culture No.	Plants	Soil Depth (") 1	2	3	4	5	6	Source: Habitat	Source: Locality
236.	174	Cosmarium granatum	-	-	+	-	-	-	Dry hill	Abbottabad.
237.	243	C. granatum var. granatum	+	-	-	-	-	-	Rice field	Methra, Distt. Peshawar.
238.	200	C. laeve	-	+	-	-	-	-	Rice field	Methra, Distt. Peshawar.
239.	1	Spondylosium pygmeum	-	-	-	-	+	-	Dry land	Peshawar.
		XANTHOPHYCEAE								
240.	144	Gloeobotrys limneticus	+	-	-	-	-	-	Dry land	Peshawar.
241.	99	Monallantus brevicylindrus	-	+	-	-	-	-	Dry land	Peshawar.
242.	165	Tribonema bombycinum var. tenue	-	-	+	-	-	-	Sorghum cane field	Peshawar.
243.	44	T. minus	+	-	-	-	-	-	Garden	Peshawar.

Table 1: continued

S.No	Culture No.	Plants	Soil Depth (") 1	2	3	4	5	6	Source: Habitat	Source: Locality
244.	67, 67A, 67B, 67C, 67D, 67E	Heterococcus longicellularis	+	+	+	+	+	+	Dry lands, Wheat fields, Maize field, Moist land.	Peshawar, Mardan, D.I.Khan.
		EUGLENOPHYCEAE								
245	170	Euglena proxima var. minima	-	-	+	-	-	-	Rice field	Methra, Distt. Peshawar.

Key:

\+ = Present

\- = Absent

Table 2: Total number of species recorded in different fields of N.W.F.P. at 0-6" depth.

Habitats	Number of species Soil Depth (")						TOTAL
	1	2	3	4	5	6	
Dry hills	2	2	6	6	4	3	23
Dry lands	30	23	16	16	11	14	110
Garden	4	4	2	2	3	2	17
Maize fields	3	6	3	6	4	3	25
Moist lands	3	2	4	2	2	1	14
Pine forests (hills)	3	6	4	1	3	2	19
Rice fields	14	14	11	5	5	4	53
Sorghum fields	1	2	2	2	1	0	8
Sugar cane fields	28	15	12	7	9	4	75
Wheat fields	10	9	5	1	1	2	28
TOTAL	98	83	65	48	43	35	372

Table 3: Total number of species recorded in the various districts of N.W.F.P. at 0-6" depth.

DISTRICT	Number of species Soil Depth (")						TOTAL
	1	2	3	4	5	6	
Abbottabad	0	0	3	4	3	2	12
Mardan	31	21	15	13	13	7	100
Peshawar	44	38	28	18	15	15	158
Kohat	1	4	5	3	1	1	15
Bannu	2	2	0	2	0	0	6
D.I.Khan	17	12	10	7	8	8	62
Parachinar (Kurram agency)	3	6	4	1	3	2	19
TOTAL	98	83	65	48	43	35	372

DISCUSSION AND CONCLUSION

A sum total of 245 species, excluding diatoms, distributed among 74 genera belonging to Cyanophyceae, Chlorophyceae, Xanthophyceae and Euglenophyceae were recorded from soils of N.W.F.P. (Table 4).

There were 31 genera with 146 species of Cyanophyceae; 93 species distributed among 38 genera of Chlorophyceae; Xanthophyceae had 4 genera with 5 species while Euglena with a single species represented Euglenophyceae.

Cyanophyceae with 146 species, followed by Chlorophyceae with 93 species, were the most common in the area; while Euglenophyceae represented by only one species was the least common group.

A. DISTRIBUTION OF SPECIES WITHIN EACH CLASS

1. Cyanophyceae

Oscillatoria and Phormidium respectively having 23 and 20 species, the commonest represented genera, were followed by 14 species of Nostoc; Anabaena, and Lyngbya each with 13 species. Chroococcus with 7 species and Microcystis and Spirulina, each with 5 species; Aphanothece and Calothrix, each with 4 species occupied an intermediate position. Aphanocapsa, Merismopedia, Schizothrix, Scytonema, and Tolypothrix each with 3 species;

Table 4: Number of genera and species recorded in various classes from N.W.F.P. Soils.

Class	Number of Genera	Number of Species
Cyanophyceae	31	146
Chlorophyceae	38	93
Xanthophyceae	4	5
Euglenophyceae	1	1
TOTAL	74	245

Aulosira, Cylindrospermum, Gloeotrichia, Microcoleus, Nodularia, Plectonema and Symploca each having 2 species followed by Chlorogloea, Coelosphaerium, Gloeocapsa, Gloeothece, Hydrocoleum, Michrochaete, Rivularia, Stichosiphon, and Synechococcus, each represented by a single species were the least frequent genera (Table 5).

2. Chlorophyceae

Among Chlorophyceae, the best represented genus was Chlorococcum having 19 species; while Chlorella, Closterium, Coelastrum, Crucigenia, Dictyococcus, Mesotaenium, Microspora, Neochloris, Palmellococcus, Pandorina, Physolinum, Planktosphaeria, Protococcus, Chlorotetraëdron, Quagrigula, Radiosphaera, Rhizoclonium, Roya and Spondylosium, each represented by a single species were the least common individuals. Tetracystis with 6 species and Chlorosarcinopsis with 5 species were intermediate in position. Bracteacoccus, Characium, Chlamydomonas, Oocystis and Scenedesmus each had 4 species. While Cosmarium and Tetraëdron were represented by 3 species. Two species were recorded for Chlorohormidium, Cladophora, Bremosphaera, Gloeocystis, Oedogonium, Palmella, Spongiochloris, Stigeoclonium and Ulothrix (Table 6).

3. Xanthophyceae

Among the 5 recorded species, 2 belonged to

Table 5: Members of Cyanophyceae recorded from N.W.F.P. Soils.

S.No	Genera	Number of species
1	Oscillatoria	23
2	Phormidium	20
3	Nostoc	14
4	Anabaena	13
5	Lyngbya	13
6	Chroococcus	7
7	Microcystis	5
8	Spirulina	5
9	Aphanothece	4
10	Calothrix	4
11	Aphanocapsa	3
12	Merismopedia	3
13	Schizothrix	3
14	Scytonema	3
15	Tolypothrix	3
16	Aulosira	2
17	Cylindrospermum	2
18	Gloeotrichia	2
19	Microcoleus	2
20	Nodularia	2
21	Plectonema	2

Table 5: continued

S.No	Genera	Number of species
22	Symploca	2
23	Chlorogloea	1
24	Coelosphaerium	1
25	Gloeocapsa	1
26	Gloeothece	1
27	Hydrocoleum	1
28	Microchaete	1
29	Rivularia	1
30	Stichosiphon	1
31	Synechococcus	1
TOTAL	31	146

Table 6: Chlorophycean members isolated from soils of N.W.F.P.

S.No	Genera	Number of species
1	Chlorococcum	19
2	Tetracystis	6
3	Chlorosarcinopsis	5
4	Bracteacoccus	4
5	Characium	4
6	Chlamydomonas	4
7	Oocystis	4
8	Scenedesmus	4
9	Cosmarium	3
10	Tetraëdron	3
11	Chlorohormidium	2
12	Cladophora	2
13	Eremosphaera	2
14	Gloeocystis	2
15	Oedogonium	2
16	Palmella	2
17	Spongiochloris	2
18	Stigeoclonium	2
19	Ulothrix	2
20	Chlorella	1
21	Closterium	1

Table 6: continued

S.No	Genera	Number of species
22	Coelastrum	1
23	Crucigenia	1
24	Dictyococcus	1
25	Mesotaenium	1
26	Microspora	1
27	Neochloris	1
28	Palmellococcus	1
29	Pandorina	1
30	Physolinum	1
31	Planktosphaeria	1
32	Protococcus	1
33	Chlorotetraëdron	1
34	Quadrigula	1
35	Radiosphaera	1
36	Rhizoclonium	1
37	Rova	1
38	Spondylosium	1
TOTAL	38	93

Tribonema while the remaining 3 species represented Gloeobotrys, Heterococcus and Monallantus (Table, 7).

4. Euglenophyceae

Euglena proxima var. minima was the only record for Euglenophyceae (Table, 7).

B. SOIL-BINDERS

Some of the algae viz; Heterococcus longicellularis, Ulothrix variabilis, Lyngbya polysiphonae, Phormidium jadinianum, P. papyraceum, P. uncinatum, P. ambiguum, P. fragile, Oscillatoria animalis, O. foreaui, O. formosa and O. splendida were observed to be good soil binders. Cyanophycean members were more than the other algae and the results agree with Jabeen (1978).

C. NITROGEN FIXING BLUE GREEN ALGAE

The ability to fix nitrogen was inferred by the presence of heterocysts in the blue-green algae. Forty-seven species belonging to 11 genera viz: Nostoc (14 spp.), Anabaena (13 spp.), Calothrix (4 spp.), Scytonema (3 spp.), Tolypothrix (3 spp.), Aulosira (2 spp.), Cylindrospermum (2 spp.), Gloeotrichia (2 spp.), Nodularia (2 spp.), Microchaete (1 sp.), and Rivularia (1 sp.) were recorded as possible nitrogen fixers (Table, 8). Findings are in aggrement with Drewes (1928), Singh (1942), Fogg (1947, 1951), Watanabe (1949, 1951), Willians and Burris (1952),

Table 7: Members of Xanthophyceae and Euglenophyceae recorded in N.W.F.P. Soils.

S.No	Genera	No. of species	Name of the plant
		XANTHOPHYCEAE	
1	Tribonema	2	Tribonema bombycinum var. tenue
			T. minus
2	Gloeobotrys	1	Gloeobotrys limneticus
3	Heterococcus	1	Heterococcus longicellularis
4	Monallantus	1	Monallantus brevicylindrus
		EUGLENOPHYCEAE	
1	Euglena	1	Euglena proxima var. minima
TOTAL	5	6	

Table 8: Nitrogen fixing blue green algae recorded from N.W.F.P. Soils.

S.No.	Genera	Species
1	Nostoc	Nostoc calcicola
		N. carneum
		N. commune
		N. comminutum
		N. ellipsosporum
		N. hatei
		N. linckia
		N. microscopicum
		N. paludosum
		N. piscinale
		N. punctiforme
		N. sphaericum
		N. spongiaeforme
		N. verrucosum
2	Anabaena	Anabaena anomala
		A. aphanizomenoides
		A. augstumalis
		A. circinalis
		A. cylindrica
		A. fertilissima
		A. gelatinicola

Table 8: continued

S.No.	Genera	Species
		Anabaena orientalis
		A. oryzae
		A. sphaerica
		A. spiroides
		A. subcylindrica
		A. variabilis
3	Calothrix	Calothrix clavata
		C. elenkinii
		C. epiphytica
		C. marchica
4	Scytonema	Scytonema hofmanni
		S. javanicum
		S. millei
5	Tolypothrix	Tolypothrix distorta
		T. fragilis
		T. tenuis
6.	Aulosira	Aulosira pseudoramosa
		A. aenigmatica
7	Cylindrospermum	Cylindrospermum minimum
		C. stagnale

Table 8: continued

S.No.	Genera	Species
8	Gloeotrichia	Gloeotrichia echinulata
		G. longicauda
9	Nodularia	Nodularia harveyana
		N. spumigena
10	Microchaete	Microchaete tenera
11	Rivularia	Rivularia dura

Fogg and Wolf (1954), Allen (1956), Desikachary (1959), Cameron and Fuller (1960), Fay and Fogg (1962), Ali and Sandhu (1972) and Ali *et al.* (1978).

D. NEW RECORDS FROM PAKISTAN

The following 46 species were reported for the first time from Pakistan.

Bracteacoccus grandis, *B. medinucleatus*, *B. minor*, *B. pseudominor*, *Chlamydomonas typica*, *Chlorococcum acidum*, *C. aureum*, *C. echinozygotum*, *C. elkhartiense*, *C. gelatinosum*, *C. hypnosporum*, *C. isabeliense*, *C. lacustre*, *C. macrostigmatum*, *C. microstigmatum*, *C. minutum*, *C. nova angliae*, *C. oviforme*, *C. pulchrum*, *C. refringens*, *C. reticulatum*, *C. salsugineum*, *C. typicum*, *Chlorohormidium sterile*, *Chlorosarcinopsis arenicola*, *C. auxotropica*, *C. deficiens*, *C. pseudominor*, *C. sempervirens*, *Chlorotetraëdron polymorphum*, *Dictyococcus varians*, *Eremosphaera eremosphaeria*, *Euglena proxima* var. *minima*, *Neochloris cohaerens*, *Palmella texensis*, *Planktosphaeria texensis*, *Radiosphaera dissecta*, *Spongiochloris incrassata*, *S. spongiosa*, *Tetracystis excentrica*, *T. intermedium*, *T. isobilateralis*, *T. pampae*, *T. tetrasporum*, *T. texensis*, *Tribonema bombycinum* var. *tenue*.

E. VERTICAL DISTRIBUTION OF THE SPECIES

With the increasing depth of soil, the number

and kind of species gradually decreased (Fig. 246). There were 98 species in the uppermost one inch of the soil, followed by 83 species recorded at a depth of 2" and it respectively decreased to 65 and 48 species at 3rd and 4th inch depths. At a distance of 5 and 6" from the top, there were respectively 43 and 35 species. Results agree with Peterson (1935), Delarge (1949), von Denferr (1949) and Durrell (1959) who observed the gradual decrease in the number of algae with increasing soil depth.

Anabaena oryzae, Nostoc punctiforme, Phormidium fragile, Chlorosarcinopsis pseudominor, Gloeocystis ampla, G. vesiculosa and Heterococcus longicellularis were recorded at all the depths. Chroococcus cohaerens, C. dispersus, Coelosphaerium dubium, Chlorogloea microcystoides, Aphanothece castagnei, A. gelatinosa, Merismopedia tenuissima, Spirulina gomontiana, Oscillatoria amphibia, O. anguina, Phormidium abronema, P. jadinianum, Nodularia harveyana, Chlamydomonas pseudopetryi, Oedogonium hirnii, Chlorococcum echinozygotum, C. isabeliense, C. reticulatum C. typicum, Palmellococcus protothecoides, Scenedesmus dimorphus, and Tetraëdron muticum, absent in the top layers of soil, were present only in the deeper layers. The findings agree with Peterson (1932) who reported similar phenomenon in soil algae.

The vertical distribution of species in soil

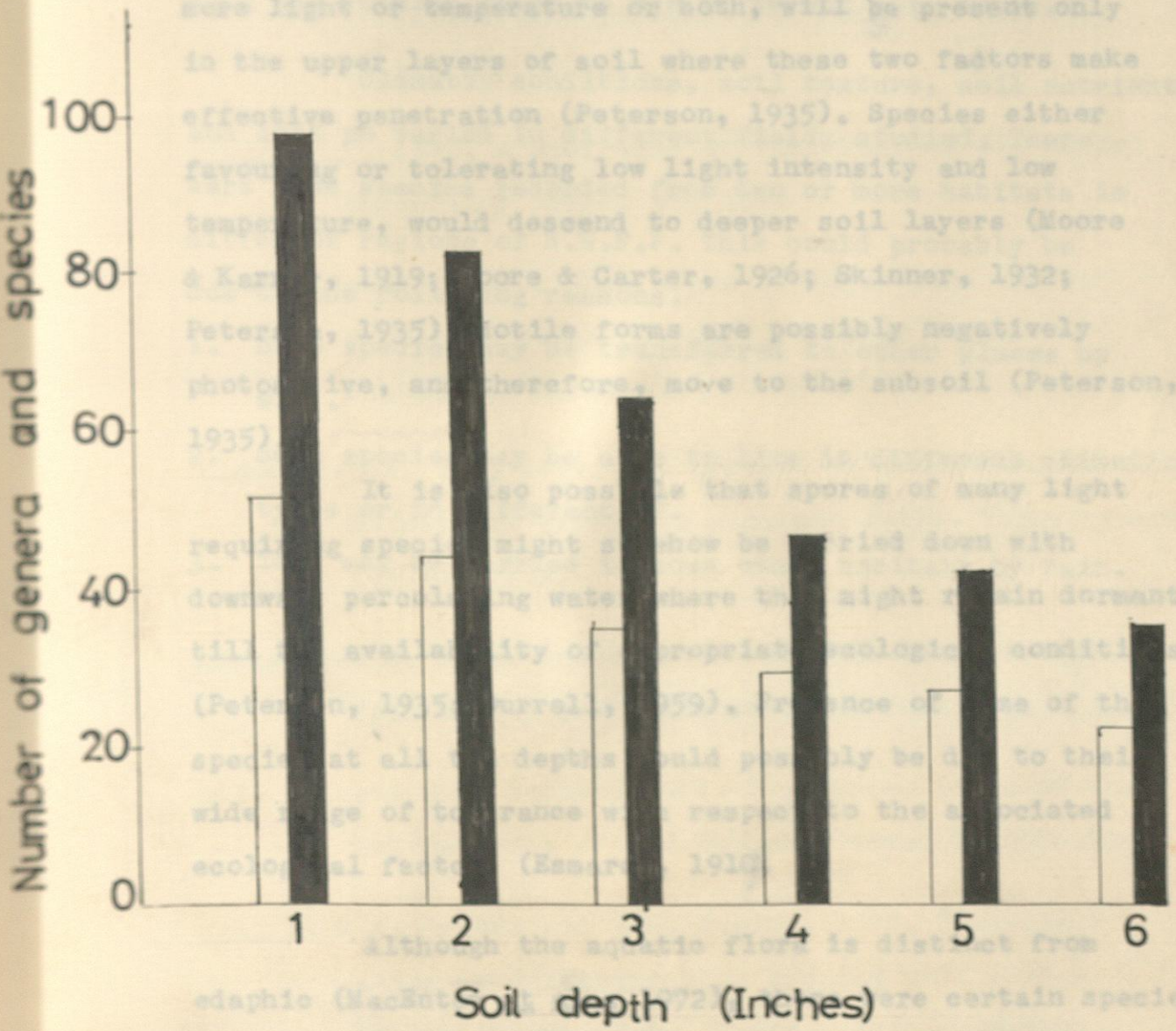


Fig. 246

The vertical distribution of genera (Blank) and species (Solid) of algae at various soil depths in N.W.F.P.

depends upon a number of factors, such as light, temperature, water and texture of the soil. Species preferring more light or temperature or both, will be present only in the upper layers of soil where these two factors make effective penetration (Peterson, 1935). Species either favouring or tolerating low light intensity and low temperature, would descend to deeper soil layers (Moore & Karrer, 1919; Moore & Carter, 1926; Skinner, 1932; Peterson, 1935). Motile forms are possibly negatively photoactive, and therefore, move to the subsoil (Peterson, 1935).

It is also possible that spores of many light requiring species might somehow be carried down with downward percolating water where they might remain dormant till the availability of appropriate ecological conditions (Peterson, 1935; Durrell, 1959). Presence of some of the species at all the depths could possibly be due to their wide range of tolerance with respect to the associated ecological factors (Esmarch, 1910).

Although the aquatic flora is distinct from edaphic (MacEntee et al., 1972), there were certain species common in both the habitats. Species like Microcystis aeruginosa, M. flosaquae, Chroococcus turgidis, Chlamydomonas spp., Euglena sp., Cladophora spp. and certain other filamentous and colonial forms, common in

aquatic habitats, were recorded from the soil. This may be due to the reason that they may have been carried with the running water to the different soil types.

Climatic conditions, soil texture, soil nutrients and soil pH varied in different fields studied. There were some species recorded from two or more habitats in different regions of N.W.F.P. This could probably be due to the following reasons.

1. Some species may be transferred to other places by wind.
2. Some species may be able to live in different climatic types or in different pH.
3. They may be carried to some other habitats by rain.

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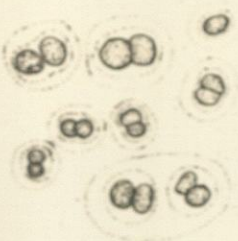
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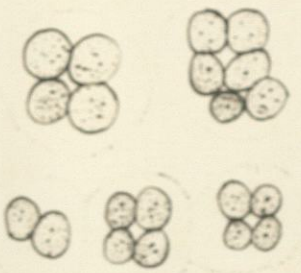
PLATE 1

Text Page	Plants	Fig.No.
41	Chroococcus varius x 1000	1
40	C. minutus x 1000	2
38	C. limneticus var. subsalsus x 1000	3
39	C. minor x 1000	4
37	C. dispersus x 1000	5
37	C. cohaerens x 1000	6
43	Microcystis aeruginosa x 675	7
44	M. flos-aquae x 1000	8
45	M. marginata x 1000	9
47	M. pulverea x 1000	10
49	Coelosphaerium dubium x 800	11
50	Chlorogloea microcystoides x 1000	12

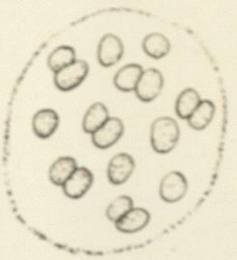
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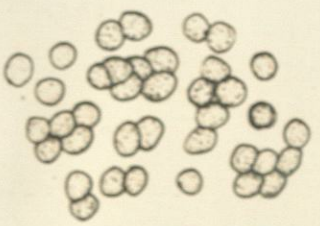
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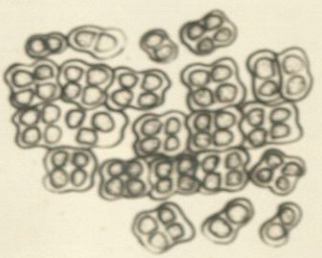
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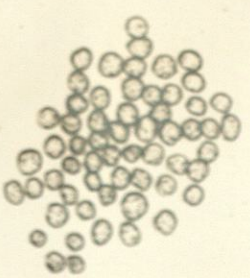
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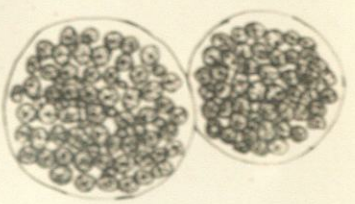
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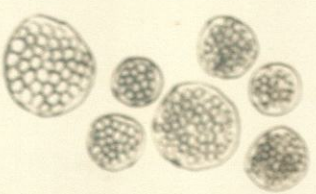
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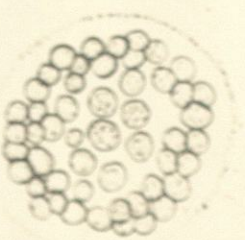
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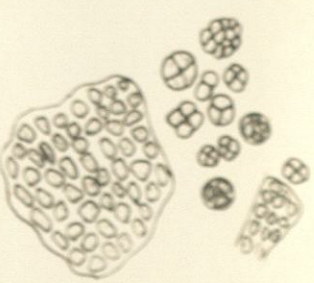
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PLATE 2

Text Page	Plants	Fig.No.
55	Aphanothece microscopica x 500	13
56	A. saxicola x 500	14
54	A. castagnei x 570	15
54	A. gelatinosa x 500	16
58	Aphanocapsa littoralis x 500	17
58	A. montana x 500	18
60	Merismopedia glauca x 500	19
61	M. punctata x 1000	20
61	M. tenuissima x 1000	21
67	Spirulina massartii x 600	22
66	S. gomontiana x 830	23
84	Oscillatoria lutea x 800	24
87	O. rubescens x 835	25
76	O. anguina x 500	26
80	O. foreaui x 665	27
90	O. terebriformis x 1000	28
73	O. agardhii x 750	29
83	O. limosa x 335	30
80	O. formosa x 750	31
77	O. animalis x 1000	32
89	O. subbrevis x 1000	33
75	O. amphibia x 1000	34
84	O. princeps x 280	35
79	O. curviceps x 500	36

PLATE 2

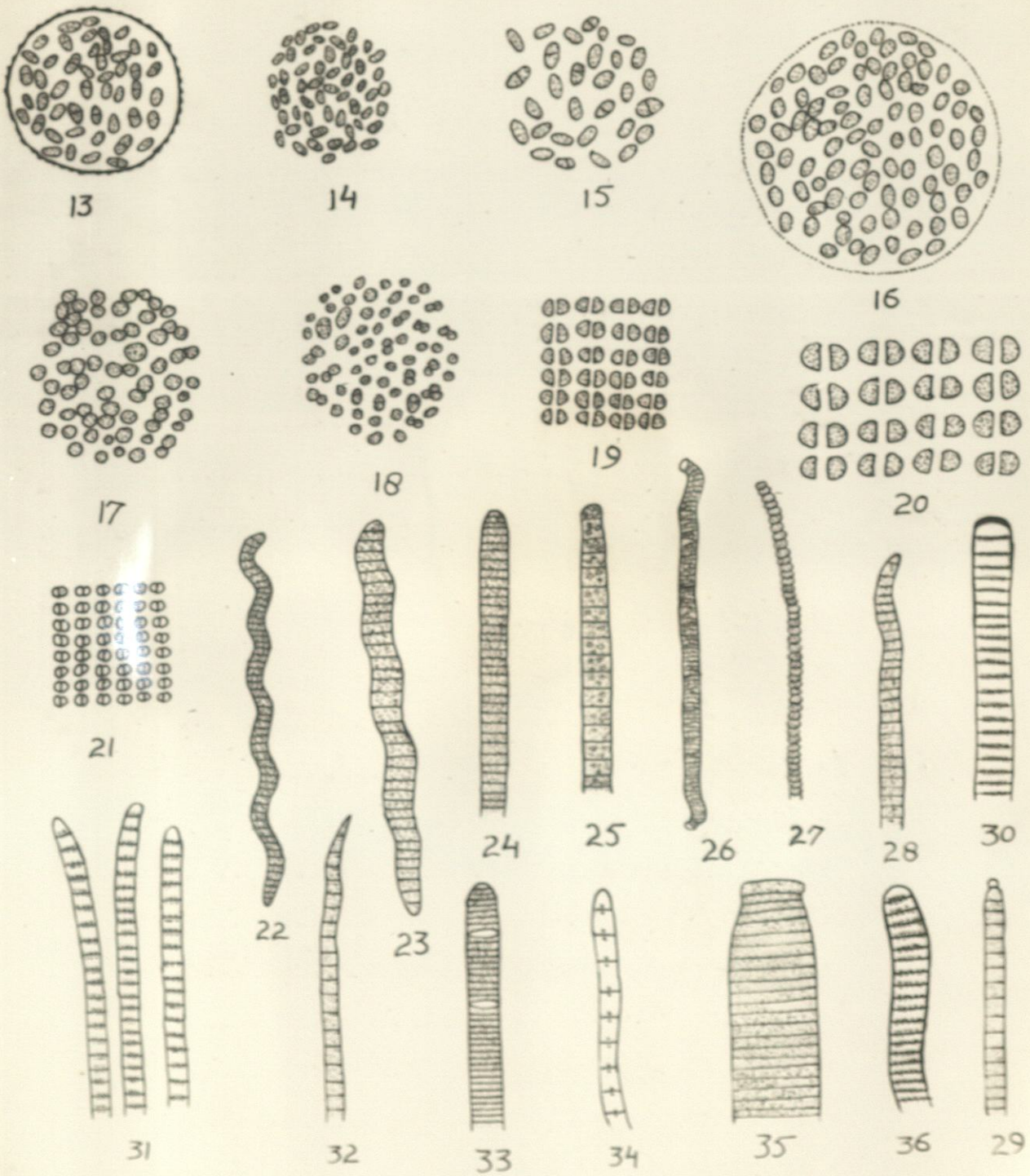


PLATE 3

Text Page	Plants	Fig.No.
99	Phormidium fragile x 1000	37
107	P. tenue x 1000	38
97	P. bohneri x 1500	39
104	P. papyraceum x 1000	40
98	P. fovoelarum x 1400	41
94	P. abronema x 1000	42
98	P. corium x 1000	43
106	P. subincrustatum x 1000	44
101	P. iadinianum x 750	45
95	P. ambiguum x 2000	46
105	P. retzii x 1000	47
102	P. jenkelianum x 2000	48
105	P. purpurascens x 2500	49
117	Lyngbya martensiana x 700	50
116	L. lagerheimii x 2500	51
113	L. aerugineo-caerulea x 1500	52
120	L. spirulinoids x 570	53
122	L. truncicola x 500	54
119	L. polysiphonae x 2500	55
123	Symploca cartilaginea x 1000	56
126	Microcoleus lacustris x 1000	57

PLATE 3

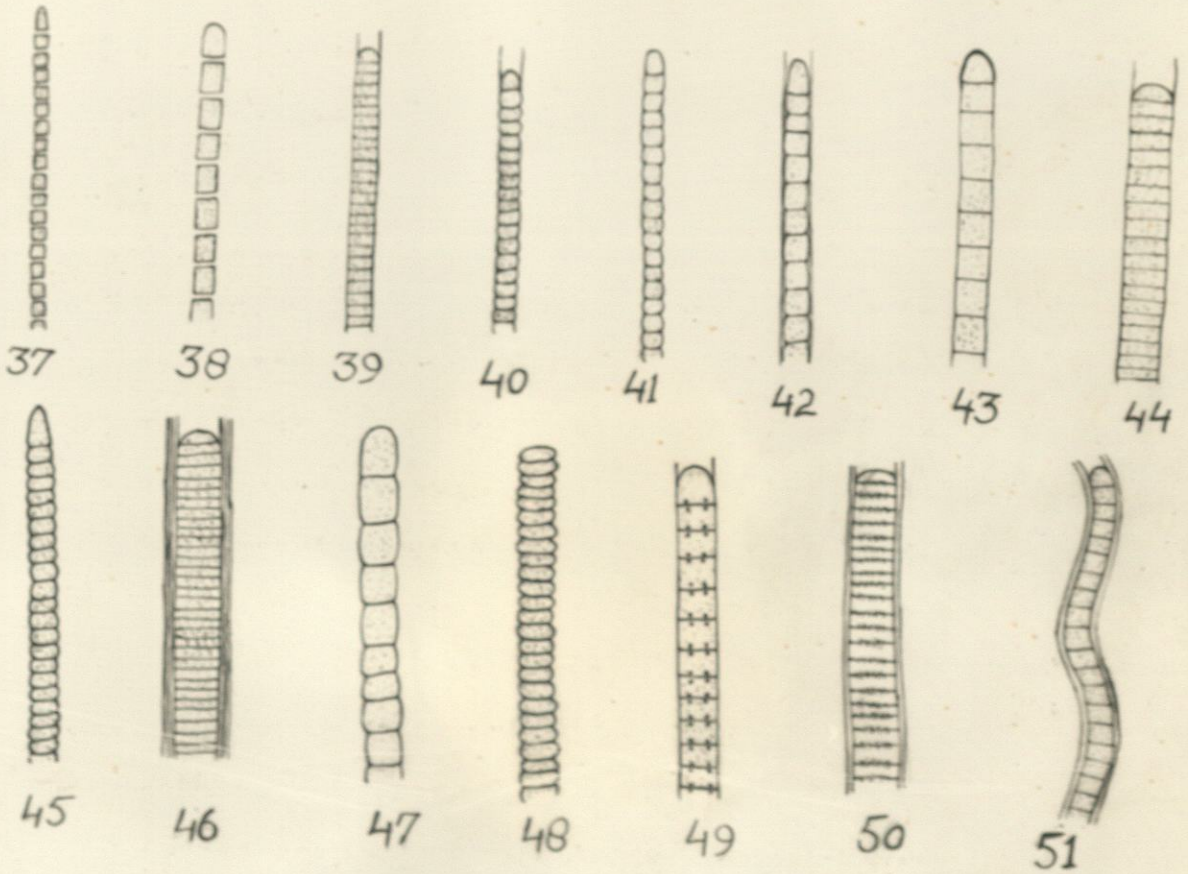


PLATE 4

Text Page	Plants	Fig.No.
127	Hydrocoleum oligotrichum x 665	58
132	Cylindrospermum stagnale x 1000	59
132	C. minimum x 1000	60
143	Nostoc punctiforme x 1000	61
142	N. paludosum x 1000	62
140	N. linckia x 250	63
142	N. piscinale x 330	64
144	N. sphaericum x 1250	65
145	N. spongiaeforme x 750	66
137	N. commune x 600	67
139	N. hatei x 1000	68
146	N. verrucosum x 665	69

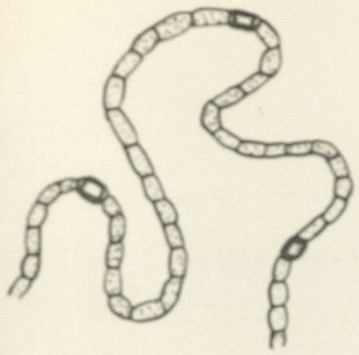
PLATE 4



PLATE 5

Text Page	Plants	Fig.No.
136	Nostoc carneum x 500	70
135	N. calcicola x 1000	71
156	Anabaena sphaerica x 800	72
157	A. spiroides x 500	73
155	A. oryzae x 1000	74
149	A. anomala x 1000	75
153	A. fertilissima x 600	76
150	A. aphanizomenoides x 500	77
154	A. orientalis x 500	78

PLATE 5



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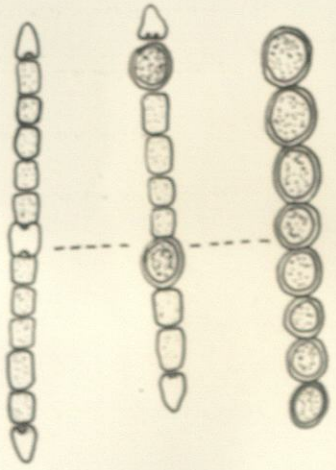
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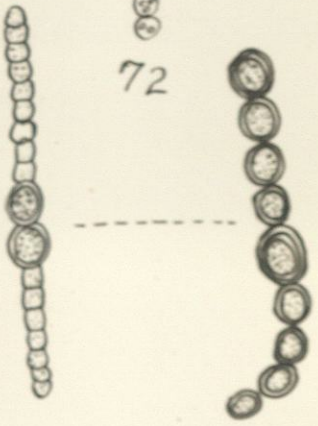
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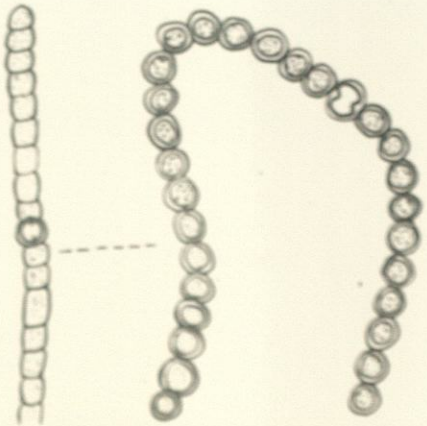
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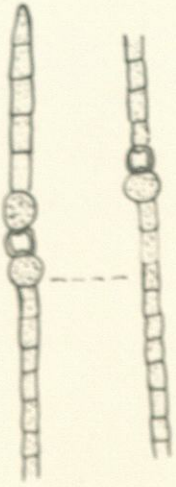
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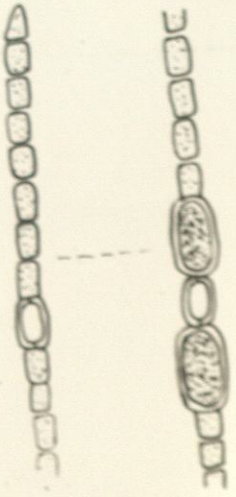
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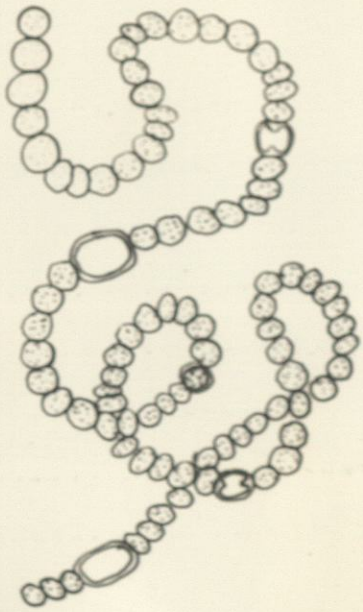
PLATE 6

Text Page	Plants	Fig.No.
158	*Anabaena variabilis* x 1000	79
151	*A. circinalis* x 500	80
158	*A. subcylindrica* x 1500	81
150	*A. augstumalis* x 750	82
152	*A. cylindrica* x 500	83
160	*Aulosira pseudoramosa* x 700	84
160	*A. aenigmatica* x 1000	85
164	*Plectonema notatum* x 1000	86

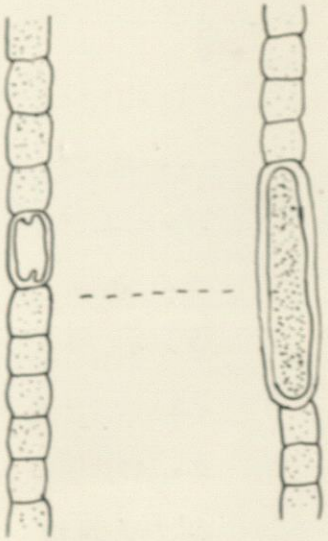
PLATE 6



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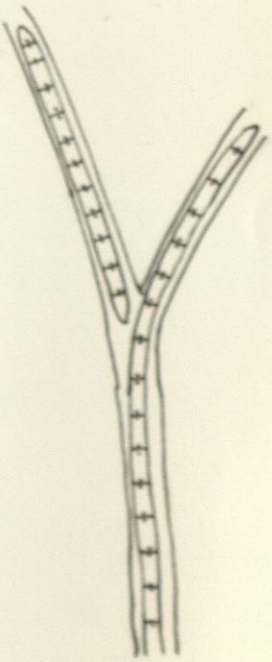
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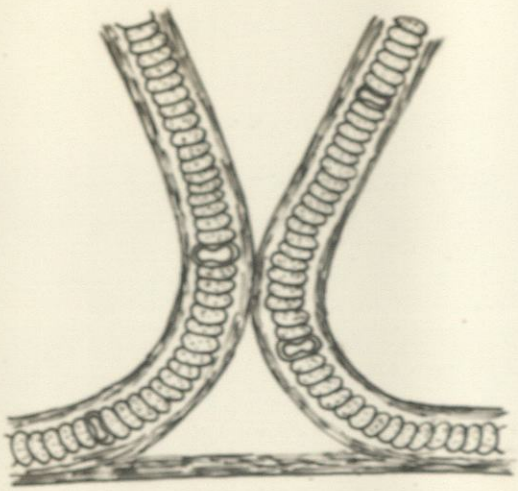


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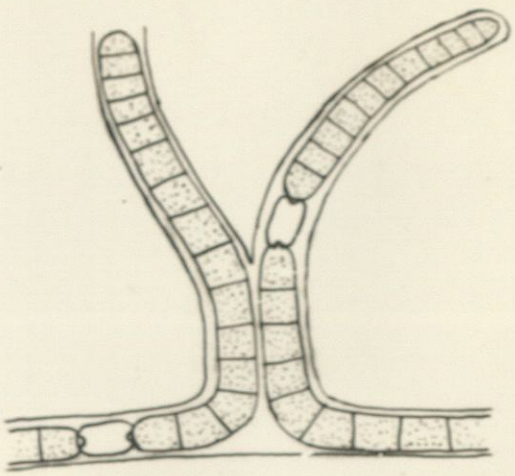
PLATE 7

Text Page	Plants	Fig.No.
167	*Scytonema millei* x 465	87
166	*S. hofmanni* x 1000	88
166	*S. javanicum* x 580	89
168	*Tolypothrix distorta* x 400	90
169	*T. fragilis* x 1000	91
171	*Microchaete tenera* x 1000	92
177	*Gloeotrichia echinulata* x 375	93

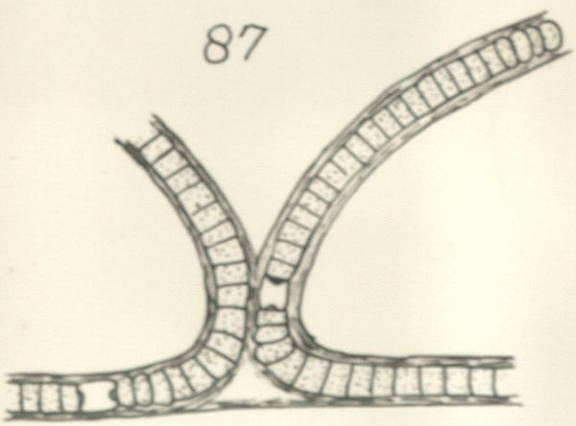
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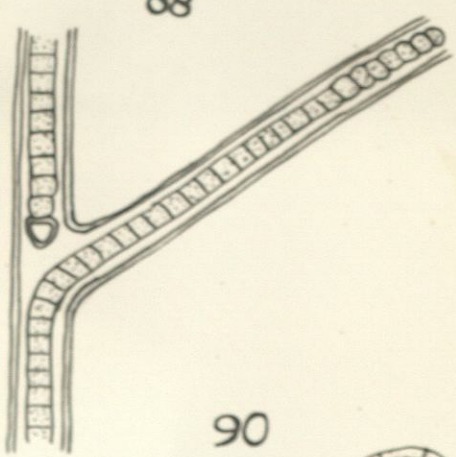
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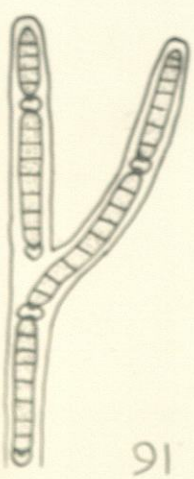
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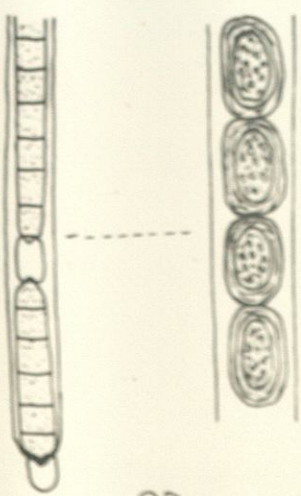
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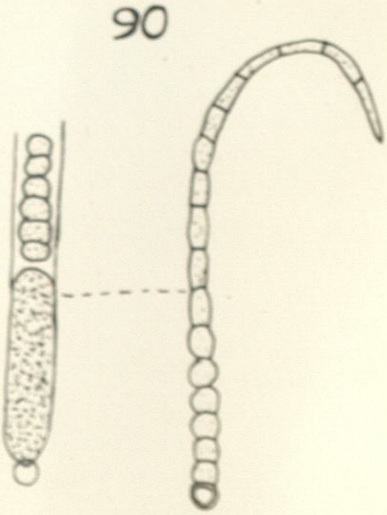
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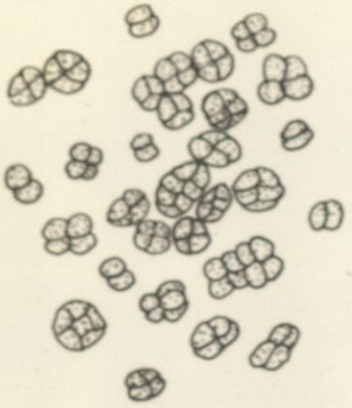


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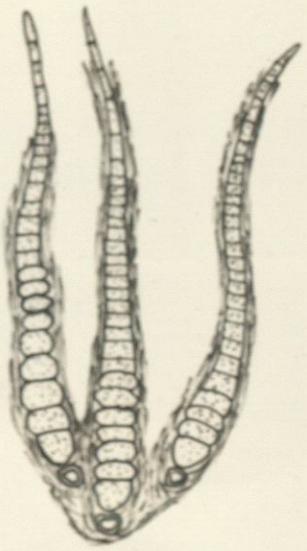
PLATE 8

Text Page	Plants	Fig.No.
51	*Gloeocapsa crepidinum* x 1000.....	94
176	*Rivularia dura* x 1000.....	95
174	*Calothrix epiphytica* x 750.....	96
175	*C. marchica* x 800.....	97
174	*C. elenkinii* x 600.....	98
173	*C. clavata* x 1000.....	99

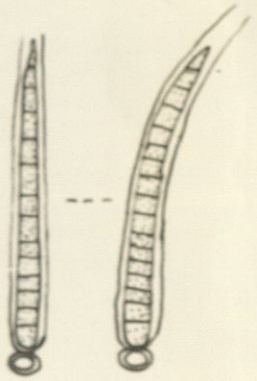
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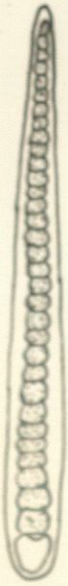
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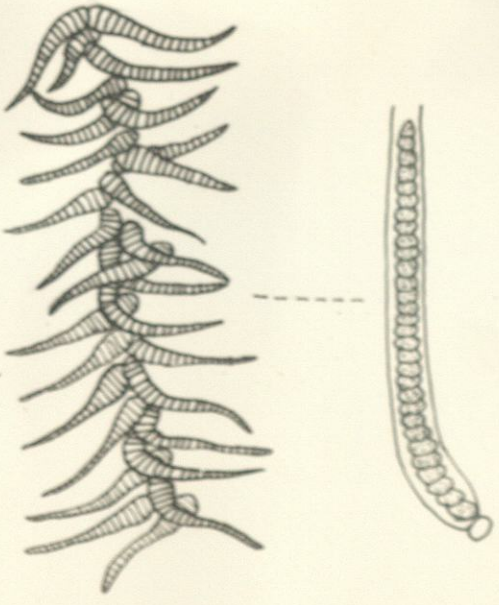
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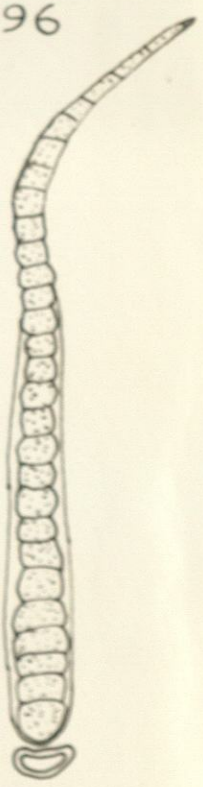
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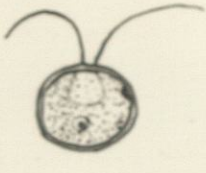
PLATE 9

Text Page	Plants	Fig.No.
186	Chlamydomonas snowii x 1000.....	100
184	C. globosa x 2200.....	101
185	C. pseudopetryi x 1000.....	102
188	Pandorina morum x 500.....	103
189	Palmella texensis x 1000.....	104
189	P. miniata x 1000.....	105
191	Gloeocystis ampla x 400.....	106
192	G. vesiculosa x 1000.....	107
196	Chlorohormidium sterile x 850.....	108
197	Microspora tumidula x 1430.....	109
200	Stigeoclonium polymorphum x 1000.....	110

PLATE 9



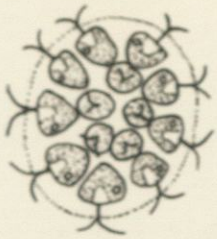
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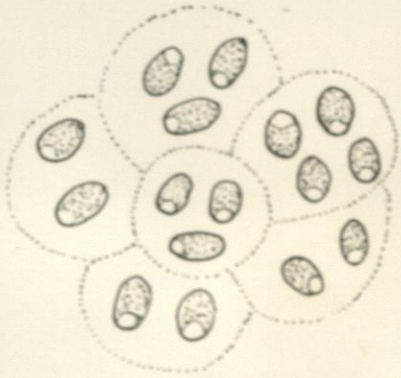
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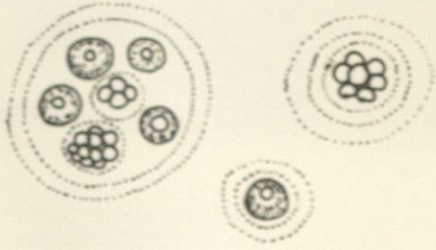
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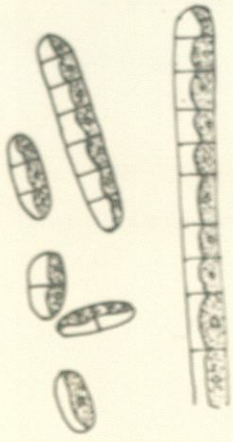
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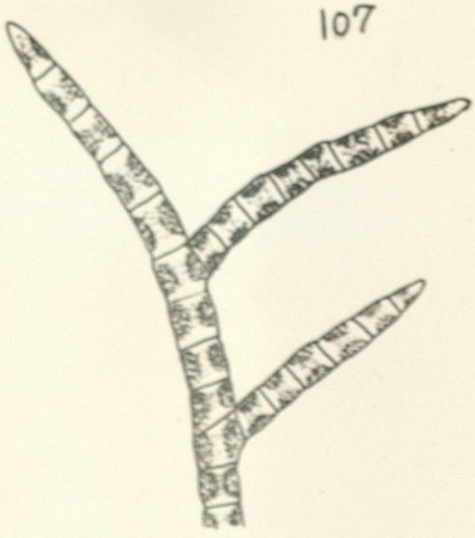
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108



109



110

PLATE 10

Text Page	Plants	Fig.No.
199	*Stigeoclonium pachydermum* x 250.....	111
193	*Ulothrix variabilis* x 1000.....	112
193	*U. idiospora* x 500.....	113
204	*Cladophora glomerata* x 50.....	114
201	*Protococcus viridis* x 1000.....	115
205	*Rhizoclonium hieroglyphicum* x 150.....	116
207	*Oedogonium hirnii* x 1000.....	117
208	*O. porrectum* x 1000.....	118

PLATE 10



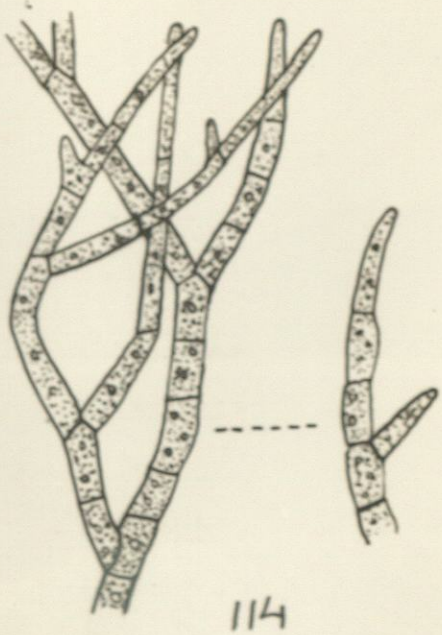
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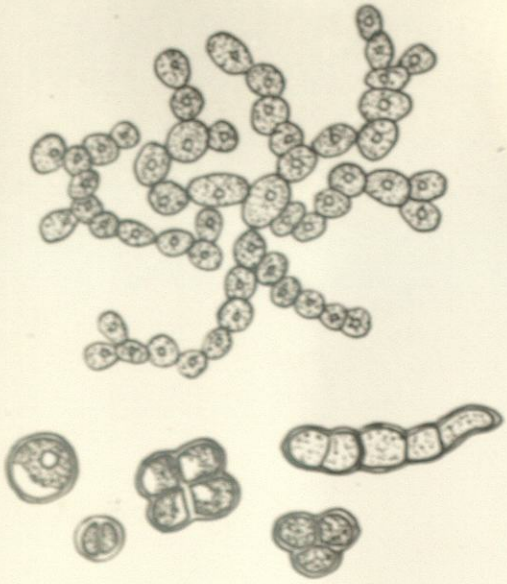
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113



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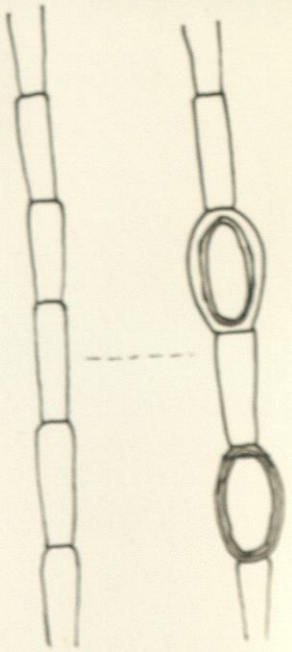
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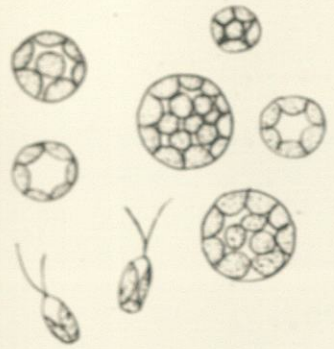


118

PLATE 11

Text Page	Plants	Fig.No.
211	*Bracteacoccus minor* x 900	119
209	*B. grandis* x 665	120
210	*B. medinucleatus* x 480	121
212	*B. pseudominor* x 400	122
217	*Chlorosarcinopsis sempervirens* x 1000	123
214	*C. auxotropica* x 1000	124
216	*C. pseudominor* x 1400	125
213	*C. arenicola* x 1000	126
215	*C. deficiens* x 2000	127

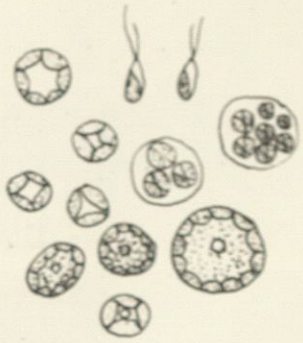
PLATE 11



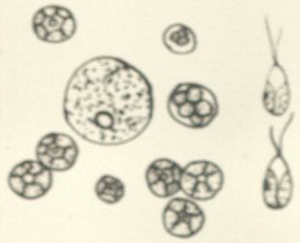
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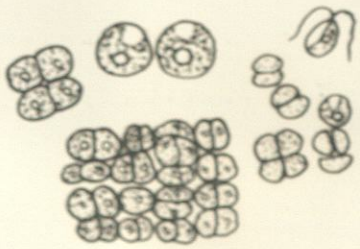
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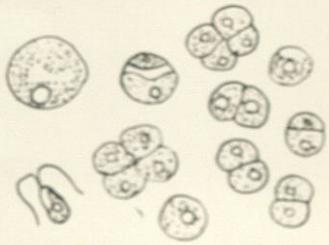
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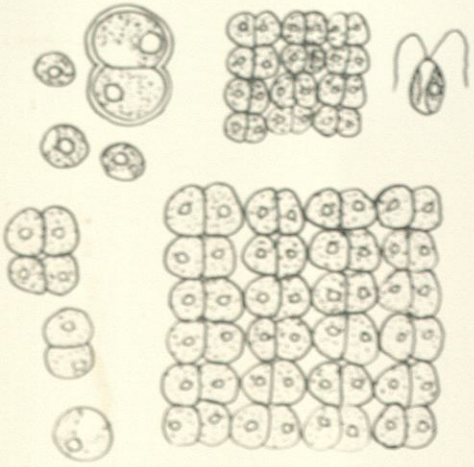
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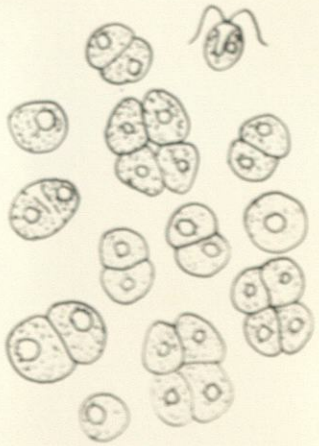
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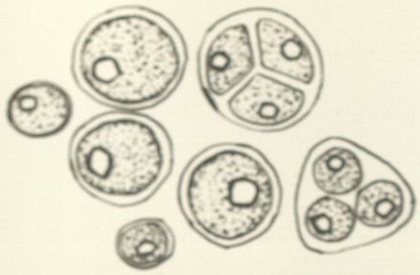


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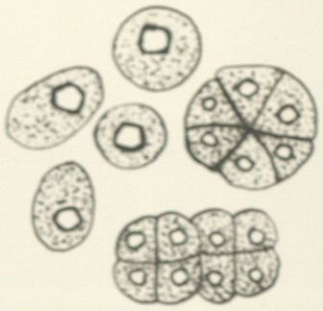
PLATE 12

Text Page	Plants	Fig.No.
219	Tetracystis excentrica x 955	128
221	T. isobilateralis x 665	129
222	T. pampae x 857	130
224	T. texensis x 730	131
220	T. intermedium x 1000	132
223	T. tetrasporum x 1000	133
228	Chlorococcum acidum x 800	134
228	C. aureum x 600	135
229	C. echinozygotum x 1000	136

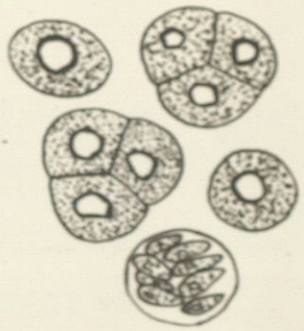
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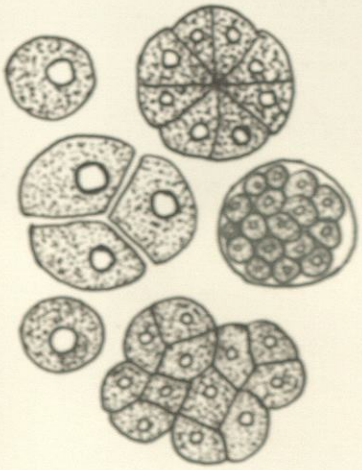
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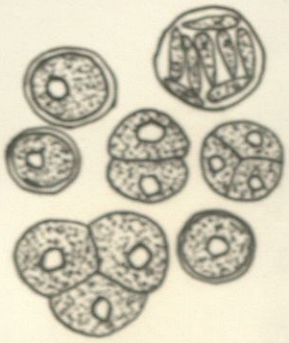
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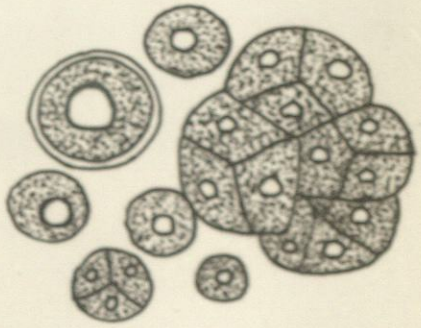
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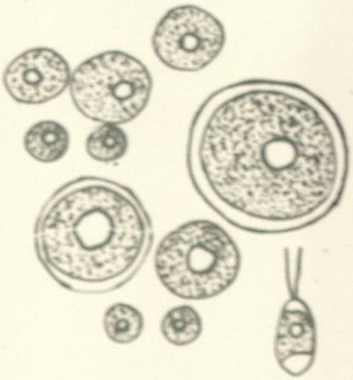
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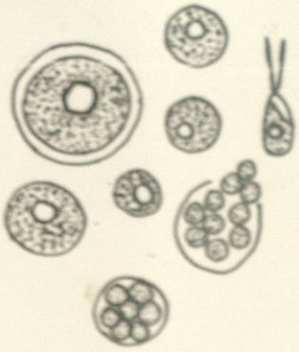
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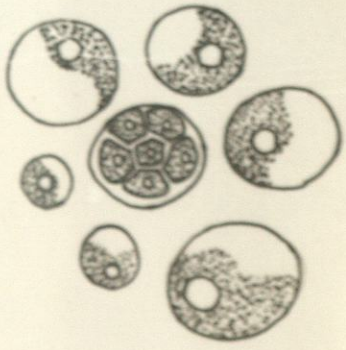
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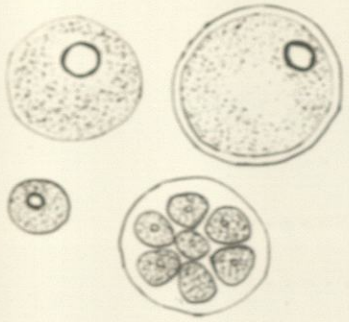


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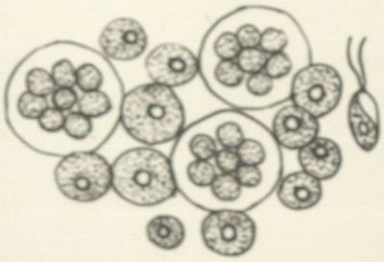
PLATE 13

Text Page	Plants	Fig.No.
230	Chlorococcum elkhartiense x 880.....	137
230	C. gelatinosum x 800.....	138
231	C. hypnosporum x 1000.....	139
232	C. isabeliense x 800.....	140
232	C. lacustre x 1000.....	141
233	C. macrostigmatum x 500.....	142
236	C. oviforme 530.....	143
237	C. pulchrum x 900.....	144
237	C. refringens x 1000.....	145

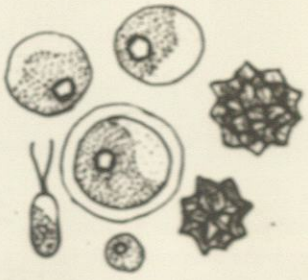
PLATE 13



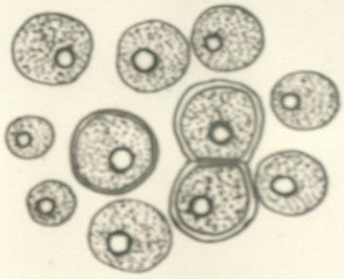
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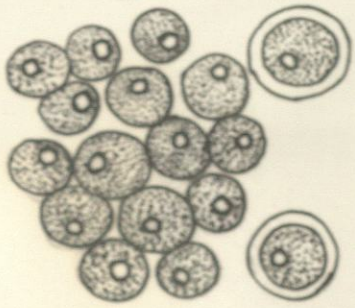
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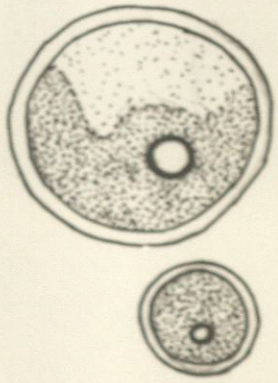
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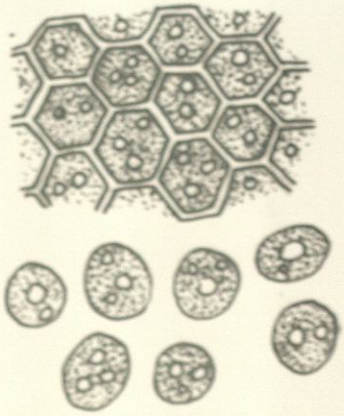
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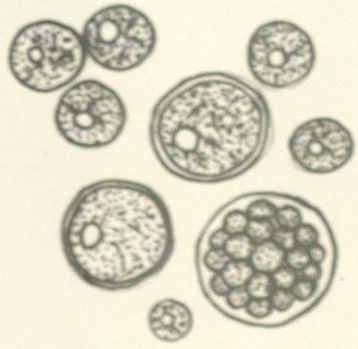
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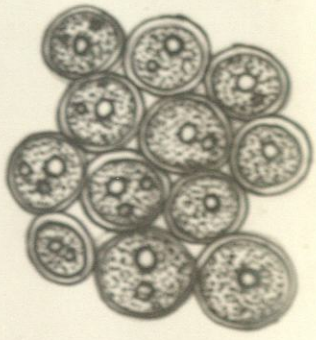
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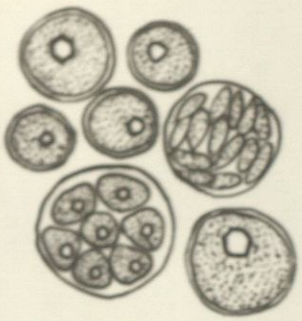


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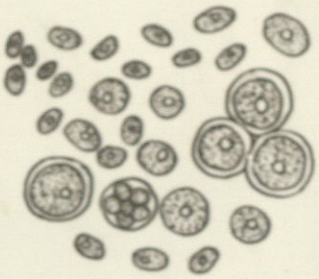
PLATE 14

Text Page	Plants	Fig.No.
238	Chlorococcum reticulatum x 750.....	146
239	C. salsugineum x 650.....	147
239	C. sphacosum x 1000.....	148
240	C. typicum x 1000.....	149
234	C. microstigmatum x 650.....	150
235	C. minutum x 1000.....	151
235	C. nova angliae x 1000.....	152
258	Palmellococcus protothecoides x 1000.....	153
257	Crucigenia irregularis x 1000.....	154

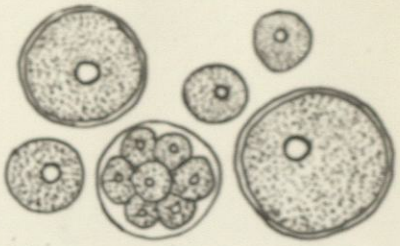
PLATE 14



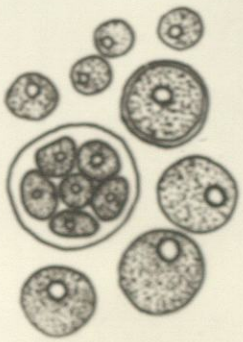
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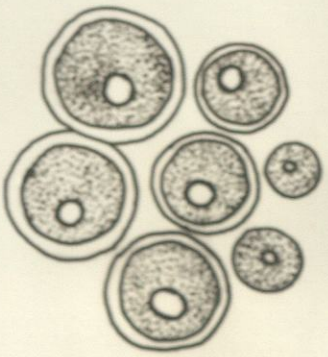
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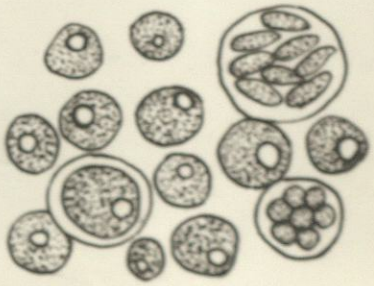
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150



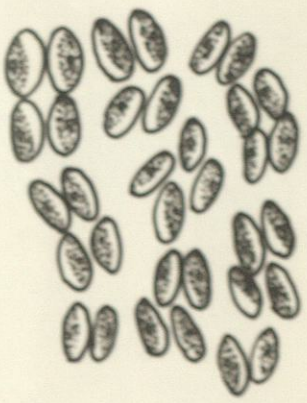
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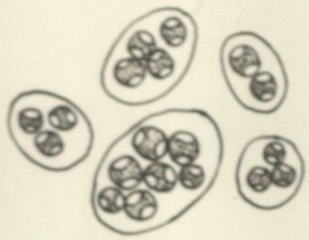


154

PLATE 15

Text Page	Plants	Fig.No.
281	*Gloeobotrys limneticus* x 700.....	155
273	*Mesotaenium purpureum* x 1000.....	156
242	*Eremosphaera viridis* x 300.....	157
241	*E. eremosphaeria* x 500.....	158
244	*Planktosphaeria texensis* x 400.....	159
261	*Scenedesmus incrassatulus* x 1000.....	160
269	*Coelastrum microporum* x 1000.....	161
245	*Dictyococcus varians* x 300.....	162
247	*Neochloris cohaerens* x 300.....	163

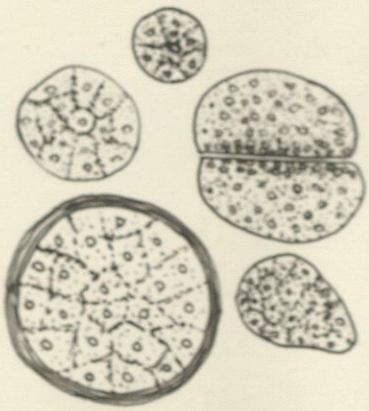
PLATE 15



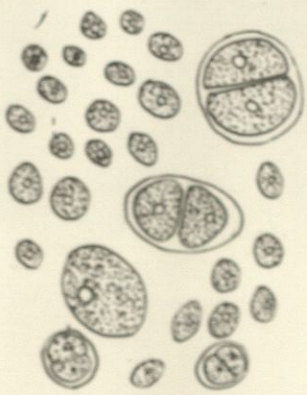
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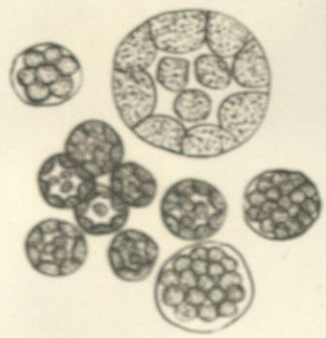
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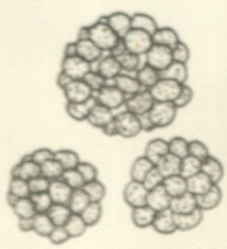
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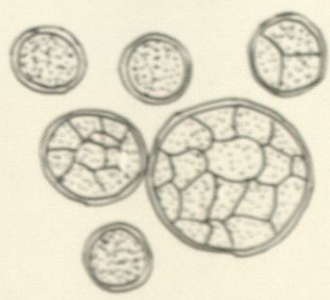
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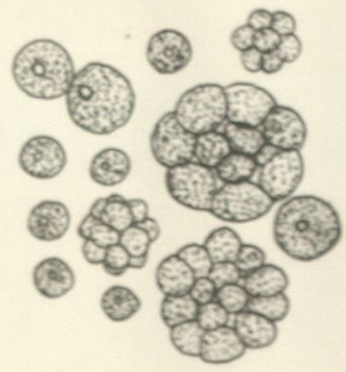
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161



162

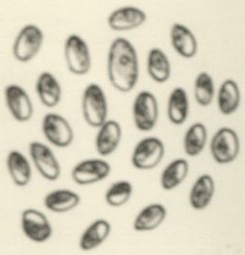


163

PLATE 16

Text Page	Plants	Fig.No.
253	Chlorella ellipsoidea x 450.....	164
256	Oocystis solitaria x 1200.....	165
256	O. pyriformis x 400.....	166
255	O. parva x 800.....	167
254	O. crassa x 1000.....	168
282	Monallantus brevicylindrus x 1000.....	169
250	Spongiochloris spongiosa x 200.....	170
249	S. incrassata x 300.....	171
251	Radiosphaera dissecta x 150.....	172

PLATE 16



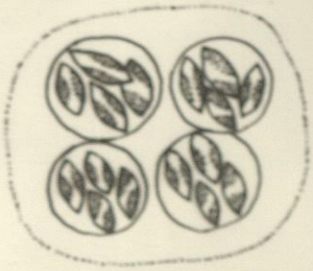
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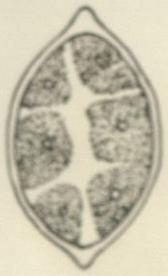
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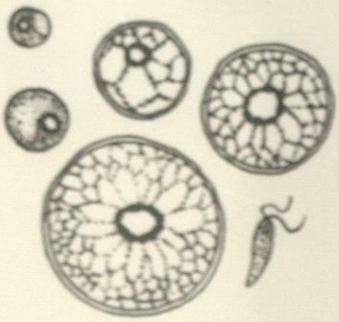
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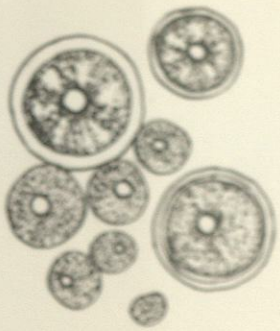
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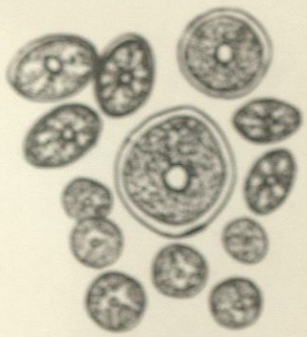
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170



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172

PLATE 17:Continued

Text Page	Plants	Fig.No.
202	Physolinum monilia x 500.....	194
186	Chlamydomonas typica x 200.....	195
287	Euglena proxima var. minima x 100.....	196

PLATE 17

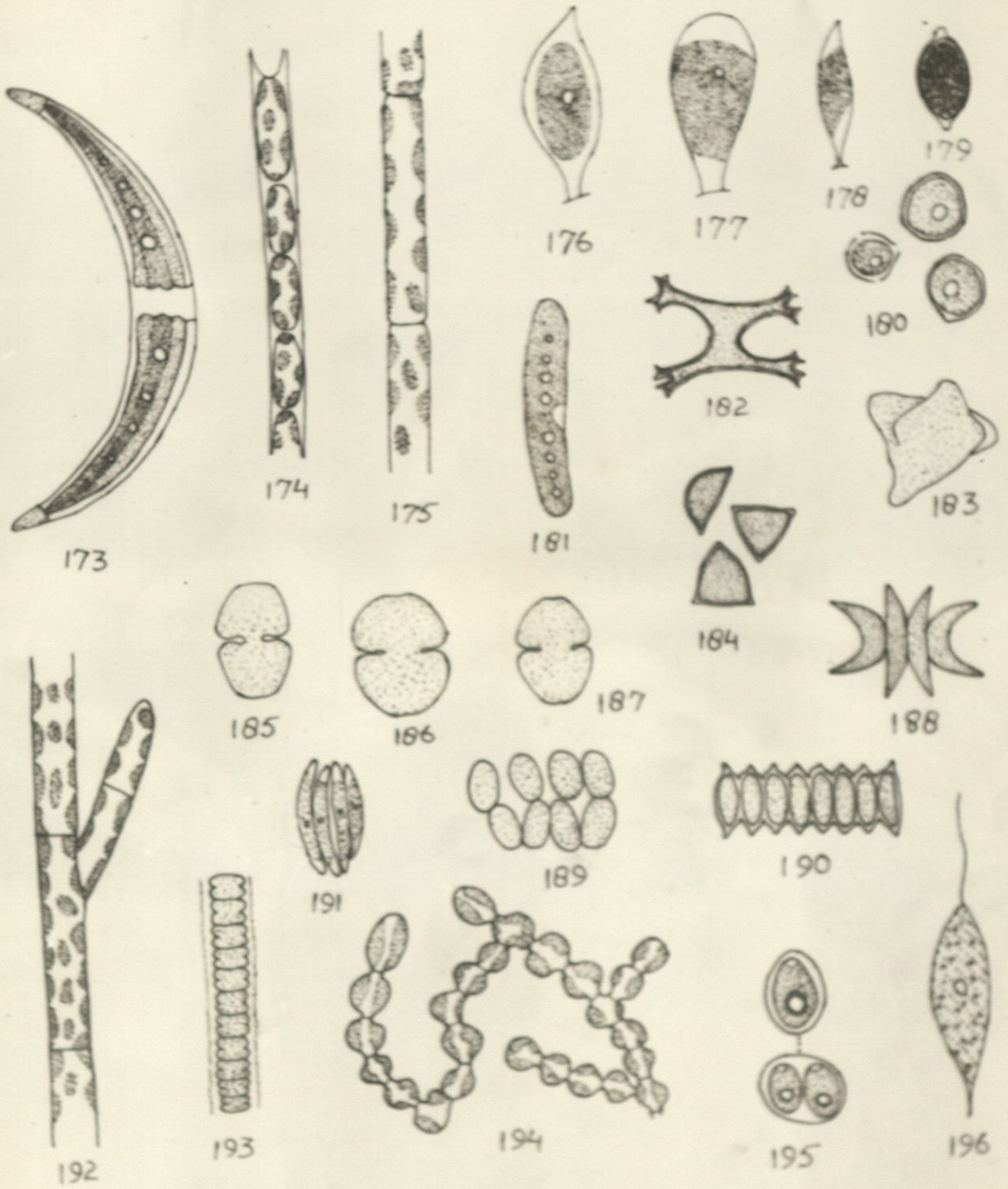

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PLATE 18

Text Page	Plants	Fig.No.
203	Cladophora fracta x 100.....	197
195	Chlorohormidium flaccidum x 500.....	198
41	Chroococcus turgidus x 200.....	199
57	Aphanocapsa banaresensis x 1000.....	200
52	Gloeothece rupestris x 800.....	201
46	Microcystis pseudofilamentosa x 500.....	202
63	Stichosiphon sansibaricus x 1000.....	203
64	Synechococcus aeruginosus x 1000.....	204
138	Nostoc ellipsosporum x 800.....	205
141	N. microscopicum x 1000.....	206
138	N. comminutum x 500.....	207
153	Anabaena gelatinicola x 1000.....	208
67	Spirulina laxissima x 1000.....	209
68	S. meneghiniana x 800.....	210
69	S. platensis x 500.....	211
124	Symploca muscorum x 1000.....	212
125	Microcoleus ethonoplastes x 1000.....	213
178	Gloeotrichia longicauda x 550.....	214
162	Nodularia spumigena x 1000.....	215

PLATE 18

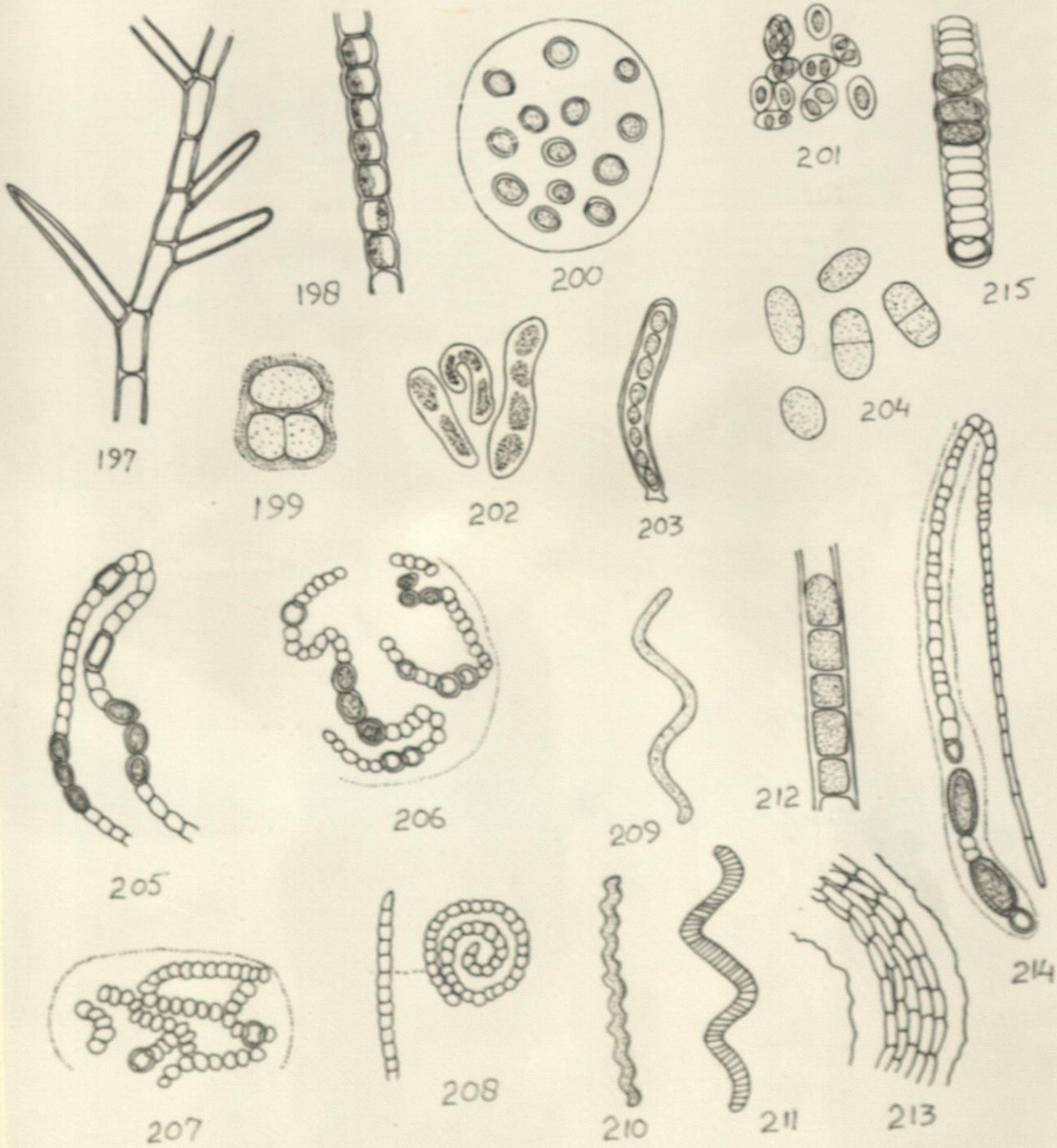

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PLATE 19

Text Page	Plants	Fig.No.
72	Oscillatoria acutissima x 500	216
74	O. amoena x 800	217
77	O. articulata x 1500	218
78	O. cortiana x 400	219
81	O. laete-virens x 1000	220
82	O. lacustris x 800	221
85	O. prolifica x 1000	222
86	O. quadripunctulata x 3000	223
88	O. splendida x 1000	224
90	O. tenuis x 1000	225
96	Phormidium autumnale x 1000	226
100	P. incrustatum x 1000	227
103	P. muscorum x 1000	228
103	P. mucicola x 1000	229
108	P. truncicola x 350	230
109	P. uncinatum x 700	231
110	P. valderianum x 1500	232
113	Lyngbya allorgei x 1500	233
114	L. contorta x 1000	234
164	Plectonema nostocorum x 1000	235
115	Lyngbya gardneri x 2000	236
116	L. kuetzingii x 1500	237
118	L. nordgaardii x 1500	238

PLATE 19:Continued

Text Page	Plants	Fig.No.
119	Lyngbya putealis x 600	239
121	L. Taylorii x 1000	240
129	Schizothrix Friesii x 800	241
130	S. vaginata x 500	242
129	S. tinctoria x 500	243
170	Tolypothrix tenuis x 500	244
162	Nodularia harveyana x 1000	245

PLATE 19: Continued

Text Page	Plants	Fig.No.
119	Lyngbya putealis x 600	239
121	L. taylorii x 1000	240
129	Schizothrix friesii x 800	241
130	S. vaginata x 500	242
129	S. tinctoria x 500	243
170	Tolypothrix tenuis x 500	244
162	Nodularia harveyana x 1000	245

PLATE 19

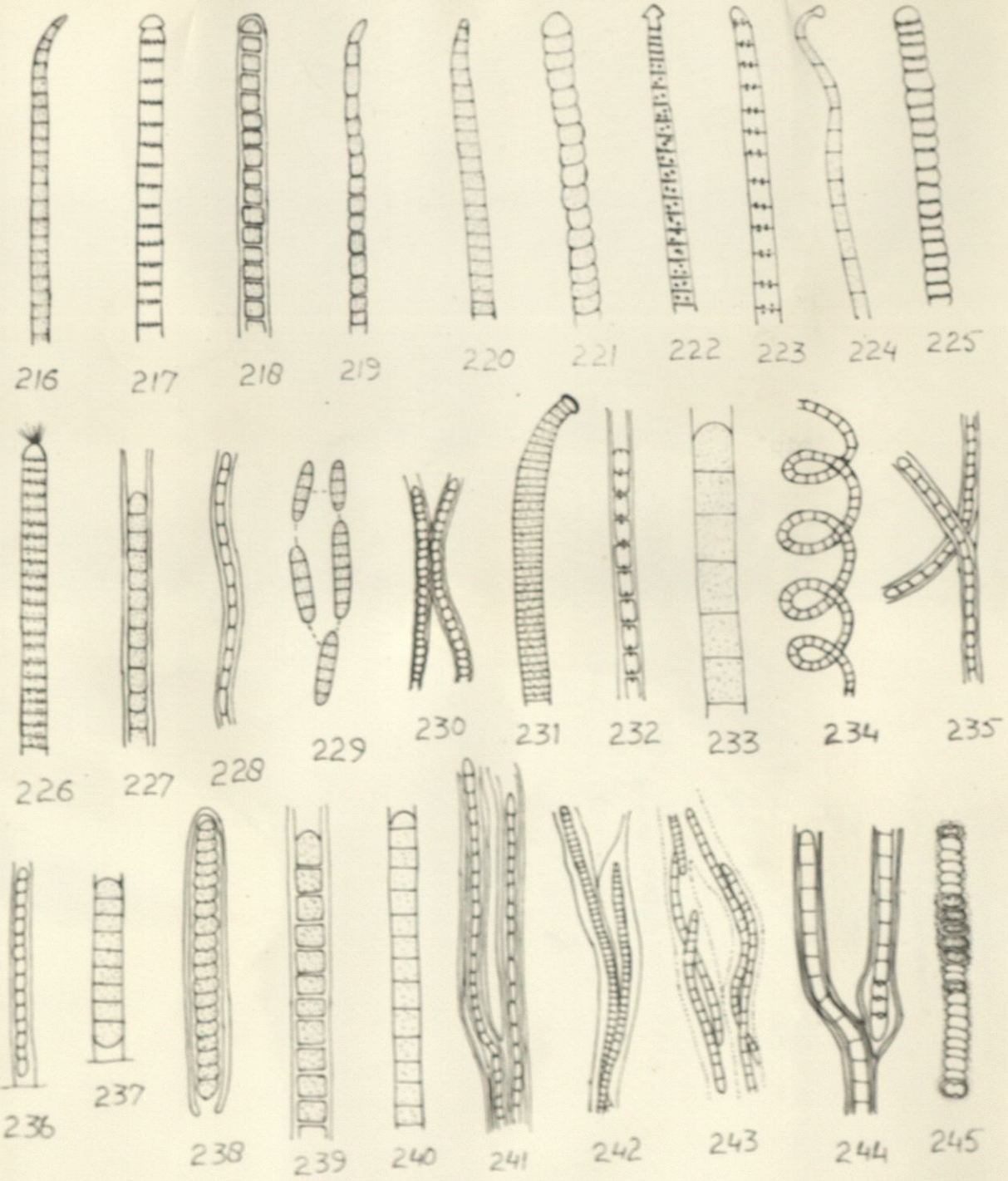
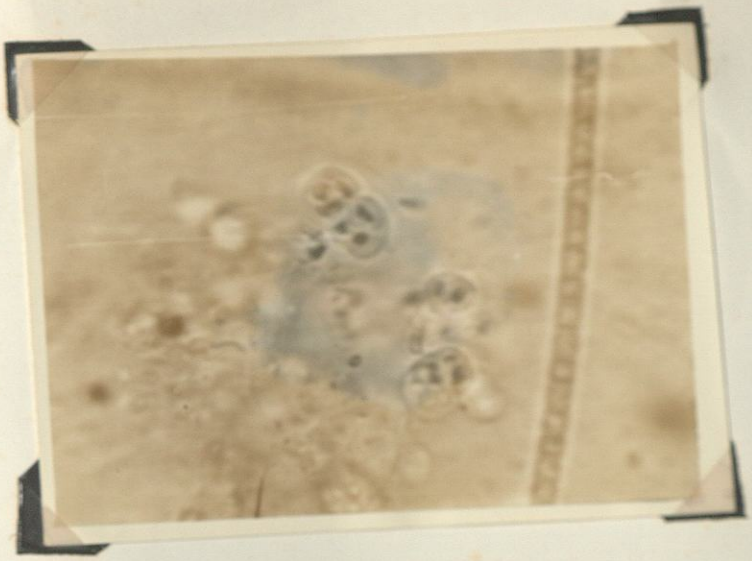
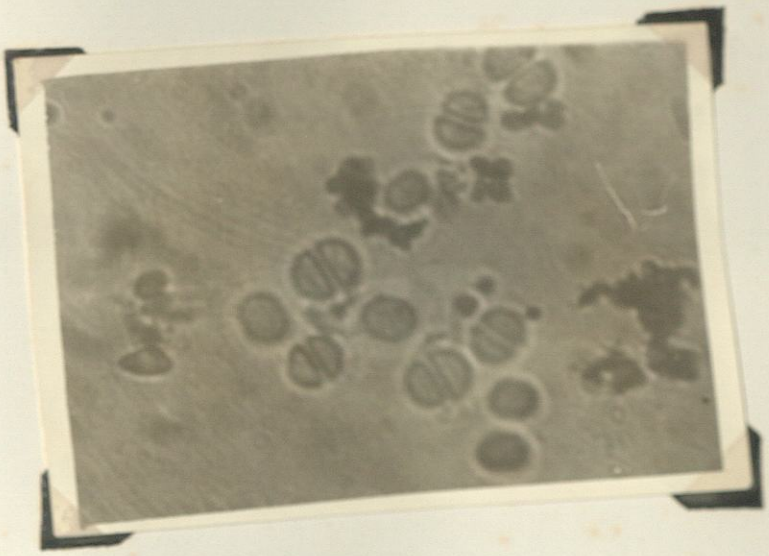

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PLATE 20

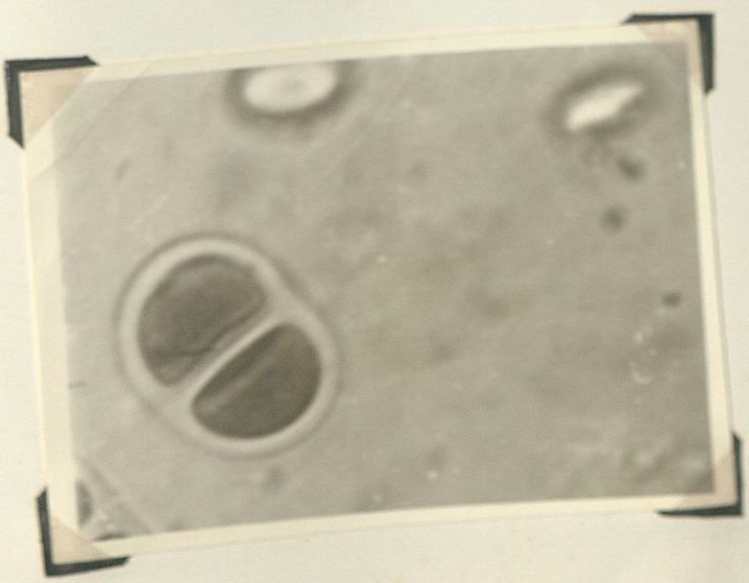
Photo No.	Plants
1	Chroococcus cohaerens x 360
2	C. limneticus var. subsalsus x 360
3	C. turgidus x 360



1



2



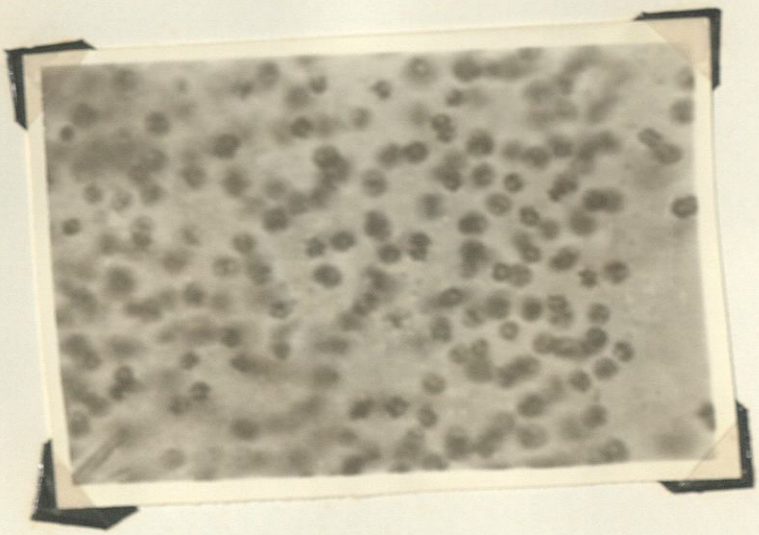
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PLATE 21

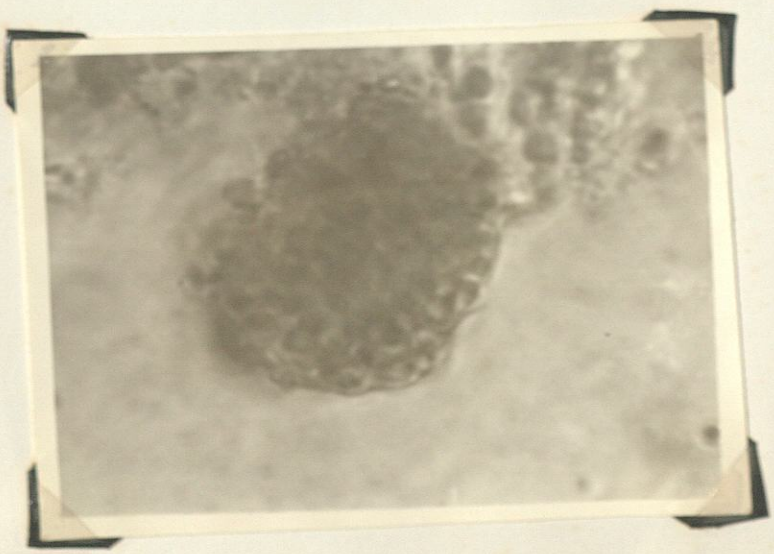
Photo No.	Plants
4	Microcystis aeruginosa : Colony x 60
5	Microcystis aeruginosa x 360
6	M. marginata x 360



4



5



6

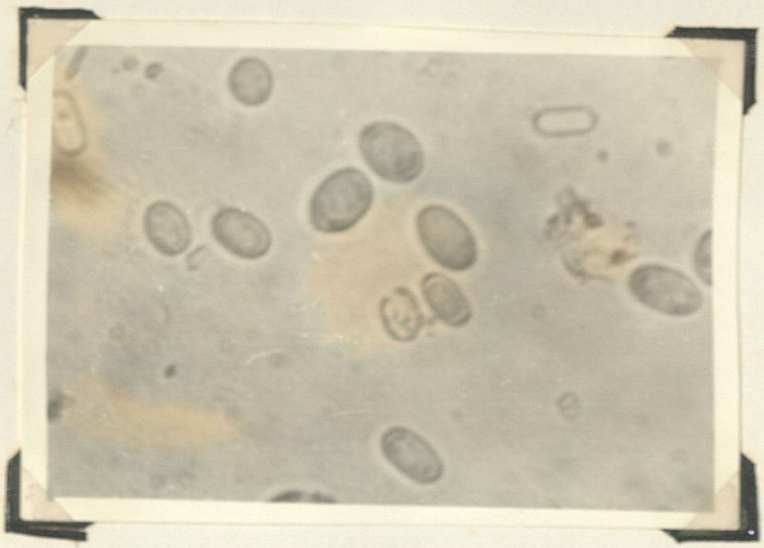
PLATE 22

Photo No.	Plants
7	Microcystis pulvera x 360
8	Aphanothece microscopica x 360
9	Gloeocapsa cripidinum x 360

7



8



9

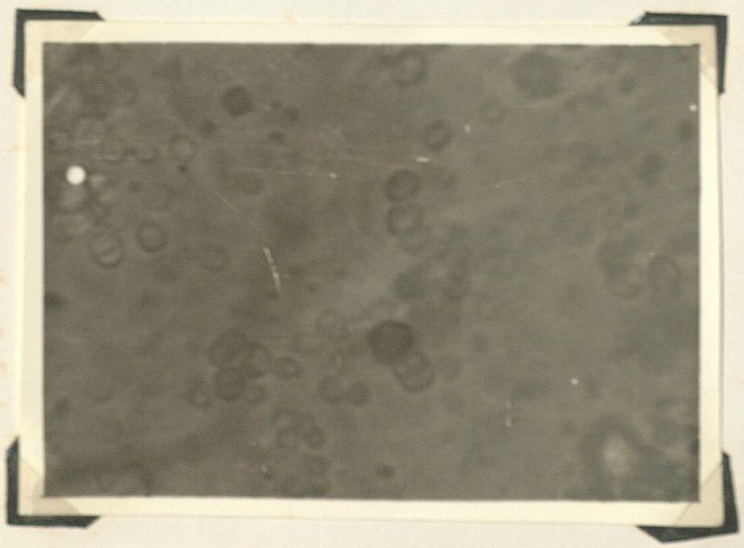
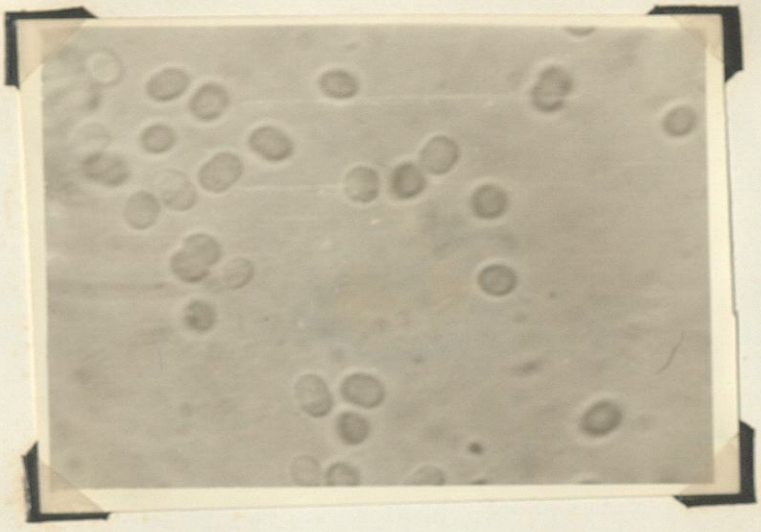


PLATE 23

Photo No.	Plants
10	Aphanocapsa littoralis x 360
11	Merismopedia tenuissima x 360
12	Spirulina platensis x 360

10



11



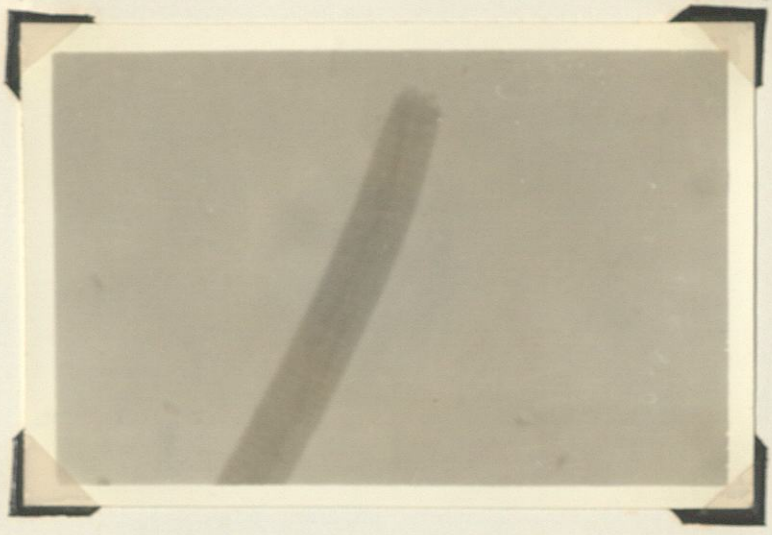
12



PLATE 24

Photo No.	Plants
13	Oscillatoria curviceps x 360
14	O. formosa x 360
15	O. princeps x 360

13



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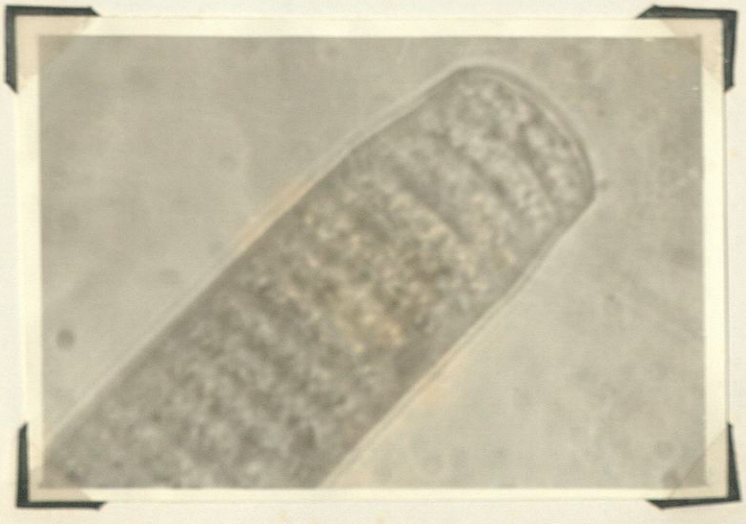


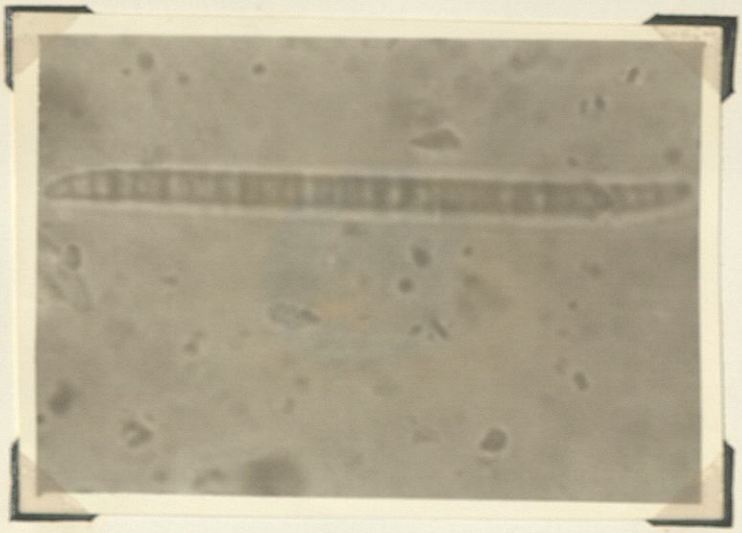
PLATE 25

Photo No.	Plants
16	Oscillatoria subbrevis x 360
17	O. terebriformis x 360
18	Phormidium ambiguum x 360

16



17



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PLATE 26

Photo No.	Plants
19	Phormidium autumnale x 360
20	P. corium x 360
21	P. fragile x 360

19



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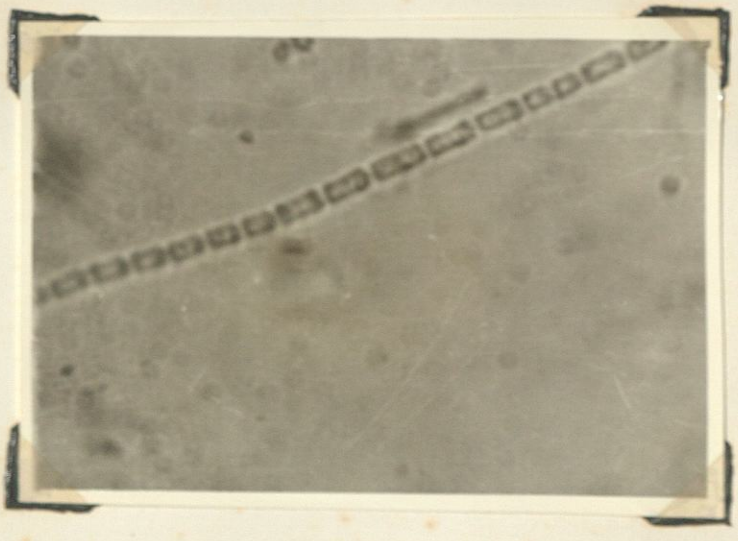


PLATE 27

Photo No.	Plants
22	*Phormidium purpurascens* x 360
23	*P. tenue* x 360
24	*Lyngbya martensiana*,: Hormogonia x 360



22



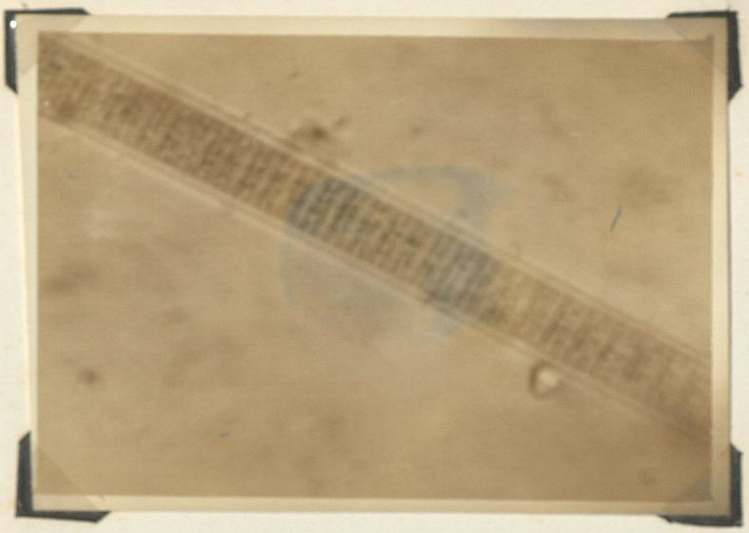
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PLATE 28

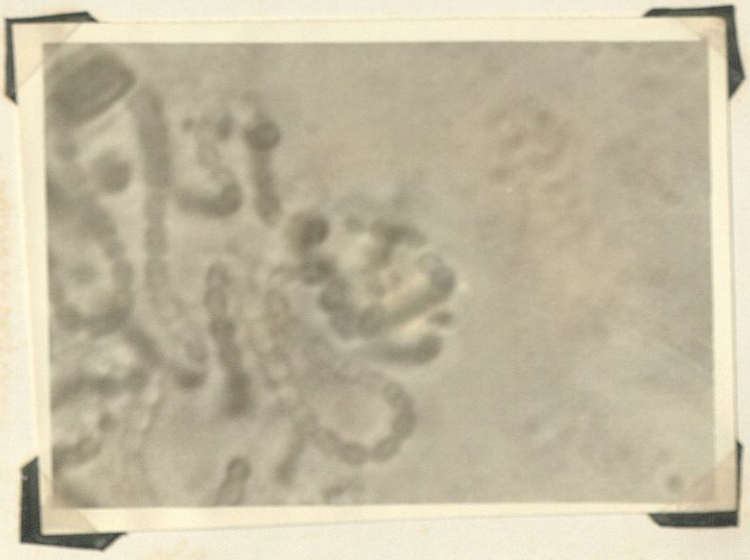
Photo No.	Plants
25	Lyngbya martensiana x 360
26	L. truncicola x 360
27	Nostoc carneum x 360



25



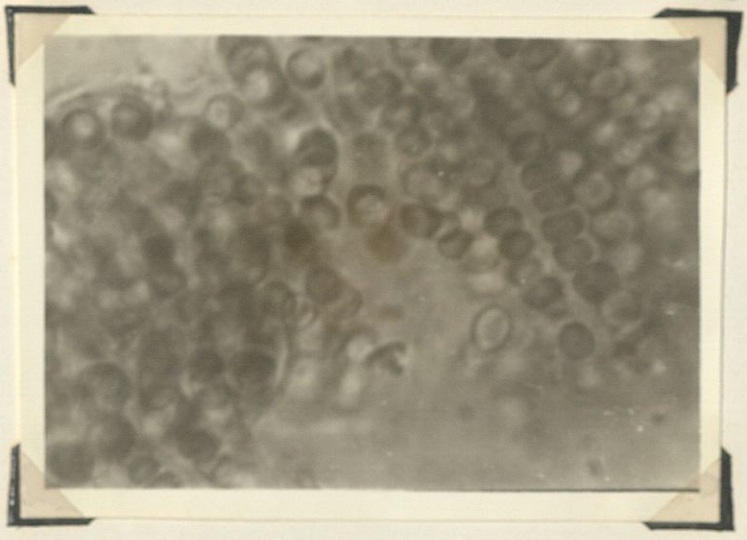
26



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PLATE 29

Photo No.	Plants
28	Nostoc commune x 360
29	N. microscopicum x 360
30	N. paludosum x 360



28



29



30

PLATE 30

Photo No.	Plants
31	Nostoc piscinale 360
32	N. piscinale : Spores in chain x 360
33	N. punctiforme x 360



31



32

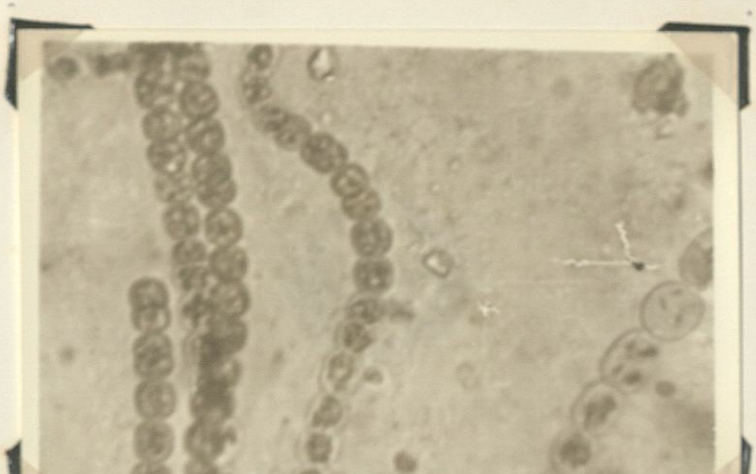


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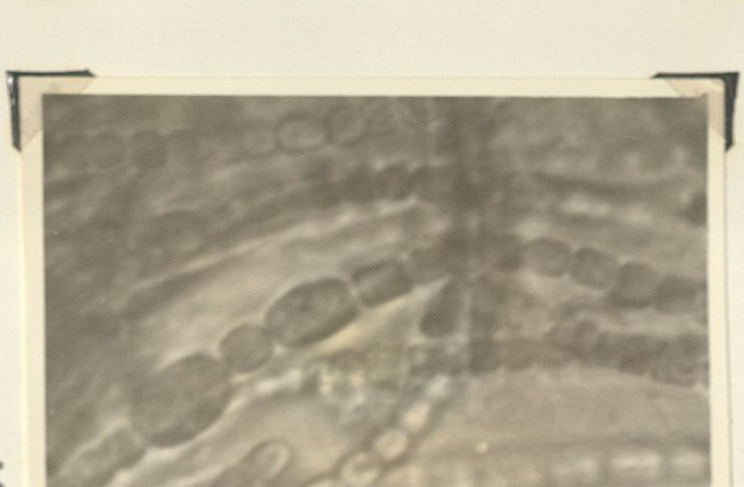
PLATE 31

Photo No.	Plants
34	Anabaena aphanizominoides x 360
35	A. aphanizominoides : Spores contiguous with the heterocyst. x 360
36	A. circinalis x 360

34



35



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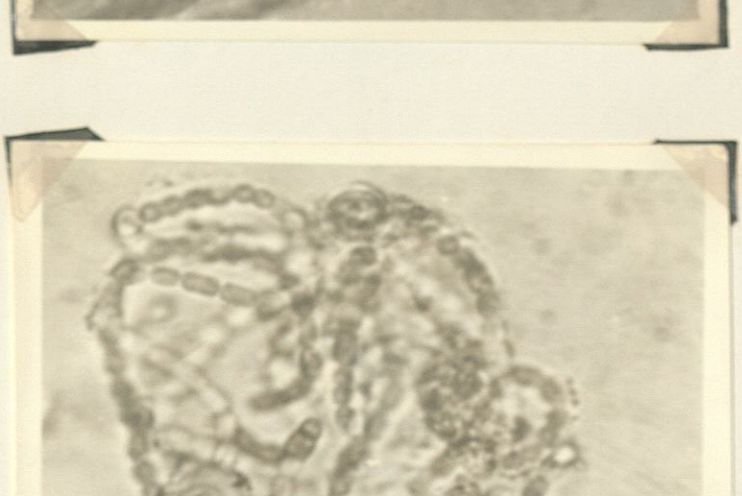
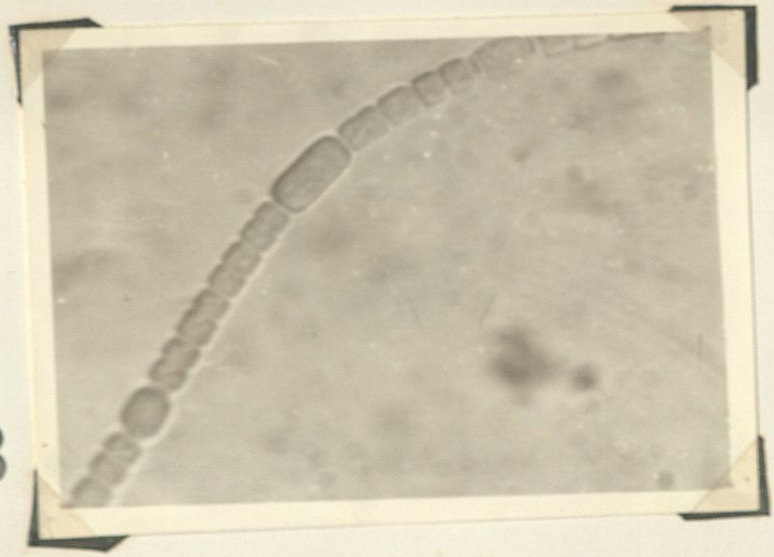


PLATE 32

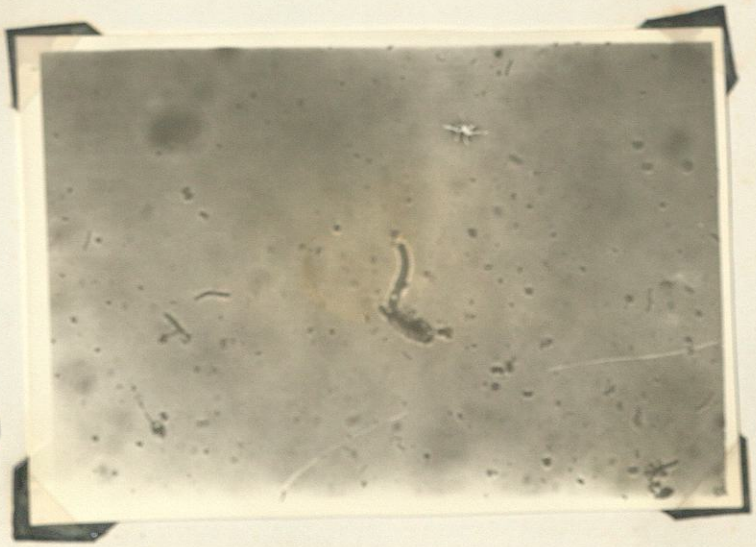
Photo No.	Plants
37	Anabaena subcylindrica x360
38	A. subcylindrica : Trichome forming spore. x360
39	Calothrix elenkinii x60



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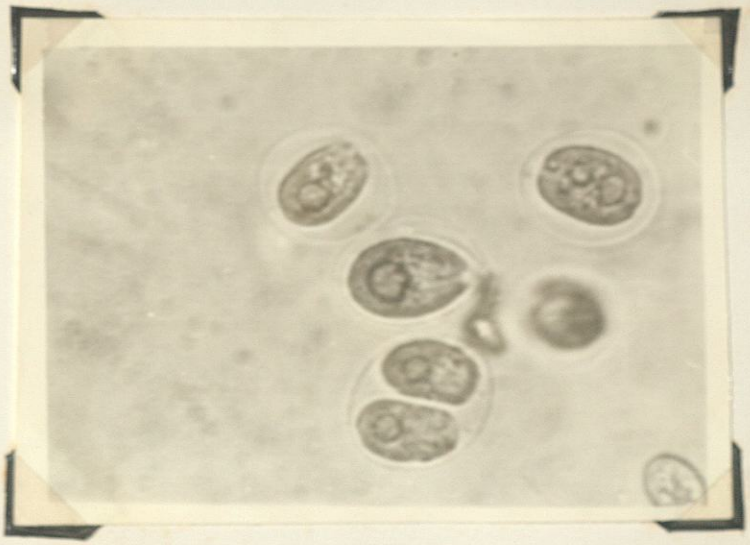
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PLATE 33

Photo No.	Plants
40	Gloeotrichia longicauda x 360
41	Chlamydomonas typica x 360
42	C. typica : Daughter cell formation. x 360



40



41



42

PLATE 34

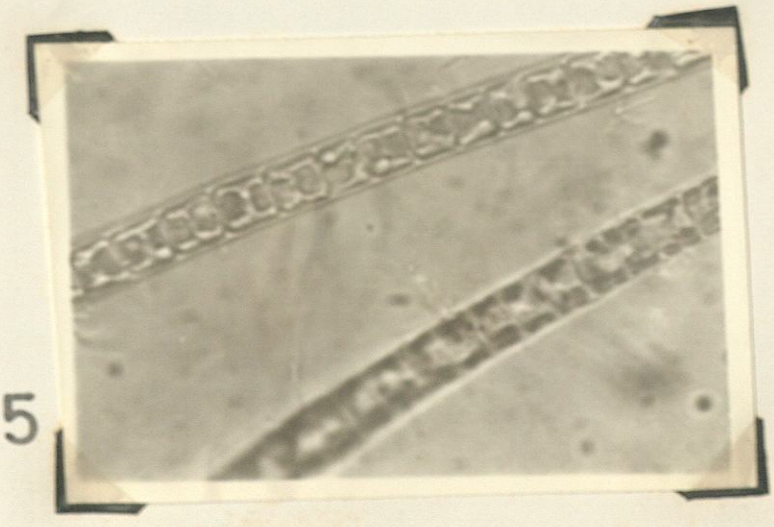
Photo No.	Plants
43	Pandorina morum x 360
44	Ulothrix idiospora x 360
45	U. variabilis x 360



43



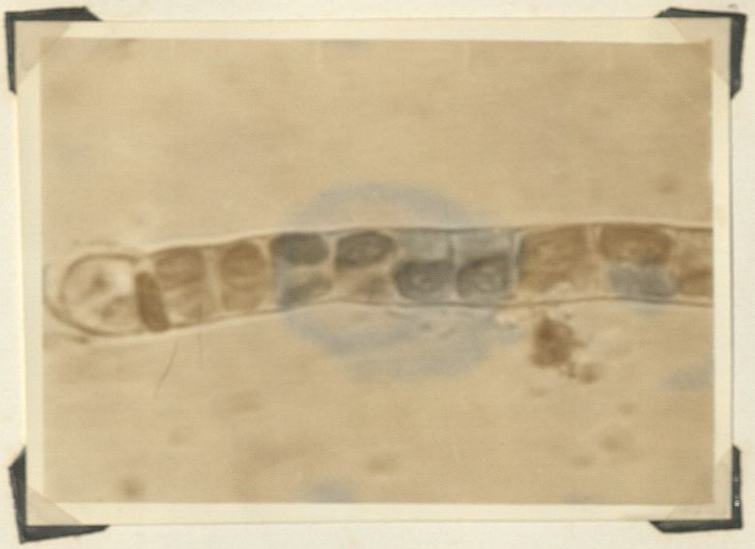
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PLATE 35

Photo No.	Plants
46	Chlorohormidium sterile x 360
47	C. sterile : Hormogone x 360
48	Stigeoclonium polymorphum x 60



46



47



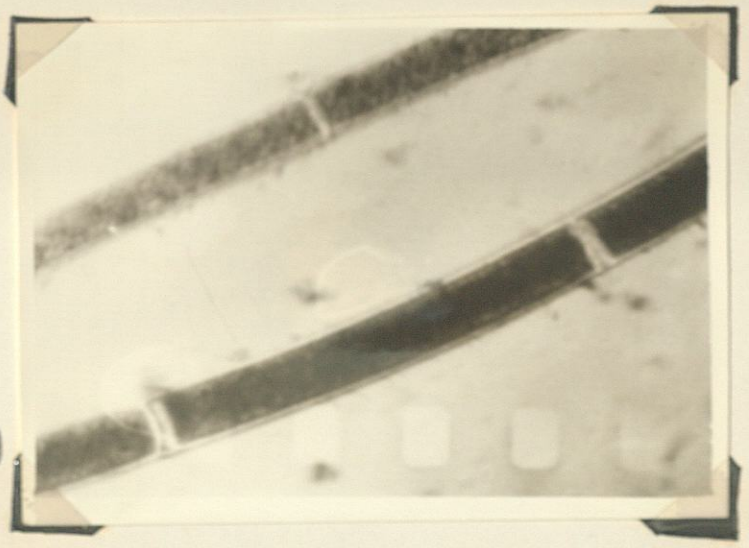
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PLATE 36

Photo No.	Plants
49	Cladophora glomerata x 60
50	Rhizoclonium hieroglyphicum x 60
51	Oedogonium hirnii x 360



49



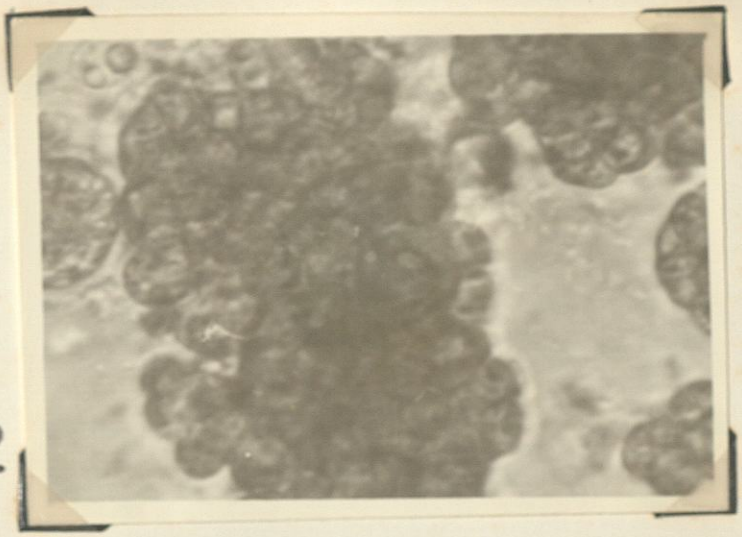
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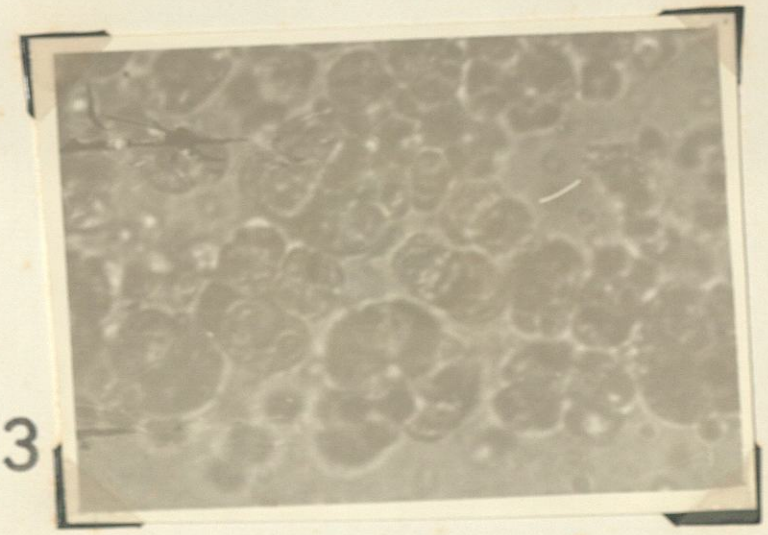
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PLATE 37

Photo No.	Plants
52	Chlorosarcinopsis pseudominor x 360
53	C. sempervirens x 360
54	Tetracystis excentrica : Diad x 360



52



53



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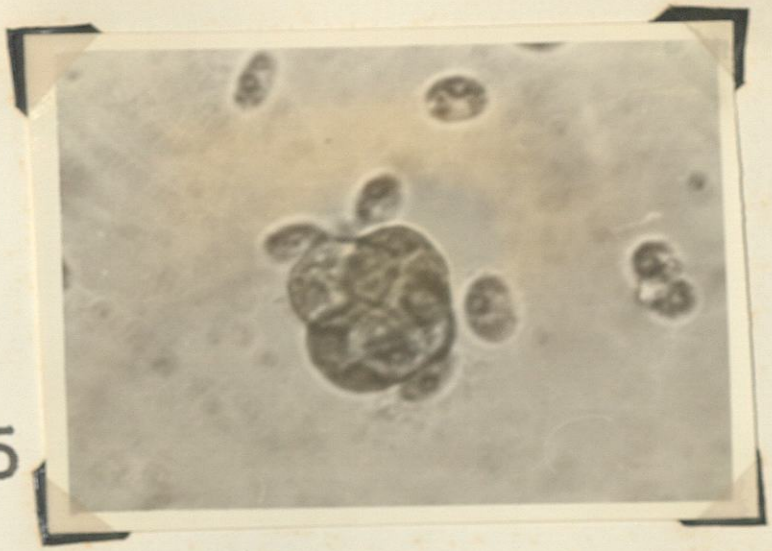
PLATE 38

Photo No. Plants

55 Tetracystis excentrica : Tetrad complex. × 360

56 T. intermedium : Octad × 360

57 T. isobilateralis × 360



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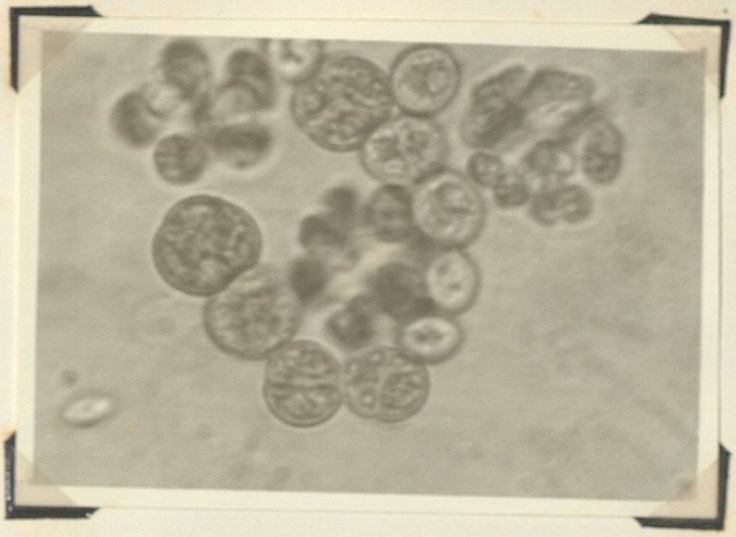
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PLATE 39

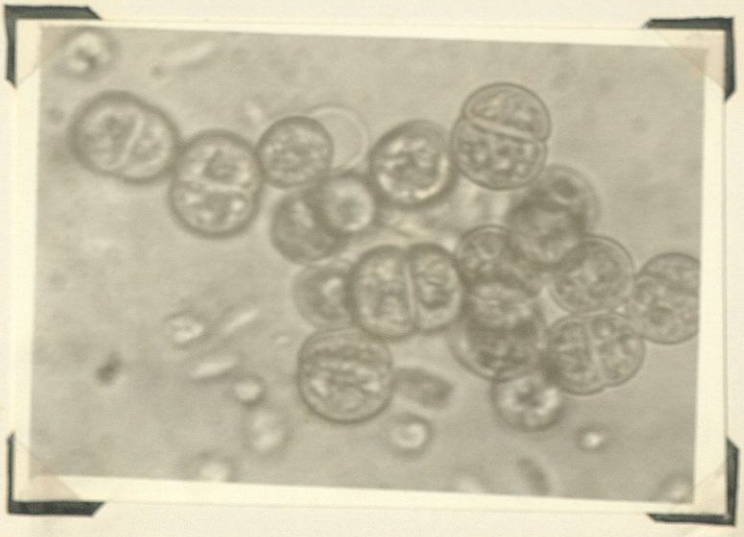
Photo No.	Plants
58	Tetracystis pampae x 360
59	T. tetrasporum x 360
60	T. texensis x 360



58



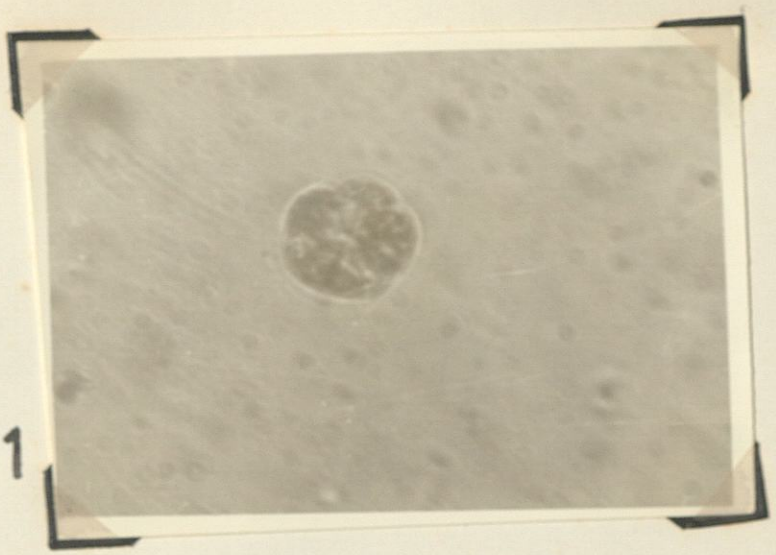
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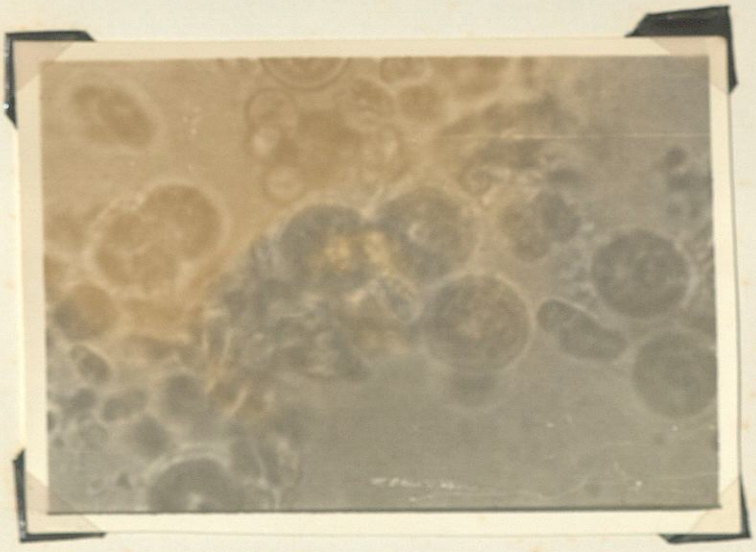
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PLATE 40

Photo No.	Plants
61	Tetracystis texensis : Octad x 360
62	Chlorococcum acidum x 360
63	C. aureum x 360



61



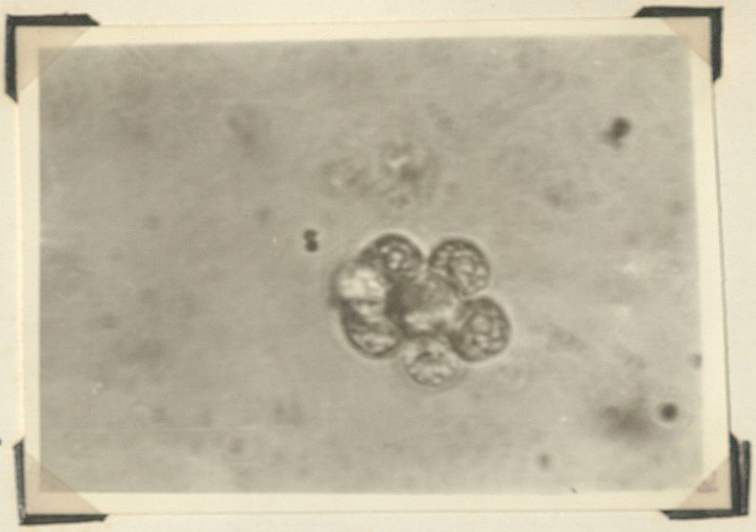
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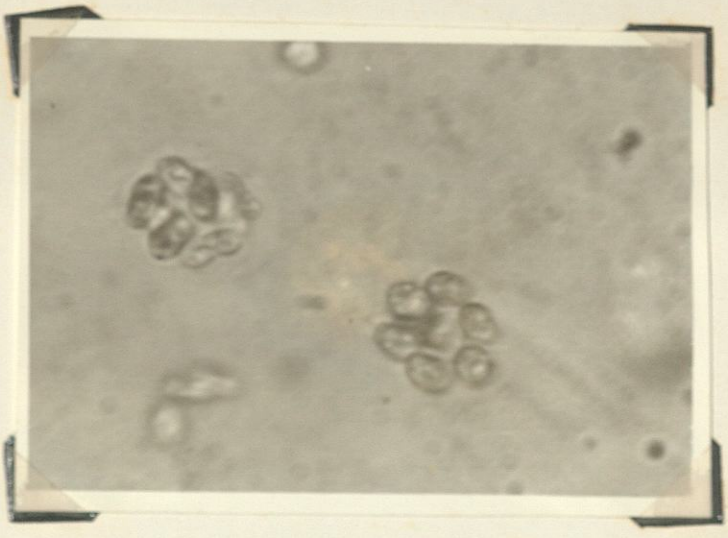
63

PLATE 41

Photo No.	Plants
64	Chlorococcum echinozygotum: Aplanosporangium ×360
65	C. elkhartiense Aplanosporangium (right) and zoosporangium (left) ×360
66	C. gelatinosum: Zoospores ×360



64



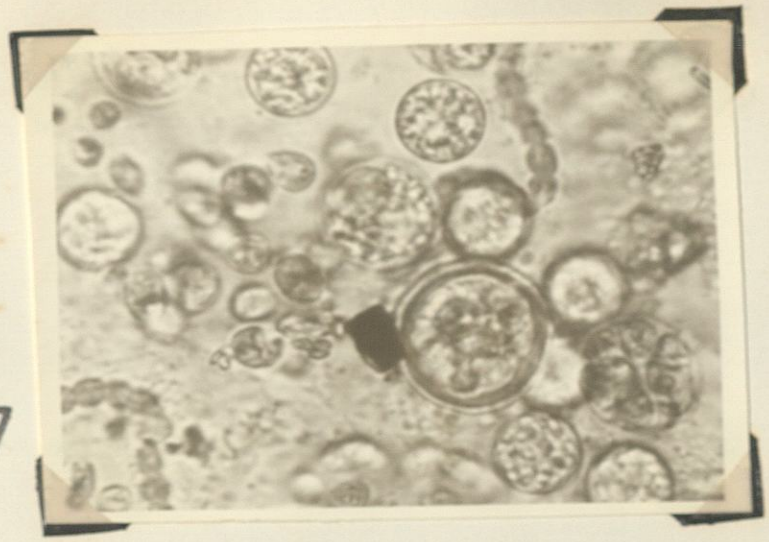
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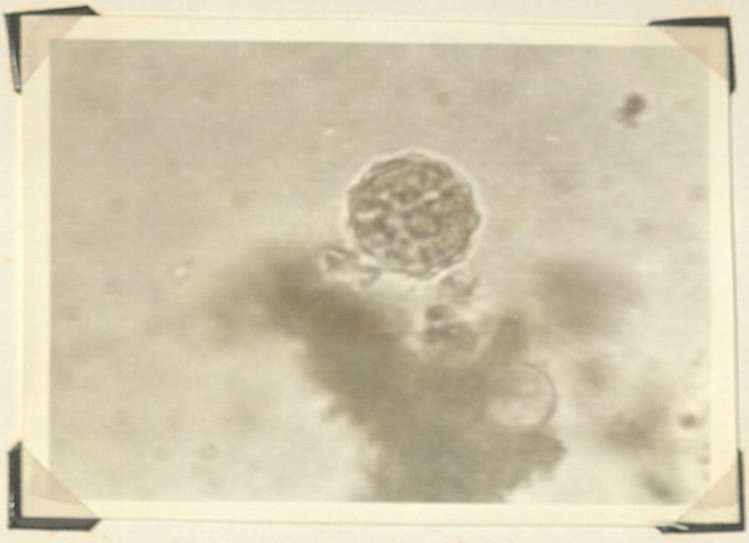
66

PLATE 42

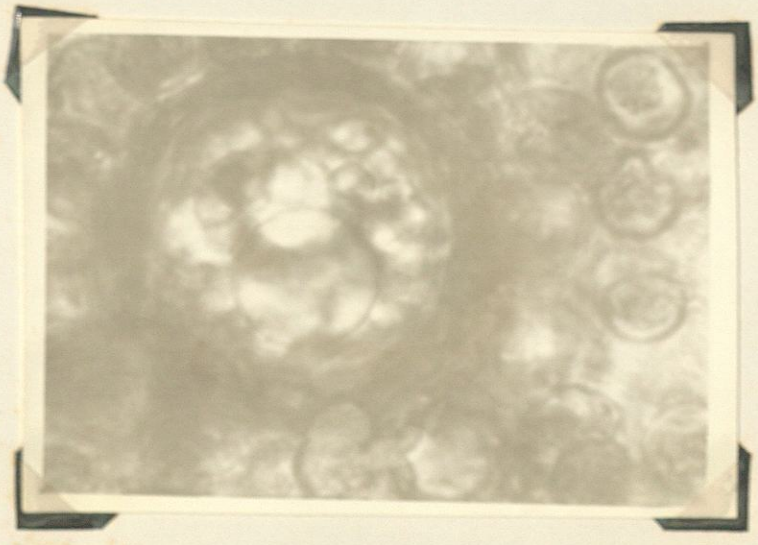
Photo No.	Plants
67	Chlorococcum hypnosporum x 360
68	C. hypnosporum: Young hypnospore x 360
69	C. hypnosporum: Mature hypnospore x 360



67



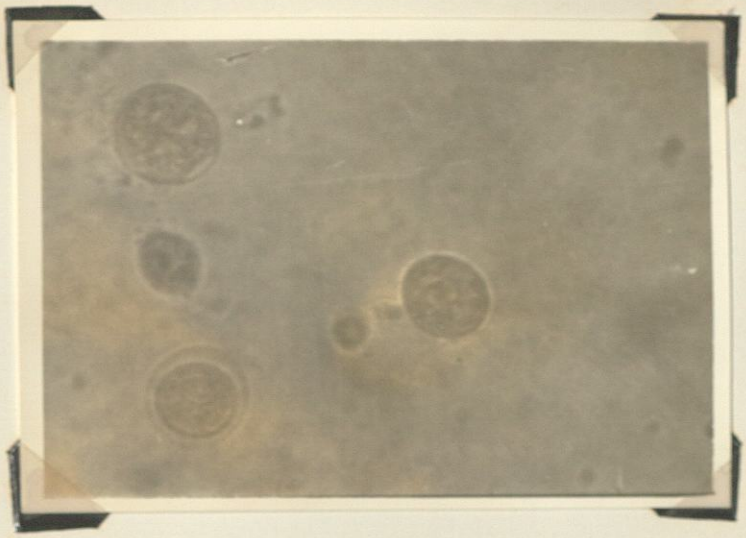
68



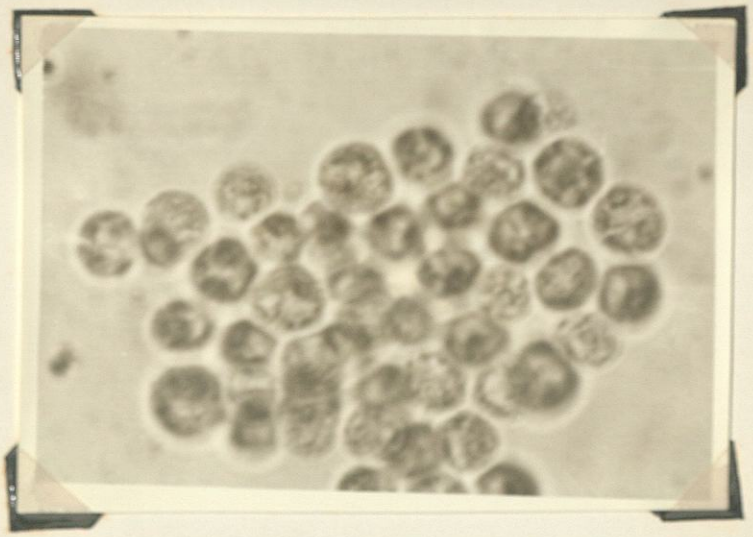
69

PLATE 43

Photo No.	Plants
70	Chlorococcum isabeliense x 360
71	C. lacustre x 360
72	C. macrostigmatum: Stationary cell. x 360



70



71



72

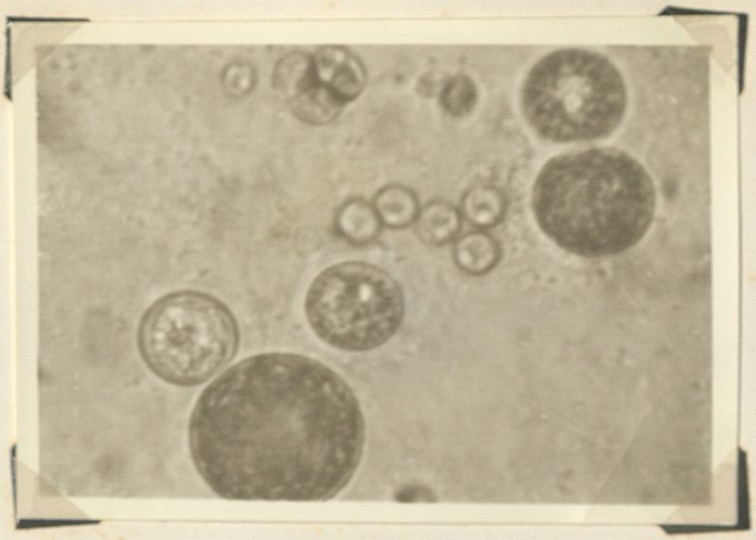
PLATE 44

Photo No. Plants

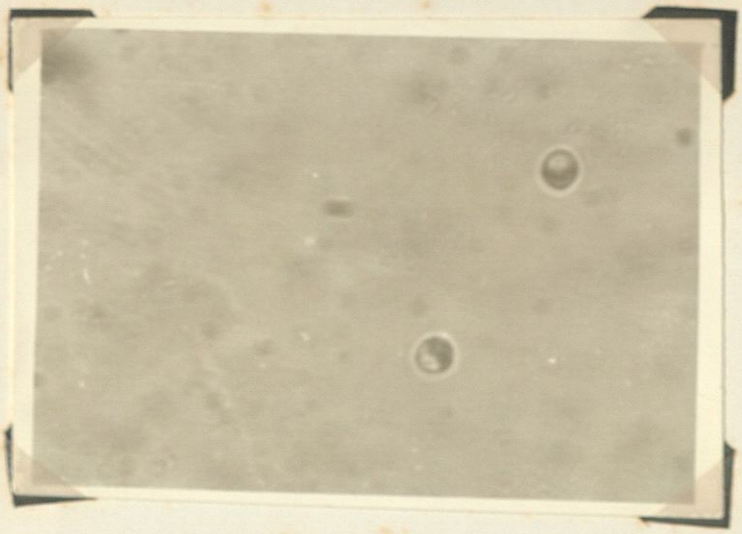
73 Chlorococcum macrostigmatum: Young and mature cells. × 360

74 C. minutum × 360

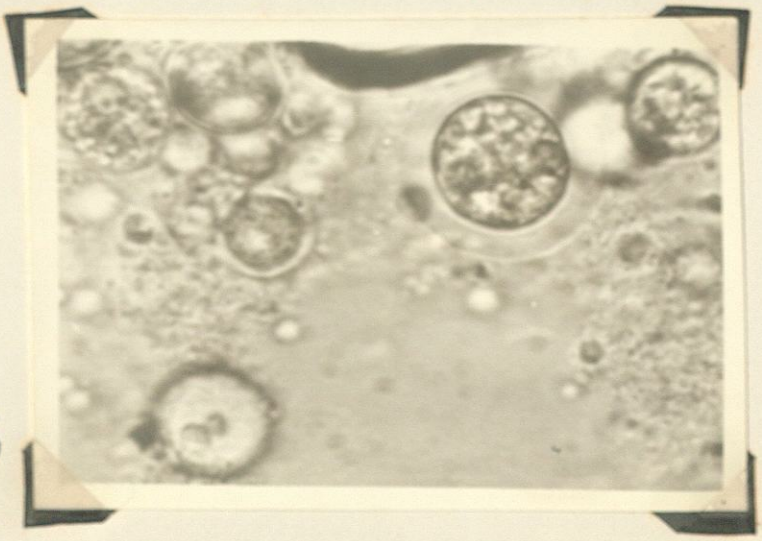
75 C. microstigmatum × 360



73



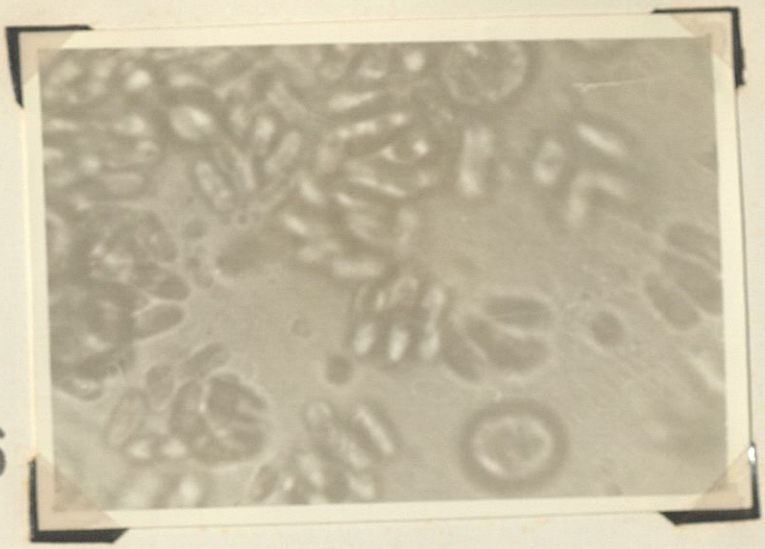
74



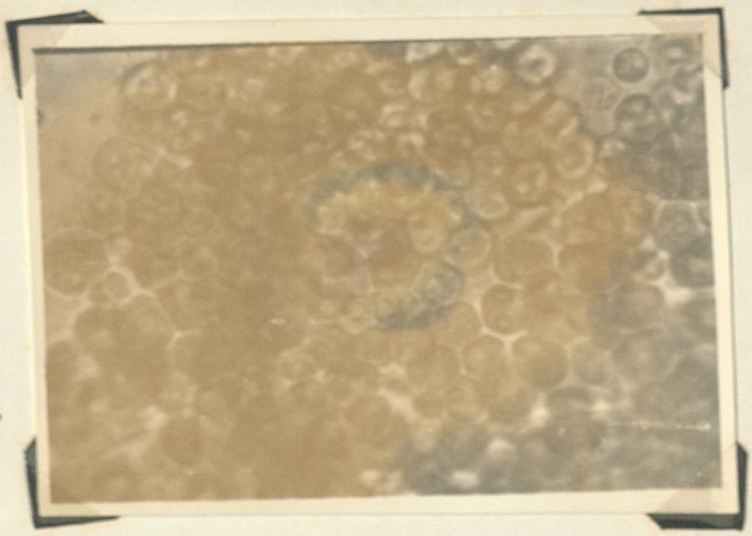
75

PLATE 45

Photo No.	Plants
76	Chlorococcum nova angliae x 360
77	C. oviforme x 360
78	C. typicum x 360



76



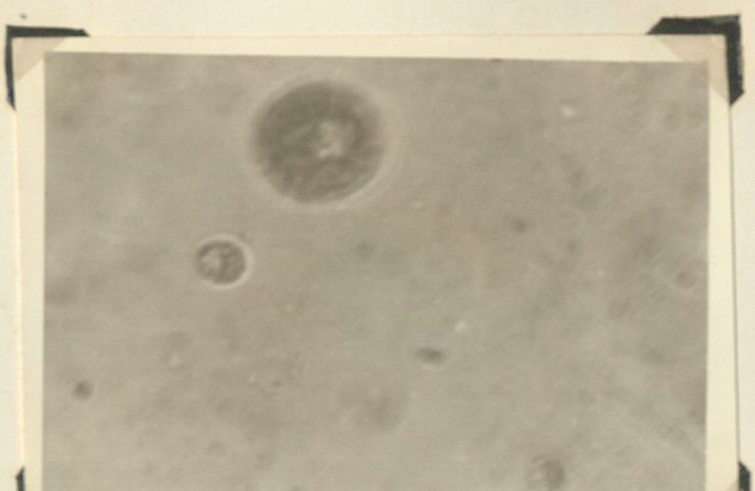
77



78

PLATE 46

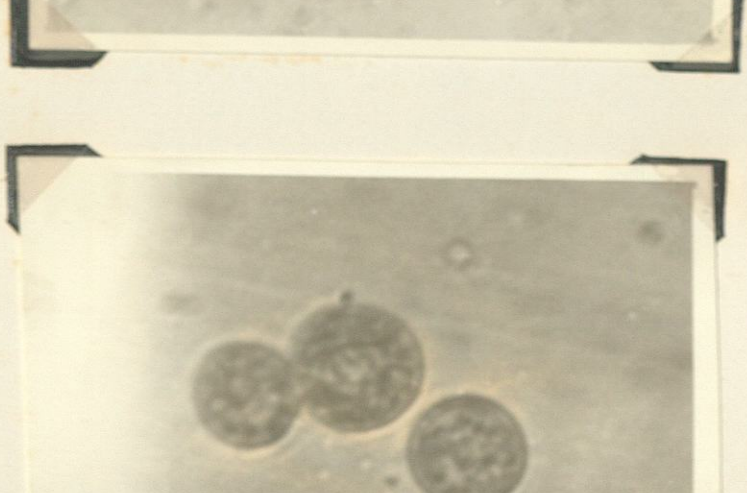
Photo No.	Plants
79	Chlorococcum pulchrum x 360
80	C. refringens x 360
81	C. reticulatum x 360



79



80



81

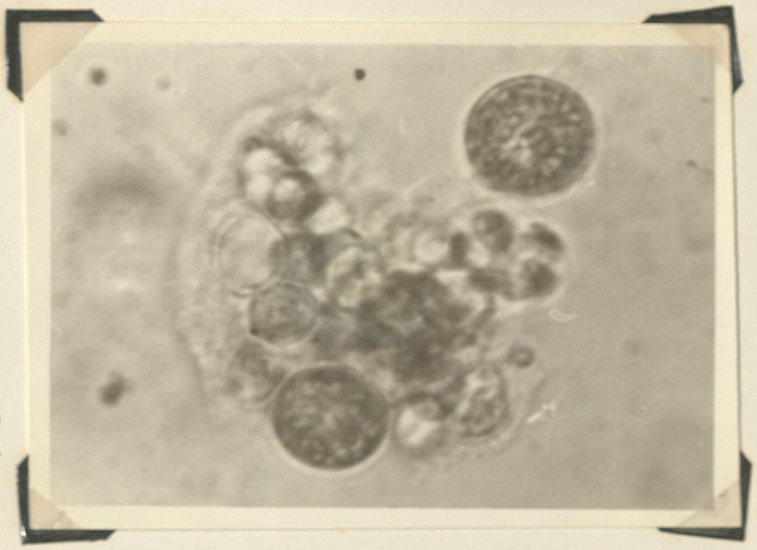
PLATE 47

Photo No. Plants

82 Chlorococcum salsugineum: Vegetative cells and zoosporangium x 360

83 C. sphacosum: Vegetative cell and zoosporangium x 360

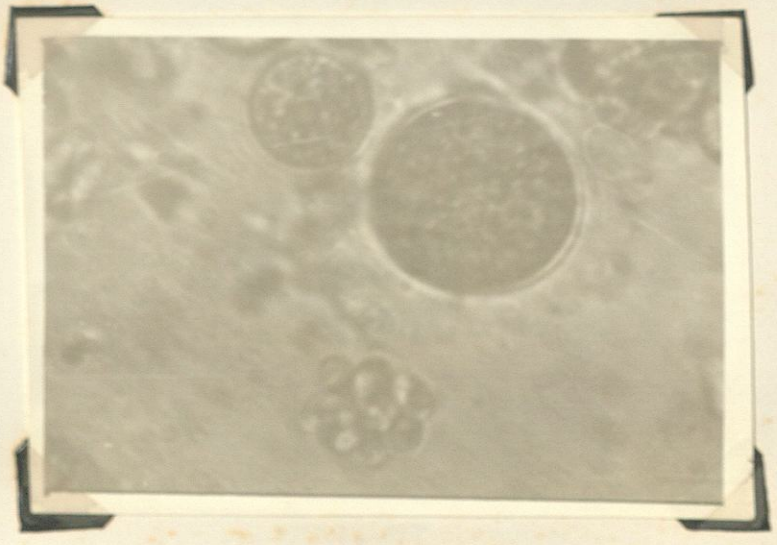
84 C. typicum: Stationary cell and zoosporangium x 360



82



83



84

PLATE 48

Photo No. Plants

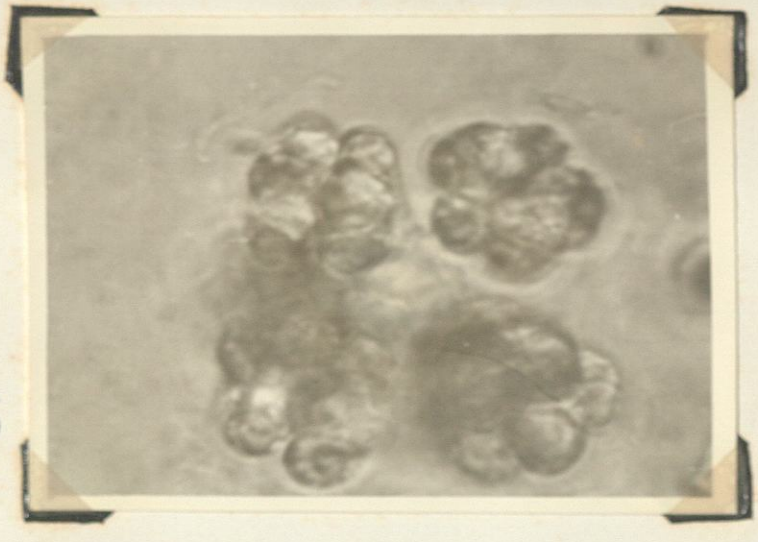
85 *Eremosphaera viridis* x 360

86 *Neochloris cohaerens*: Autospores x 360

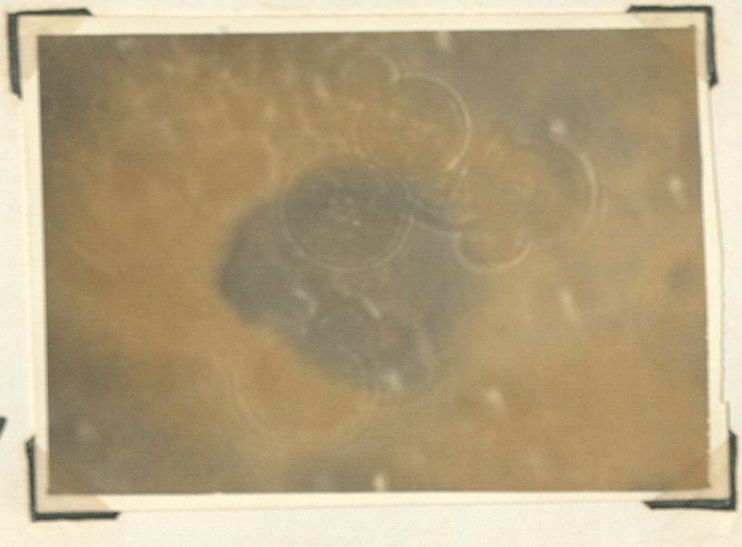
87 *Bracteacoccus grandis* x 360



85



86



87

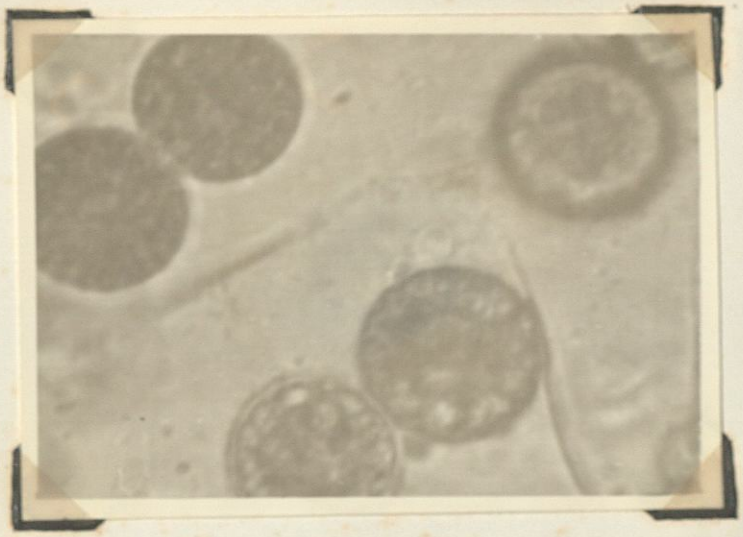
PLATE 49

Photo No. Plants

88 Spongiochloris incrassata × 360

89 Scenedesmus incrassatulus × 360

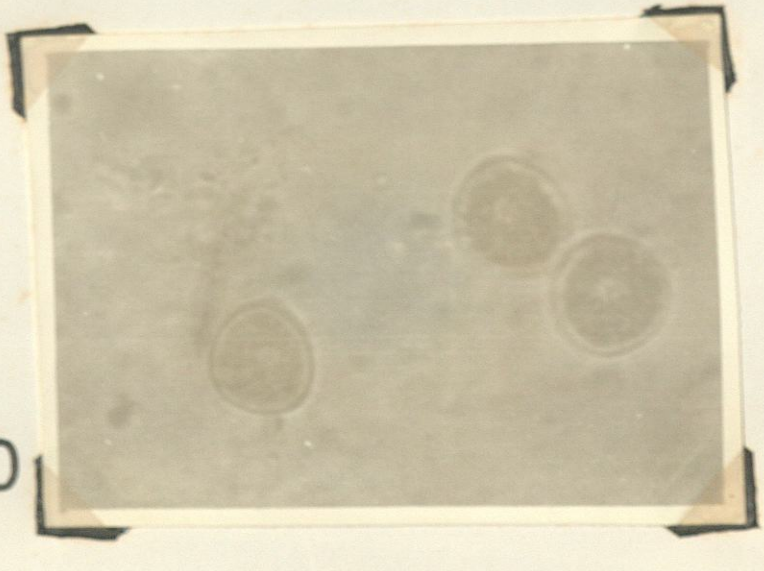
90 Chlorotetraëdron polymorphum × 360



88



89



90

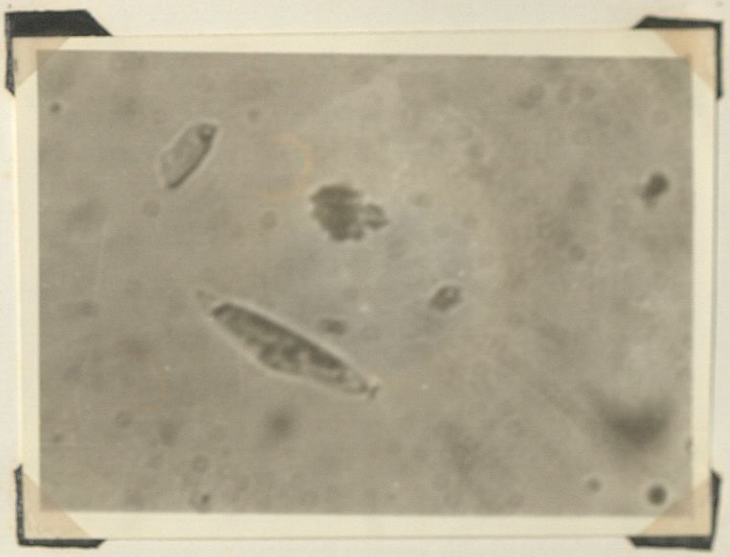
PLATE 50

Photo No. Plants

91 *Characium ambiguum* x 360

92 *C. naegeli* x 360

93 *Cosmarium granatum* var. *granatum* x 360



91



92



93

PLATE 51

Photo No. Plants

94 Cosmarium laeve × 360

95 Tribonema bombycinum var. tenue × 360

96 T. minus × 360



94



95



96

PLATE 52

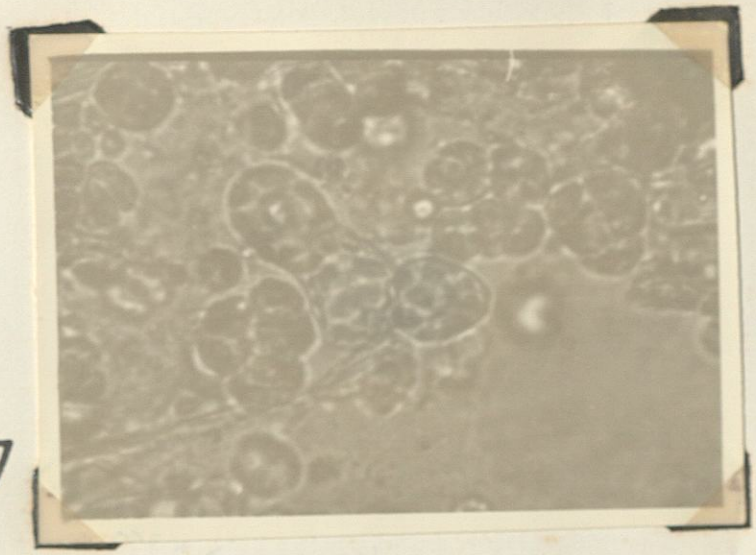
Photo No. Plants

97 Heterococcus longicellularis: Germination x 360

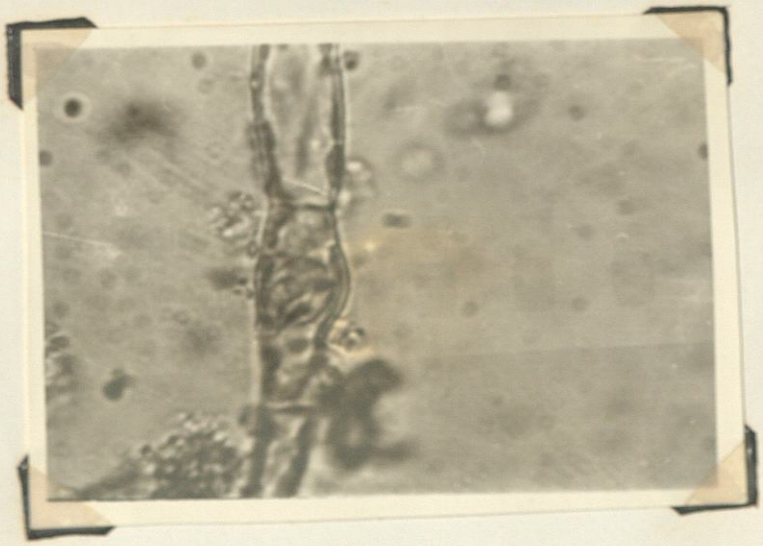
98 H. longicellularis: lateral primordia of a new branch. x 360

99 H. longicellularis: Single cell of a filament. x 360

97



98



99



GLOSSERY OF TERMS USED IN THE PRESENT TEXT

Acute-conical:	Sharply conical.
Agglutinated:	Sticking together; adherent, as with mucilaginous sheaths.
Akinete:	A spore produced from a vegetative cell which has developed a thick wall about a concentrated food reserve.
Anastomose:	Referring to sheaths, filaments, or thalli which intermittently join and separate; sometimes joining in such a way as to form a network.
Apiculate:	Abruptly tapering to a fine point.
Arcuate:	Arched; bow-shaped; sharply crescent-shaped.
Attenuation:	Diminishing, slenderly tapering.
Axial chloroplast:	Chloroplast in the median plane or centre of a cell, arranged along a median line.
Bluntly-conical:	Obtuse-conical; rounded-conical.
Bulose:	Bubble-like; swelling.
Caespitose:	Clustered; in fascicles; forming a mat.
Calyptrate:	A thickening; a thick covering or membrane at the tip of a trichome.

Capitate: With a head; swollen at one end, or at both the ends.

Capitellate: Slightly swollen or enlarged at one end.

Circinate: Coiled; rolled; twisted.

Clathrate: With openings; intermittent spaces.

Confluent: Growing into one another; soft sheaths which run together or which become intermingled.

Constricted: Deeply incised; narrowed suddenly at one or more points along the length.

Contorted: Irregularly twisted.

Coriaceous: Leathry.

Costate: Ribbed.

Crustaceous: Hard and brittle.

Cushion-like: Thallus composed of a mound of cells, two to many layers of cells; parenchymatous.

Cylindrical: Elongate and round in cross-section with parallel lateral margins.

Depressed-globose: Not quite spherical, like a slightly flattened sphere.

Diffluent: Flowing off; dissolving away.

Ellipsoid: Showing an elliptical section.

Endospore: In the Cyanophyceae, spores formed by

repeated division of the protoplast within a cell wall or successively cut off at the distal end of the protoplast.

Excentric: Not situated at the centre; somewhat towards periphery.

Fasciculate: In bundles or fascicles.

Filiform: Thread-like.

Flexuous: Not firm or rigid; pliable.

Floccose: Cottony or wooly; matted.

Foliose: Flat, leaf-like.

Fragile: Delicate.

Fusiform: Spindle-shaped.

Gelatinous envelope: A sheath or investment of mucilage-like substance.

Geminate: Produced in pairs.

Gregarious: Growing in clusters or in close association.

Hemispherical: In the form of a half sphere.

Heterocyst: A specialized cell in some filamentous, Cyanophyceae which is usually larger than and of a different shape from the vegetative cells.

Homogeneous: Of uniform character of substances; similar.

Hormogone: A fregment of a filament; a short

section broken away from a mature trichome (Cyanophyceae).

Hypnospore: Small, thick-walled, asexual spore.

Intercalary: Occuring in the continuity of a filament.

Interwined: Coiled.

Intricate: Entangled.

Lamellate: Composed of concentric layers.

Lanceolate: Longer than broad, tapering upward from below the middle.

Lenticular: Lens-shaped.

Linear: Long and narrow, with parallel sides.

Lunate: Half-moon or crescent-shaped.

Macrandrous: Referring to dioecious species having male gametes borne on filaments equal in size, or nearly so, to those bearing female gametes, as in Oedogonium.

Moniliform: Resembling a string of beads.

Monostromatic: Cells in one layer.

Nodulose: Provided with little knobs or knobs or nodules.

Oblong: Elliptical, blunt at each end, having nearly parallel sides, and two to four times as long as broad.

Orbiculate: Of approximately circular outline.

Ovoid:	Shape-like an egg.
Papillate:	Furnished with papillae.
Papyraceous:	Papery in texture.
Parietal:	Borne on or approximate to the side walls.
Penicillate:	In the form of a brush-like tuft.
Plicate:	Folded.
Polyhedric:	With many corners.
Pseudovacuoles:	Small cavities filled with gas in the protoplast of certain species of Cyanophyceae.
Pulvinate:	Cushion-like.
Punctate:	Having punctae.
Pyramidal:	In the shape of a pyramid.
Pyriform:	Pear-shaped.
Reticulate:	Arranged as a network.
Rhomboid:	Having sides of equal length, but not square, and being attached by one of the acute angles.
Rostrate:	With a beak.
Saccate:	Sac or pouch-shape.
Sedentary:	Near the bottom.
Scrobiculate:	Having numerous small shallow depressions or pits.
Stipitate:	Borne on a stipe or stalk.
Striate:	Marked with fine lines or ridges.

Tomentose:	Closely hairy; woolly.
Torn:	Broken.
Torulose:	With alternate swelling to constrictions.
Trapizoid:	Of unsymmetrical four-sided shape.
Trichothallic:	That form of a growth by which the growing point produces thallus cells below and hair cells above.
Truncate:	Flat at the tip, flately rounded.
Tuberculate:	With irregular rounded superficial projections.
Undulate:	With a wavy surface or margin.
Vesicular:	Bladdery; with vesicles.
Vestigial:	Functionless.
Verrucose:	Warty.
Wiry:	Coiled like a wire.

Index

Acanthococcus 265,266
Asmenellum 59
quadruplicatum 60,61
Anacystis 42
cyanea 43,45,47
montana 41
montana f. gelatinosa 55
montana f. minor 48
montana f. montana 46,59
thermalis 37
thermalis f. major 38
Anabaena 147,vii,viii,23,24
25,26,35,319,322,326,328
anomala 149,148,302,328,
f.374
aphanizomenoides 150,148,
302,328, f.374,pl.428
augstumalis 150,149,302,
328,f.374
circinalis 151,148,302,
328,f.376,pl.428
cylindrica 152,20,149,
303,328,f.376
fertilissima 153,24,149,
303, 328,f.374
flos-aquae var.circinalis
151
gelatinicola 153,148,303,
328,f.401
gelatinosa 155
indica 158
laxa 16
orientalis 154,148,303,
329,f.374
oryzae 155,148,303,329,
332,f.374
oscillatoroides var.terrestris
16
sphaerica 156,149,303,329,
f.374
spiroides 157,148,303,329,
f.374
stagnalis 132
subcylindrica 158,148,303,
329,f.376,pl.430
thermalis var.indica 149
variabilis 158,20,148,
303,329,f.376
Anabaenopsis 20
Aphanocapsa 57,vii,25,26,32,
319,322
banaresensis 57,293,f.401
littoralis 58,57,293,f.368,
pl.412
montana 58,57,293,f.368
Aphanothece 53,vii,32,319,322
castagnei 54,292,332,f.368
gelatinosa 54,292,332,f.368
microscopica 55,54,292,
f.368,pl.410
saxicola 56,53,293,f.368
Arthrospira 65
gomontiana 66
massartii 68
platensis 69
Asteriçium 265,266
Asterococcus 250
spongiosus 250
Aulosira 159,vii,viii,24,35,
321,322,326,329
aenigmatica 160,303,329,f.376
fertilissima 20
pseudoramosa 160,304,329,
f.376
Botrydiopsis 211
minor 211
Botrydium 13
Bracteacoccus 209,vii,25,183,
321,324
grandis 209,308,331,f.386
pl.462
medinucleatus 210,209,308,
331,f.386
minor 211,209,308,331,f.386
pseudominor 212,209,308,331,
f.386
Calothrix 172,vii,viii,24,35,
319,322,326
brevissima 20
clavata 173,305,329,f.380
elenkinii 174,173,305,329,
f.380,pl.430
epiphytica 174,173,305,329,
f.380
marchica 175,173,305,329,
f.380
Camptylonemopsis 26
Cerasterias 265,266
Chamaesiphon 63
filamentosa 63
zanzibaricus 63
willei 63
Chara 25
Characium 269,vii,20,182,271,
321,324
acuminatum 270,314,f.398
ambiguum 271,270,314,f.398,
pl.466
naegeli 271,270,314,f.398,
pl.466
pringsheimii 272,270,314,f.398

Chlamydomonas 184,vii,22,24,
25,26,180,321,324
globosa 184,306,f.382
pseudopetryi 185,184,306,
332,f.382
snowii 186,184,306,f.382
typica 186,184,306,331,
f.399,pl.432
Chlorella 252,vii,183,321,324
ellipsoidea 253,312,f.396
Chlorellidiopsis 26
Chlorococcum 225,vii,13,22,23,24,
25,26,183,321,324
acidum 228,227,309,331,
f.388,pl.446
aureum 228,227,310,331,
f.388,pl.446
echinozygotum 229,227,310,
331,332,f.388,pl.448
elkhartiense 230,227,310,
331,f.390,pl.448
gelatinosum 230,226,310,
331,f.390,pl.448
humicola 16,18
hypnosporum 231,226,310,331,
f.390,pl.450
intermedium 220
isabeliense 232,227,310,
331,332,f.390,pl.452
lacustre 232,226,310,
331,f.390,pl.452
macrostigmatum 233,226,310,
331,f.390,pl.452,454
microstigmatum 234,227,310,
331,f.392,pl.454
minutum 235,226,310,331,
f.392,pl.454
nova angliae 235,227,310,
331,f.392,pl.456
oviforme 236,227,310,331,
f.390,pl.456
pulchrum 237,227,311,331,
f.390,pl.458
refringens 237,226,311,
331,f.390,pl.458
reticulatum 238,226,311,
331,332,f.392,pl.458
salsugineum 239,227,311,
331,f.392,pl.460
sphacosum 239,227,311,331,
f.392,pl.460
tetrasporum 223,
typicum 240, 227,311,331,
332,f.392,pl.456,460
Chlorogloea 50,vii,32,321,323
fritschii 20
microcystoides 50,292,
332,f.366
Chloronormidium 194,vii,22,
181,321,324
flaccidum 195,307,f.401
sterile 196,195,307,331,
Chlorosarcinopsis 213,vii,
13,22,182,321,324
arenicola 213,308,331,f.386
auxotropica 214,213,309,
331,f.386
deficiens 215,213,309,
331,f.386
pseudominor 216,213,309,
331,332,f.386,pl.440
semperv[illegible]rens 217,213,309,
331,f.386,pl.440
Chlorosphera 242
oliver 242
Chlorotetraëdron 267,viii,182
321,325
polymorphum 267,312,331,
f.398,pl.464
Chroococcus 35,vii,24,25,26,
32,319,322
cohaerens 37,36,291,332,
f.366,pl.406
dispersus 37,36,291,332,
f.366
limneticus var.subsalsus
38,36,291,f.366,pl.406
minor 39,36,291,f.366
minutus 40,36,291,f.366
turgidus 41,36,291,334,
f.401,pl.406
varius 41,36,291,f.366
Chthonoblastus 125
lyngbyei 125
salinus 125
Cladophora 203,vii,25,26,
180,321,324
crispata 204
fracta 203,308,f.401
glomerata 204,203,308,
f.384,pl.438
Clathrocystis 42
aeruginosa 44
Coccochloris 53
elabens 54
parietina 20
peniocystis 56
stagnina 40,55

Coleochaete 25,26
Closterium 275,vii,25,183,
321,324
porrectum 276
Coelastrum 268,vii,181,
321,325
indicum 269
microporum 269,314,f.394
robustum 269
sphaericum var.compactum 269
Coelosphaerium 48,vii,25,32,321,
323
dubium 49,292,332,f.366
Cosmarium 276,vii,182,321,324
granatum 277,315,f.398
granatum var.granatum 278
277,315,f.398,pl.466
laeve 279,277,315,f.398,pl.468
Crucigenia 257,vii,182,321,325
irregularis 258,312,f.392
Cylindrospermum 131,vii,viii,25,
34,321,322,326,329
gorakhporense 20
licheniforme 16,20
macrospermum 132,131
meius 20
minimum 132,131,301,329,f.372
stagnale 132,131,301,329,f.372
Cylindrocystis 18
Cystococcus 13
Dactylococcus 13,18
Dermocarpa 26
Dichothrix 26
Dictyococcus 245,vii,183,321,325
varians 245,311,331,f.394
Endoclonium 200
polymorphum 200
Entophysalis 58,25
deusta 58
Eremosphaera 241,vii,23,25,183,
321,324
eremosphaeria 241,311,331,f.394
viridis 242,241,311,f.394,pl.462
viridis var.nodosa 243
viridis var.ovalis 243
Euglena 287,327
proxima var. minima 287,viii,316,
326,327,331,f.398
Fortiea 24
Fremyella 171
tenera 171
Glochiococcus 265,266
Gloeobotrys 281,viii,25,326,327
limneticus 281,315,327,f.394
Gloeocapsa 51,32,321,323
crepidinum 51,292,f.380
pl.410
Gloeocystis 190,vii,13,18,25
181,321,324
ampla 191,306,332,f.382
vesiculosa 192,191,306,
332,f.382
Gloeothece 52,vii,32,321,323
rupestris 52,292,f.401
Gloeotrichia 177,vii,viii,24
25,35,321,322,326,329
echinulata 177,305,329,f.
378
longicauda 178,177,305,
329,f.401,pl.432
Haplosiphon 16
flexuosus 16
Heterococcus 285,viii,25,27,
281,326,327
longicellularis 285,316,
326,327,332,f.398,pl.470
Hormidium 194,18
flaccida 195
flaccidum 195
sterile 196
variabilis 194
Hormococcus 195
flaccidus & flaccida 195
Hydrocoleum 127,vii,25,34,
321,323
oligotrichum 127,300,f.372
Hyphaeothrix 107
subtilissima 107
Leptothrix 107
subtilissima 107
Lyngbya 111,vii,viii,24,25,
26,34,319,322
aerugineo-caerulea 113,112,
299,f.370
allorgei 113,299,f.403
contorta 114,112,299,f.403
epiphytica 118
errecta 115
gardneri 115,112,299,f.403
kuetzingii 116,112,299,f.403
lagerheimii 116,112,299,
f.370
martensiana 117,112,299,
f.370,pl.420,422
nordgaardii 118,112,299,
f.403
polysiphonae 119,112,299,
326,f.370

prolifica 80
putealis 119,112,299,f.404
rupestris 109
Spirulinoides 120,111,300, pl.370
taylorii 121,112,300,f.404,
truncicola 122,112,300, f.370,pl.422
wellei 118
Macrochloris 251
dissecta 251
Mastigocladus 20
laminosus 20
Merismopedia 59,vii,25,32, 319,322
glauca 60,293,f.368
punctata 61,60,293,f.368
tenuissima 61,60,293,332, f.368,pl.412
Mesotaenium 273,vii,25,183, 321,325
purpureum 273,314,f.394
violascens 18
Michrochaete 171,vii,viii,25,26, 35,321,323,326,329
tenera 171,305,329,f.378
Microcoleus 125,vii,23,26,34, 321,322
chthonoplastes 125,300,f.401
lacustris 126,125,300,f.370
Microcystis 42,vii,25,26,32,319, 322
aeruginosa 43,291,334,f.366, pl.408
f.flos-aquae 45
f.marginata 46
f.pseudofilamentosa 47
FLOS-AQUAE
flos-aquae 44,43,291,334, f.366
marginata 45,43,292,f.366,pl.408
pseudofilamentosa 46,43,292,f.401
pulverea 47,43,292,f.366,pl.410
Microspora 197,vii,25,181,321,325
tumida 197,307,f.382
Monallantus 282,viii,281,326,327
brevicylindrus 282,315,327, f.396
Neochloris 247,vii,22,183,321,325
cohaerens 247,312,331,f.394, pl.462
Nitzschia 16
palea 16
Nodularia 161,vii,viii,24,26,34, 321,322,326
harveyana 162,16,304,322,f.404
spumigena 162,304,f.401
Nostoc 133,vii,viii,23,24,25, 26,35,319,322,326
calcicola 135,134,301,328, f.374
carneum 136,134,301,328, f.374,pl.422
commune 137,16,135,301,328, f.372,pl.424
comminutum 138,134,301, 328,f.401
ellipsosporum 138,134,301,328, f.401
hatei 139,134,301,328,f.372
hederulae 143
kurzianum 137
linckia 140,135,142,302, 328,f.372
f.spongiaeforme 145
microscopicum 141,135,302, 328,f.401,pl.424
muscorum 16,20,
paludosum 142,134,201,302, 328,f.372,pl.424
passerianum 16
piscinale 142,134,302,328, f.372,pl.426
punctiforme 143,20,134,302, 328,332,f.372,pl.425
purpurescens 136
sphaericum 144,135,302, 328,f.372
spongiaeforme 145,134,302, 328,f.372
verrucosum 146,135,302, 328,f.372
Oedogonium 206,vii,25,26,181, 321,324
hirnii 207,308,332,f.384, pl.438
porrectum 208,207,308,f.384
Oocystis 253,vii,23,26,182, 321,324
crassa 254,312,f.396
eremosphaeria 242
parva 255,254,312,f.396
pyriformis 256,254,312,f.396
solitaria 255,254,312,f.396
Oscillatoria 70,vii,viii,16,23, 24,25,26,32,319,322
acutissima 72,294,f.403
agardhii 73,71,294,f.368
amoena 74,71,294,f.368
amphibia 75,72,294,332,f.368
anguina 76,71,294,332,f.368
animalis 77,72,295,326,f.368
articulata 77,72,96,295,f.403
f.physiodes 109
cortiana 78,71,295,f.403

curviceps 79,72,295,f.368,pl.414
foreaui 80,71,295,326,f.368
formosa 80,72,295,326,f.368,
pl.414
grunowiana var.articulata 78
laete-virens 81,71,295,f.403
lacustris 82,71,295,f.403
limosa 83,72,295,f.368
lutea 84,71,295,f.368
princeps 84,71,296,f.368,pl.414
prolifica 85,71,296,f.403
quadripunctulata 86,72,296,f.403
rubescens 87,71,296,f.368
splendida 88,71,296,326,f.403
subbrevis 89,72,296,f.368,pl.416
tenuis 90,71,296,f.403
terebriformis 90,72,296,f.368,
pl.416
Palmella 188,vii,25,181,321,324
miniata 189,306,f.382
texensis 189,306,331,f.382
Palmellococcus 258,vii,25,183,321,325
protothecoides 258,313,332,f.392
PANDORINA Pandorina 187,vii,25,26,
180,321,325
morum 188,306,f.382,pl.434
Phormidium 91,vii,viii,18,24,25,26,
34,319,322
abronema 94,93,296,332,f.370
ambiguum 95,92,297,326,f.370,pl.416
autumnale 96,93,297,f.403,pl.418
bohneri 97,93,297,f.370
corium 98,94,297,f.370,pl.418
foveolarum 98,93,297,f.370
fragile 99,92,297,326,332,
f.370,pl.418
incrustatum 100,94,297,f.403
jadinianum 101,92,297,326,332,
f.370
jenkelianum 102,93,297,f.370
mucicola 103,92,298,f.403
muscorum 103,93,298,f.403
papyraceum 104,94,298,326,f.370
purpurascens 105,93,298,f.370
pl.420
retzii 105,93,298,f.370
subincrustatum 106,93,298,f.370
tenue 107,16,92,298,f.370,pl.420
truncicola 108,92,298,f.403
uncinatum 109,93,298,326,f.403
valderianum 110,93,298,f.403
Physolinum 201,vii,180,321,325
monilia 202,307,f.399
Planktosphaeria 244,vii,181,321,325
texensis 244,311,331,f.394
Plectonema 163,vii,26,32,321,322
battersii 16
postocorum 164,304,f.403
notatum 164,304,f.376
Pleurastrum 22
Pleurococcus 201
naegeli 201
vulgaris 201
Polyedrium 265,266
gigas 266
muticum 266
Polycystis 42
Porphyrisiphon 23
Prasiola 18
Protococcus 200,viii,25,26,
181,321,325
monas 253
viridis 201,20,307,f.384
Protosiphon 13
Pseudotetraedron 267
polymorphum 267
Quadrigula 263,viii,183,321,325
closterioides 263,313,f.398
Radiosphaera 251,viii,183,
321,325
dissecta 251,312,331,f.396
Rhizoclonium 205,viii,25,
180,321
hieroglyphicum 205,308,
f.384,pl.438
Rivularia 176,vii,viii,24,35,
321,323,326,329
dura 176,305,329,f.380
Roya 274,26,183,321,325
obtusa 274,314,f.398
Scenedesmus 259,vii,25,182,
321,324
acutus f.parvus & magnus 262
arcuatus 260,313,f.398
dimorphus 261,260,313,
332,f.398
incrassatulus 261,259,313,
f.398
obliquus 262,260,313,
f.394,pl.464
Schizothrix 128,vii,23,25,34,
319,322
friesii 129,128,300,f.404
tinctoria 129,301,f.404
vaginata 130,129,301,f.404
Scytonema 165,vii,viii,20,35,
hofmanni 166,165,304,329,
f.378
javanicum 166,165,304,329,
f.378
kurzianum 166
millei 167,165,304,329,f.378
Spherella 26
Spirulina 65,vii,26,32,319,322
gomontiana 66,294,332,f.368

laxissima 67,66,294,f.401
massartii 67,66,294,f.368
meneghiniana 68,66,294,f.401
platensis 69,66,294,f.401,pl.412
Spondylosium 279,viii,180,321,325
pygmaeum 280,315,f.398
Spongiochloris 248,vii,183,321,324
incrassata 249,312,331,f.396 pl.464
spongiosa 250,249,312,331,f.396
Spongiococcum 22
Stichoccus 195
bacillaris 16
flaccidus 195
Stichosiphon 62,vii,26,32,321,323
filamentosa 63
indica var.tenuis 63
indicus 63
sansibaricus 63,293,f.401
Stigeoclonium 198,vii,25,180, 321,324
pachydermum 199,307,f.384
polymorphum 200,199,307,f.382, pl.436
Stratonostoc 144
commune 144
linckia 135,142,145
verrucosum 146
Symploca 123,vii,26,34,321,323
cartilaginea 123,300,f.370
muscorum 124,123,300,f.401
Synechococcus 64,vii,32,321,323
aeruginosus 64,293,f.401
Tetracystis 218,vii,13,22,25, 182,321,324
excentrica 219,218,309,331, f.388,pl.440,442
intermedium 220,219,309,331, f.388,pl.442
isobilateralis 221,218,309,331, f.368,pl.442
pampae 222,219,309,331,f.388, pl.444
tetrasporum 223,219,309,331, f.388,pl.444
texensis 224,219,309,331, f.388,pl.444,446
Tetraëdron 264,vii,26,182,265, 266,321,324
constrictum 265,264,313,f.398
gigas 265,264,313,f.398
muticum 266,264,313,332,f.398
Tribonema 283,viii,281,326,327
bombycinum var.tenue 284,283, 315,327,331,f.398,pl.468
minus 284,283,315,327,f.398,pl.468
Trichodesmium 82
lacustre 82
Trochiscia 265,266,13
aspera 16
Tolypothrix 168,vii,24,25,26, 35,319,322,326,329
distorta 168,304,329,f.378
fragilis 169,168,304,329,f.378
inflata 170
lanata 170
mucicola 170
tenuis 170,20,168,305,329, f.404
Ulothrix 192,vii,viii,18,25, 181,321,324
flaccida 195
idiospora 193,307,f.384, pl.434
subtilis var.variabilis 194
variabilis 193,307,326, f.384,pl.434
Zygogonium 18
ericetorum 18