

CONTRIBUTIONS TO OUR KNOWLEDGE OF SOUTH INDIAN ALGAE—VII*

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Received January 15, 1974

(Communicated by Prof. T. V. Desikachary, F.A.Sc.)

Gloeococcus Braun

THE genus *Gloeococcus* Braun (1851) has remained for nearly a century a little known genus. Four species have been attributed to this genus, *G. mucosus* Br., *G. minor* Br., *G. agilis* Grunow and *G. minutus* Grunow. Much discussion centred around the validity of this genus, its affinities with *Chlamydomonas* and the distinctness of *Sphaerocystis* Chodat *vis-a-vis* this genus. Iyengar (1954; 1960) clearly established the distinctness of Braun's genus and demonstrated its affinities with *Chlamydomonas*. He placed the Indian alga in a new species, *G. pyriformis*, but he did not validly publish it. Iyengar (1960) transferred Schmidle's *Ch. kleninii* to *Gloeococcus*. Lund (1957) described another species from Britain, *G. braunii*.

Gloeococcus pyriformis is formally described here. A few more collections of algae belonging to this genus have been made from diverse localities in and around Madras. These are also described here.

Gloeococcus pyriformis Iyengar sp. nov.

Alga gelatinous, pyriform, attached by the narrow end, colonial boundaries with a firm limit, 1–3 cm long, 0.5–1.5 cm broad; cells biflagellated, chlamydomonadine, in large numbers embedded in a soft gelatinous matrix; cells continuous moving or oscillating inside the colony with short forward and backward movements; cell division longitudinal, at division cells losing flagella and becoming ultimately quiescent, forming 2, 4 or 8 daughter cells, becoming ultimately walled and flagellated and somewhat motile; motile cells escaping from the colony; cells 7–13 μ broad and 9–18 μ long; chloroplasts cup shaped, pyrenoid median, single; eyespot median; contractile vacuoles

* Memoir No. 173 from the Centre for Advanced Study in Botany, University Botany Laboratory, Madras 600005, India.

† The late Prof. M. O. P. Iyengar left behind a large amount of unpublished material. These are being published as a series of contributions.—T. V. Desikachary.

two, anterior below the flagella; sexual reproduction isogamous or anisogamous.

Habitat.—Shallow margins of irrigation tanks, Vandalur, near Madras (26-8-1933; also 23, 28-8-1933; 10-8-1949, etc.); Also from muddy water pools, Nekkundram, Madras (11-10-1949).

Type.—Fig. 1, A-N.

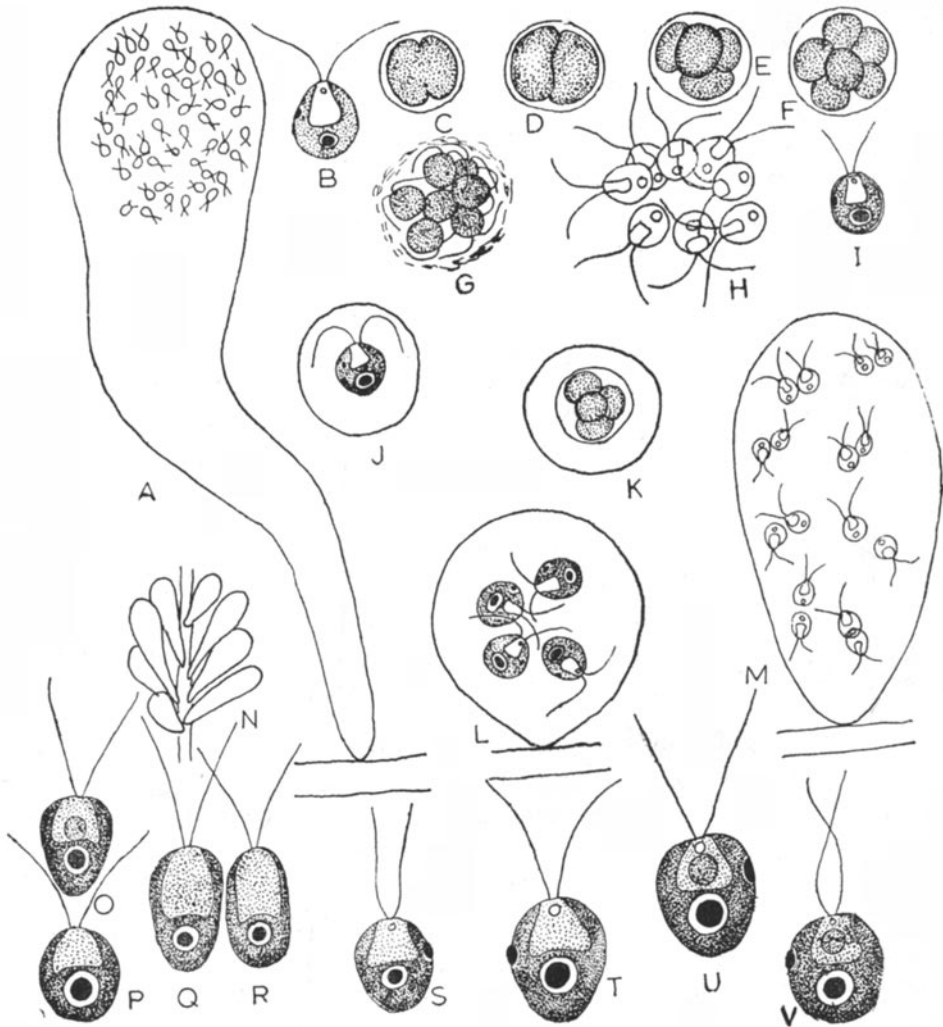


FIG. 1. *Gloeococcus pyriformis* Iyengar. A, Colony; B, Cell; C-H, K, Cell division and zoospore formation; I, Zoospore; J, Simple colony with a single cell; M, A young colony with 16 cells; N, A number of colonies growing epiphytically; O-V, Individual cells showing variations. (all after Iyengar; A, $\times 185$; B-L, $\times 1,500$; M $\times 700$; N, same size; O-V, $\times 2,250$).

Iyengar (1954; 1960) considers that *Gloeococcus* clearly belongs to the Chlamydomonadaceae, since the cells are exactly like those of a chlamydomonad. In both *Chlamydomonas* and *Gloeococcus* a long active flagellated motile vegetative period and a very short non-motile, non-flagellated asexually reproducing phase during which cell divisions take place follow each other regularly for several generations. The only difference between these two algae is that while in *Chlamydomonas* the flagellated cells swim away over long distances in water the range of swimming of the flagellated cells of *Gloeococcus* is very limited and confined to the extremely small area around themselves inside the gelatinous matrix of the colony. *Gloeococcus* according to Iyengar (1960) must be considered as an independent genus (see also Fott, 1972). Iyengar considers that *Chlamydomonas kleini* Schmilde (1893) is really a *Gloeococcus* as its cells are flagellated and motile inside their mucilaginous envelopes and they show limited motility within the limits of their envelopes. Thus Iyengar (1960) places both attached and free floating forms under *Gloeococcus*.

Fott (1972) in a recent treatment of the genus includes 8 species in this genus including two species of Skuja (1956; 1964), *Chlamydomonas planctogloea* and *C. alsius*. He treats Lund's *G. braunii* as *G. minor* Br. He also transfers *Gloeocystis maxima* Mainx to this genus (see, however, Iyengar, 1971).

G. pyriformis was repeatedly collected from the muddy water pools in Nekkundram (9-9-1951; 8, 9-1-1952; 1-1-1954). In these collections some of the cells showed a definite papilla at high magnifications. In others papillae were not noticeable. Cells (smaller ones) 6-10 μ broad and 9-12 μ long, larger ones 12-15 μ broad and 12-18 μ long (Fig. 1, O-V).

In some collections from Nekkundram (9-10-1950; 9-2-1954; 10-2-1954) the pyrenoids were sometimes seen to be lateral. At the end of the season, cells lost their flagella and the eyespot but retained the 2 contractile vacuoles, looking like a coccoid cell. This appeared to be the beginning of cyst formation. — Colonies small up to 2.5 cm in diam., attached and pyriform, or microscopic and free floating and nearly spherical; colonial mucilage thin inside and very firm and forming a definite layer on the outside; cells somewhat longer than broad, slightly dorsiventral when young, papilla tiny or absent; cells motile inside the mucilaginous envelope, 7.5-12 μ broad and 9-15 μ long; chloroplast single, plate like with a single lateral pyrenoid; eyespot a small streak, median, flagella about as long as the body; contractile vacuoles 2, anterior (Fig. 2, A-O).

The Vandalur form of *G. pyriformis* (type) had cells 9.3–11 μ broad and 10–12.5 μ long. Occasionally the cells appeared as though connected by fine processes. These latter appear to be remnants of the old mother walls. In a collection of the alga from the same locality (10–8–1954) isogamous

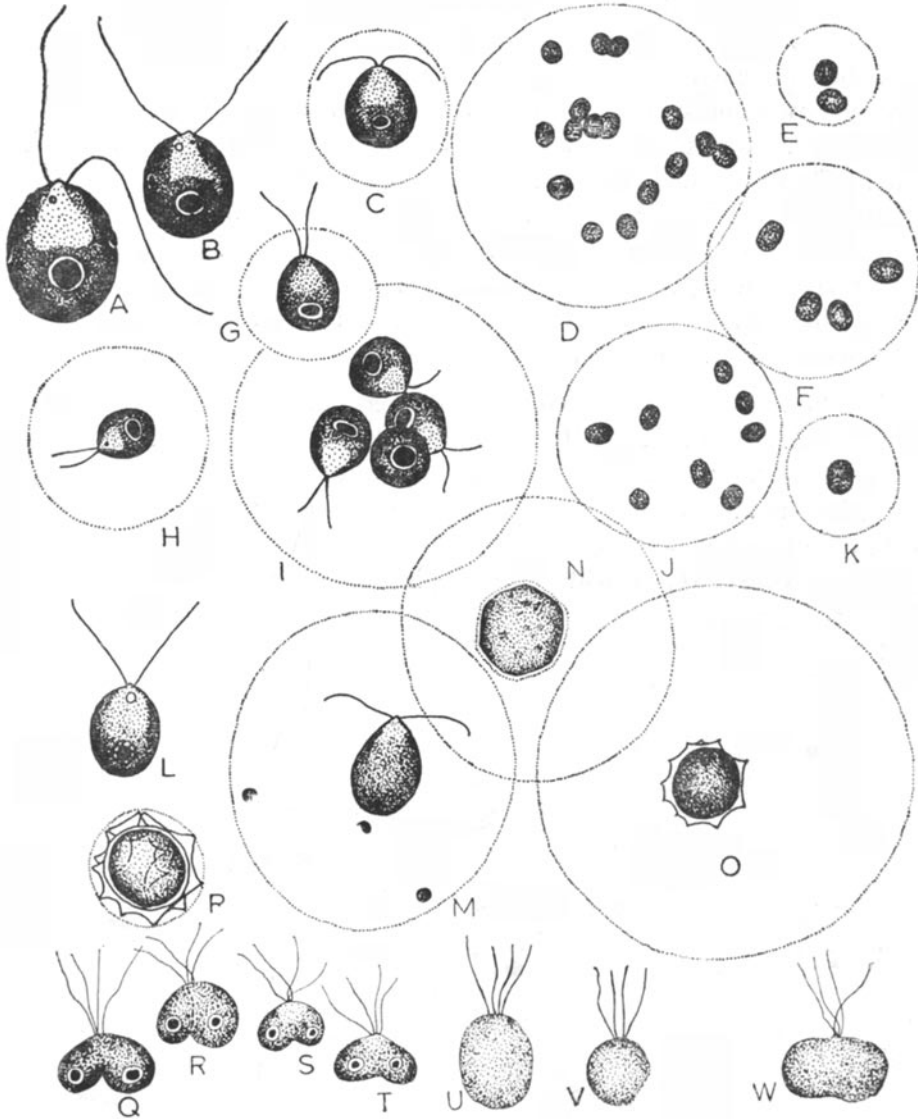


FIG. 2. *Gloeococcus pyriformis* Iyengar. A, B, L, Cells; C, G, H, Simple colonies; D-F, J, K, Colonies; I, M, Four celled and one celled colonies; N-P, Cyst formation; Q-W, Sexual reproduction. (all after Iyengar. A, B, L, $\times 2,400$; C, G $\times 1,500$; D, E, F, J, K, $\times 700$; M-P. $\times 1,100$; H, I, $\times 1,560$; Q-W, $\times 3,000$).

and slightly anisogamous conjugation of biflagellated gametes was observed to take place in the mornings (8 A.M.). The planozygotes were not observed (Fig. 2, Q-W).

Observations made on the many collections clearly demonstrate varying positions of the flagella with respect to the gelatinous envelope secreted (Fig. 2, C and H). It appears as though the cell gradually withdraws into a shell of mucilage secreted by it until ultimately it is enclosed in it. The same type of behaviour can be imagined to take place in the case of cells which become attached prior to mucilage secretion and form an attached colony. Thus it would appear to be correct to place under *Gloeococcus* both attached and free floating forms (*see also* Fott, 1972), as one finds both the conditions existing in one and the same collection and as the manner of thallus formation appears to be basically the same, in both the forms, that is, by a simultaneous secretion of mucilage and withdrawal of the flagella to the inside of the envelope.

Free floating colonies of *Gloeococcus* were also collected from a pool in A.H. Gardens, Madras (1-10-1935). The large cylindrical thalloid condition has not been observed or collected from this locality. This also resembles closely the muddy water form. In the actively multiplying condition, the cells may not immediately form flagella but do so later on. Colonies up to $40\ \mu$ diam., cells $5-7\ \mu$ broad, nearly spherical (Fig. 3, A-O).

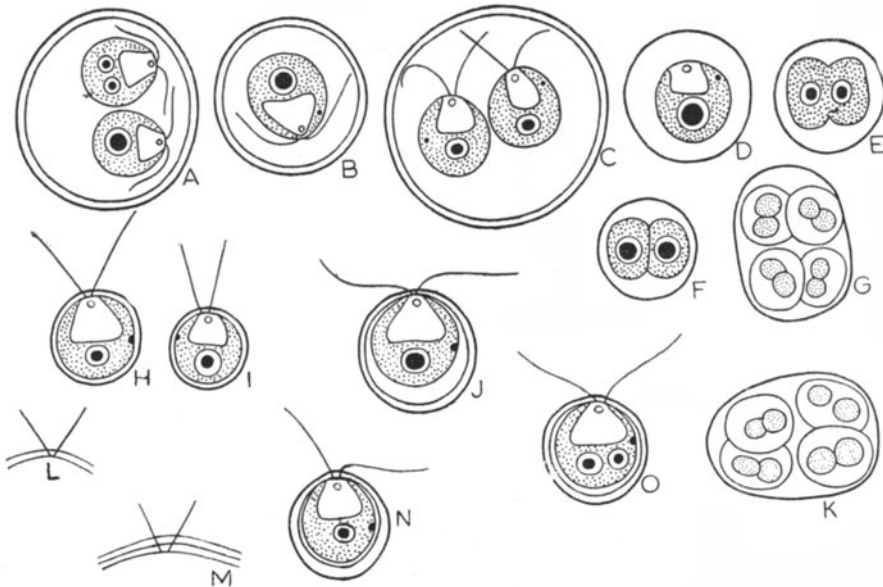


FIG. 3. *G. pyriformis* Iyengar, free-floating in a pool in A.H. gardens, Madras. (all after Iyengar. all, $\times 1,560$).

Balakrishnan *et al.* (1972) have described a new variety, *G. pyriformis* v. *lobosus*. This variety essentially differs from Iyengar's form in the markedly lobed nature of the mature thallus. The cells are $8-15 \times 7-12 \mu$ and slightly smaller than those described by Iyengar. In fact, the cells show a great deal

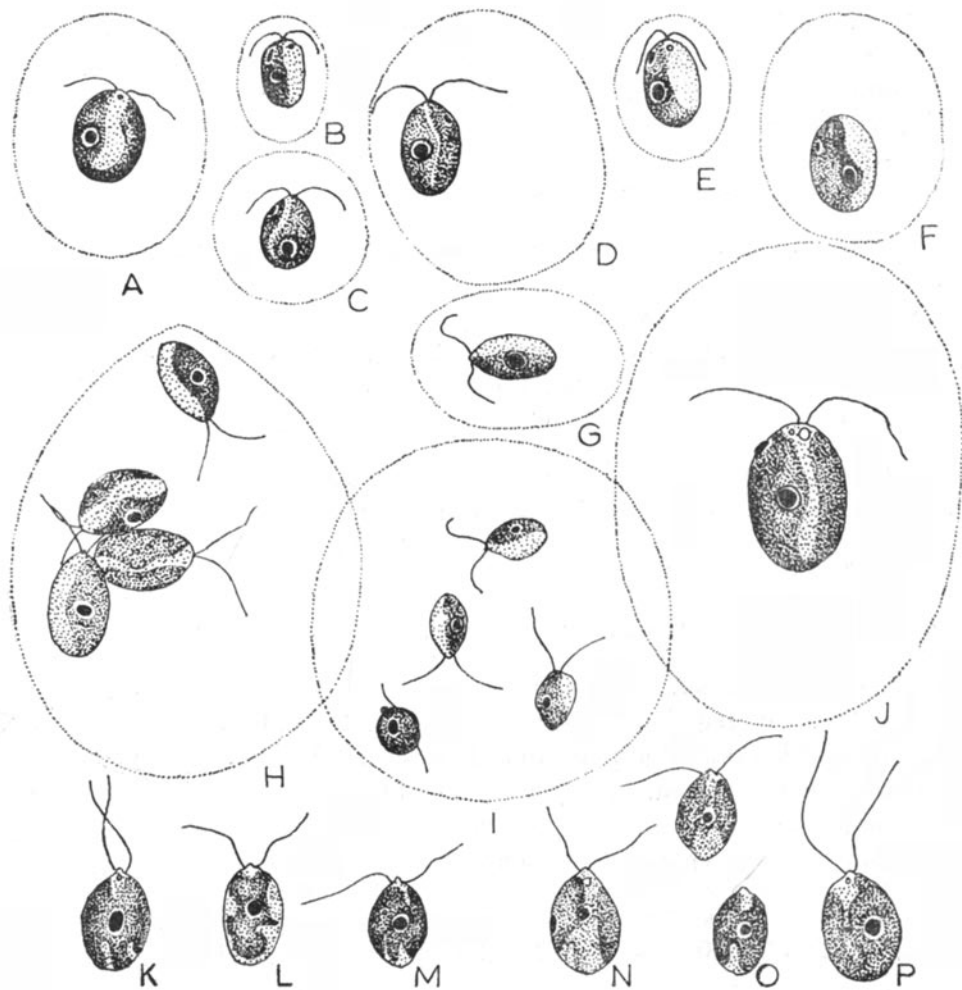


FIG. 4. *G. lateralis* Iyengar. A-J. 1-4 celled colonies; K-P. Cells showing variations in chloroplast. (all after Iyengar. A-I, $\times 1,560$; J, $\times 2,400$; K-P, $\times 2,000$).

of variation in cell dimensions. Ramanathan (personal communication) found a similar form growing in paddy fields, in Madras. — Thallus gelatinous and cylindrical, somewhat branched when older, basal end narrowed

and attached to the decaying parts of submerged plants, terminal portion of the thallus broadly rounded, thallus limited by a thin firm outermost layer and a firm rim like portion; interior of the thallus made up of very thin and loose mucilaginous substance, cells concentrated more or less in the middle portion and constantly making an oscillatory movement, papilla seen; chloroplast single, bell shaped with a single posterior pyrenoid; eyespot elongated; anterior; contractile vacuoles 2, anterior; flagella long; cells dividing into twos and fours in a non-flagellated condition; young cells often with a tiny papilla.

***Gloeococcus lateralis* Iyengar sp. nov.**

Cells chlamydomonadine, embedded in mucilage; colony short cylindrical, slimy or worm like, light green in colour; cells $4\text{--}5.7\ \mu$ broad and $6\text{--}7.3\ \mu$ long, asymmetrical and dorsiventral, papillate; biflagellate, flagella as long as or slightly longer than the body; chloroplast bell-shaped or plate-like and lateral parietal, dissected or nearly reticulate; pyrenoid single, lateral; eyespot not easily seen, streak-like, median; cells dividing into two.

Habitat.—Muddy water pools, Nekkundram, Madras (1–10–1950); also muddy water pools, Tambaram near Madras (21–1–1936).

Type.—Fig. 4, A–I.

***Gloeococcus simplex* Iyengar sp. nov.**

Planktonic Colony spherical with 1, 2, 4, or 8 cells, $39\text{--}52\ \mu$ diam; cells cylindrical, papillate, $9\text{--}13.5\ \mu$ broad, and $17\text{--}20\ \mu$ long, motile inside the colonial limits; chloroplast ribbed or striated, generally with 6–7 ribs; pyrenoid single, median; eyespot streak like, anterior or near median; contractile vacuoles 2, anterior, at the base of the flagella; nucleus inside the hollow of the chloroplast; flagella two, anterior, as long as the body.

Habitat.—Planktonic in a small temporary pool, at the Elliot's Beach, Madras (27–12–1960; also 16, 28–12–1960) (Fig. 5, A–H). *Type*: Fig. 5A.

[In a recent treatment of the Volvocales by Iyengar and Desikachary (in press) both *Physocytium* and *Gloeococcus* were excluded and only motile members were included. *Physocytium* and *Gloeococcus* are peculiar in having motile cells while the thallus itself is not motile. They do not come under the tetrasporine and palmellate groups nor do they strictly conform to the definition of the Volvocales (sensu str.). Iyengar (1960) considers them as true Chlamydomonadaceae. Fritsch (1935) who extends Volvocles

to include palmellate and tetrasporine members includes *Physocytium* under Chlamydomonadaceae and *Gloeococcus* under the Palmellaceae. Lund (1957) enlarges the genus *Gloeococcus* and retains it in the palmellate Volvocales. He points out that one has yet to decide the role played by the environment in the development of the peculiar habit in *Gloeococcus* by *Chlamydomonas* spp. Ettl (1964) creates a new family Gloeococcaceae

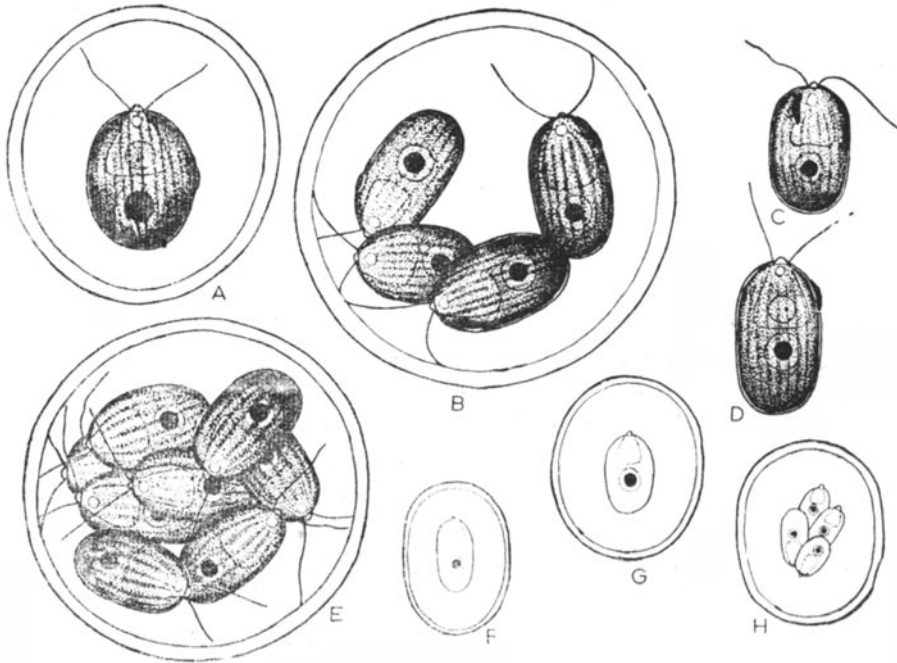


FIG. 5. *G. simplex* Iyengar. A, B, E-H. Colonies with 1-8 cells; C, D. Single cell showing structure. (all after Iyengar. A-D, $\times 2,400$; E, $\times 2,200$; F-H, $\times 1,500$).

(see also Fott, 1972) but he includes in it many other members which do not share the features peculiar to *Gloeococcus*. In fact, he seems to define it as a palmellate family. In a later treatment he includes all palmelloid nonmotile forms which have contractile vacuoles (see Ettl, 1964). Bourrelly (1966, p. 113) keeps both these genera in the Tetrasporales, *Physocytium* under the Chloragiellaceae and *Gloeococcus* under Gloeocystaceae. In this he obviously overlooks the fact that these cells have flagella and not pseudocilia and probably attaches little significance to the flagellated condition of the component cells of the colony. He considers *Gloeococcus* as a link between the Volvocales and the Tetrasporales. It is now clear from the many records of these algae that their resemblance to *Gloeocystis*

and similar palmelloid algae or stages is superficial. As Iyengar has pointed out these algae are really close to the Chlamydomonadaceae. Fott (1972) restricts Gloeococcaceae to *Gloeococcus* and includes other genera which resemble *Gloeococcus* but without flagellation in Nautococcaceae. These include *Hypnomonas* and other allied genera which differ from *Nautococcus* so much. T.V.D.J.

Iyengar visualized the creation of a separate family for this group of organisms. Individuals of this group are in all respects like *Chlamydomonas* in structure but are surrounded by mucilage as during palmella condition, individual cells possess two flagella and keep moving with their help inside the confines of its gelatinous envelope and swarm for some time or a short time and soon settle down and after a time lose their flagella and surround themselves with a gelatinous wall. The protoplast of the cell then divides into two or four parts inside the envelope and then each protoplast develops two cilia and keeps moving inside the gelatinous envelope in an oscillatory manner. The individuals possess their cilia and motility throughout their life-history. The only time in its life-history when it is without any flagella is during cell division. He calls this condition as pseudopalmelloid. Iyengar derived the true palmelloid members from these algae by the cells failing to develop flagella after cell division, while they may also be derived directly from the palmelloid states seen in many Chlamydomonadaceae. The Tetrasporaceae with their pseudocilia might have been derived probably from some non-colonial chlamydomonadine ancestor.

[In contrast to *Gloeococcus*, genera such *Hypnomonas* resemble *Chlamydomonas* very closely but differ in having the motile flagellated phase developed only during reproduction. *Planctococcus alsius* Skuja seems to belong to this group of individuals and is not strictly a *Gloeococcus* as Fott (1972) considers it. Fott's new genus *Chlamydocapsa* does not differ greatly from *Hypnomonas*. The only difference appears to be in the presence of colonial mucilage in *Chlamydocapsa* and its absence in *Hypnomonas*. This in many cases appears to be too variable a character to be relied solely for generic differentiation judging from Iyengar's experience with muddy water algae and other phycologists' observations on the presence or absence of a mucilaginous matrix in one and the same coccoid form. Genera such as *Radiococcus*, *Apiococcus* and *Hypnomonas* do not really belong to the Nautococcaceae and must be placed near *Asterococcus* and similar other genera included by Fott (1972) in his *Asterococcaceae*. T.V.D.J.]

Hynomonas indicus Iyengar sp. nov.

Cells chlamydomonadine, non-flagellated enclosed in a gelatinous envelope which is often lamellated; cells papillate; chloroplast cup-shaped, pyrenoid single, basal; eyespot seen in some cells, long streak-like, anterior; contractile vacuoles 2, anterior; cell division obliquely longitudinal; cells $5.5-7\ \mu$ broad and $9-10\ \mu$ long.

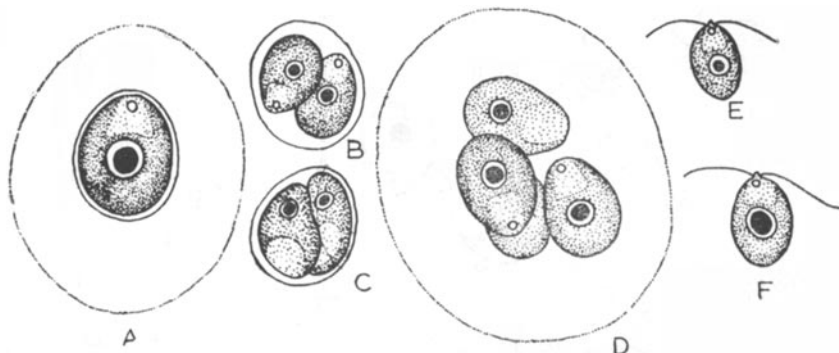


FIG. 6. *Hynomonas indicus* Iyengar. A, B, D, Colonies; C. Cell division; E, F. Motile swimmers. (all after Iyengar. all, $\times 2,500$).

Habitat.—On moist garden soil, A.H. Gardens, Madras (7-9-1934).
Type: Fig. 6.

Physocytium indicum Iyengar sp. nov.

Alga balloon like or globose vesicle, attached by two thin flagella-like stalks, stalks of varying lengths; cells 1, 2, 4 or 8 or even 16 enclosed inside each vesicle, biflagellated, motile inside the vesicle; chloroplast cup-shaped with a basal pyrenoid; eyespot median; contractile vacuole single, anterior; asexual reproduction by cell division into two, each forming a zoospore; zoospores liberated by a rupturing of the vesicle, settling down by the flagellated end and secreting a vesicle and the two flagellary stalks; each zoospore forming a 8 or 16 celled colony enclosed in a gradually enlarging gelatinous vesicle, sometimes with distinct daughter vesicles or envelopes around pairs of cells, but generally daughter envelopes gelatinizing and becoming indistinct; cells globose, $18-20\ \mu$ broad and $20-26\ \mu$ long.

Habitat.—Epiphytic in a stream, at Viyampatti, near Tiruchirapalli, S. India; also on algae in ponds and temporary pools (leg. Iyengar; also K. R. Ramanathan); on *Tetrasporidium javanicum*, in a stream, Saugar, M.P. (leg. T. V. Desikachary) Fig. 8; on algae, Poona (leg. M. S. Balakrishnan Fig. 9).

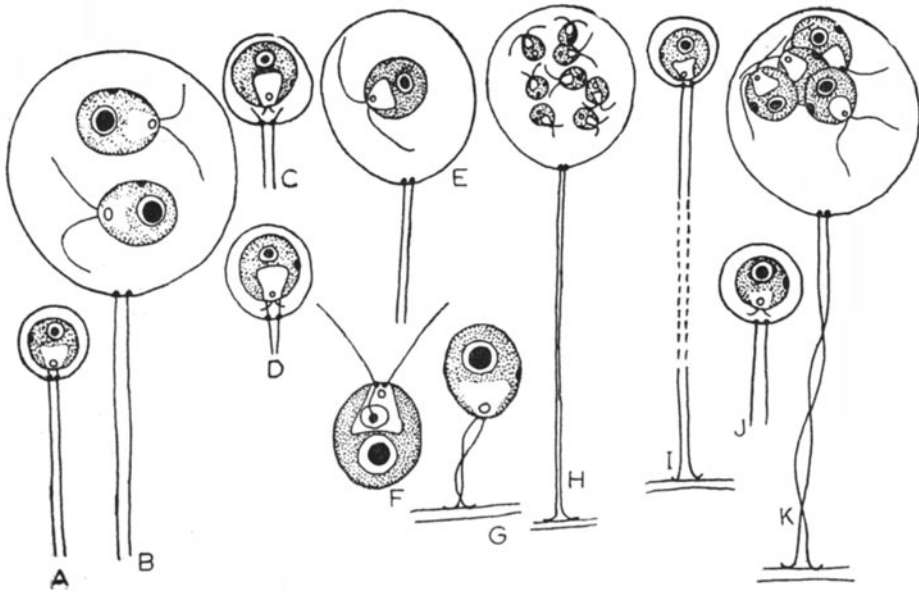


FIG. 7. *Physocytium indicum* Iyengar (after Iyengar).

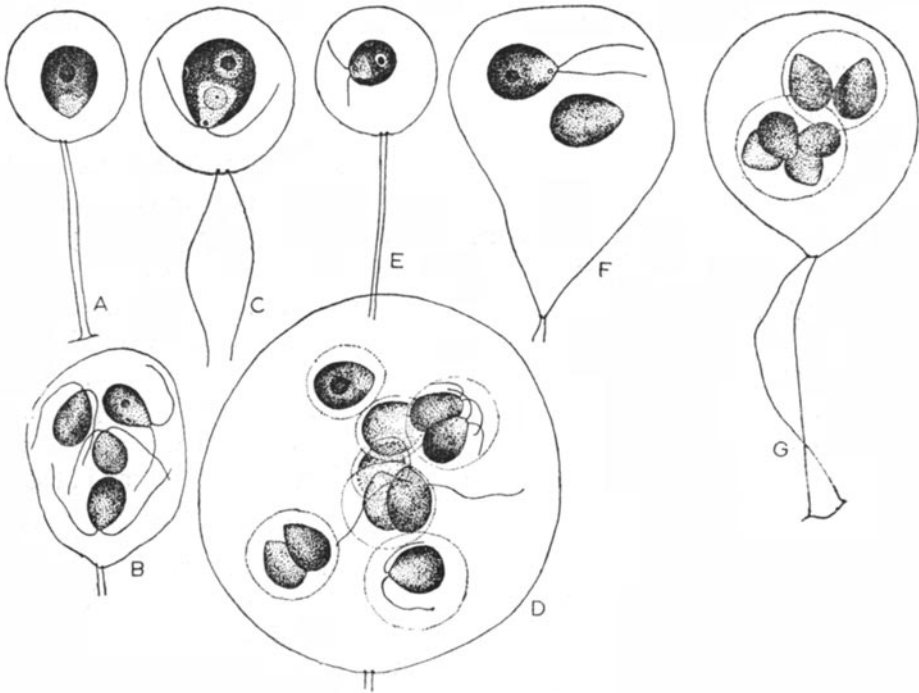


FIG. 8. *Physocytium indicum* Iyengar (after Desikachary).

Type.—Fig. 7, A-K.

Iyengar (1960, pp. 394-395) gave details account of this species but did not give a latin diagnosis. Hence the validation here.

LATIN DIAGNOSES

Gloeococcus pyriformis Iyengar sp. nov.

Alga gelatinosa, pyriformis, affixa angusto extremo, colonialibus finibus firmo limite, 1-3 cm. longa, 0.5-1.5 cm lata; cellulae biflagellatae, chlamydomonadinae, valde numerosae, inclusae in matrice molli gelatinosa; cellulae continuae oscillantes intra coloniam parvis motibus progredientibus et regredientibus; divisio cellulae in longitudinem, amissis flagellis et ultimam quiescentes, cellulis filialibus 2, 4 vel 8, postremo indutis parietibus, flagellis et plus minusve mobilibus; cellulae erraticaev evadentes ex colonia; 7-13 μ latae et 9-18 μ longae; chloroplasti cupulati, pyrenoide mediana, singula;

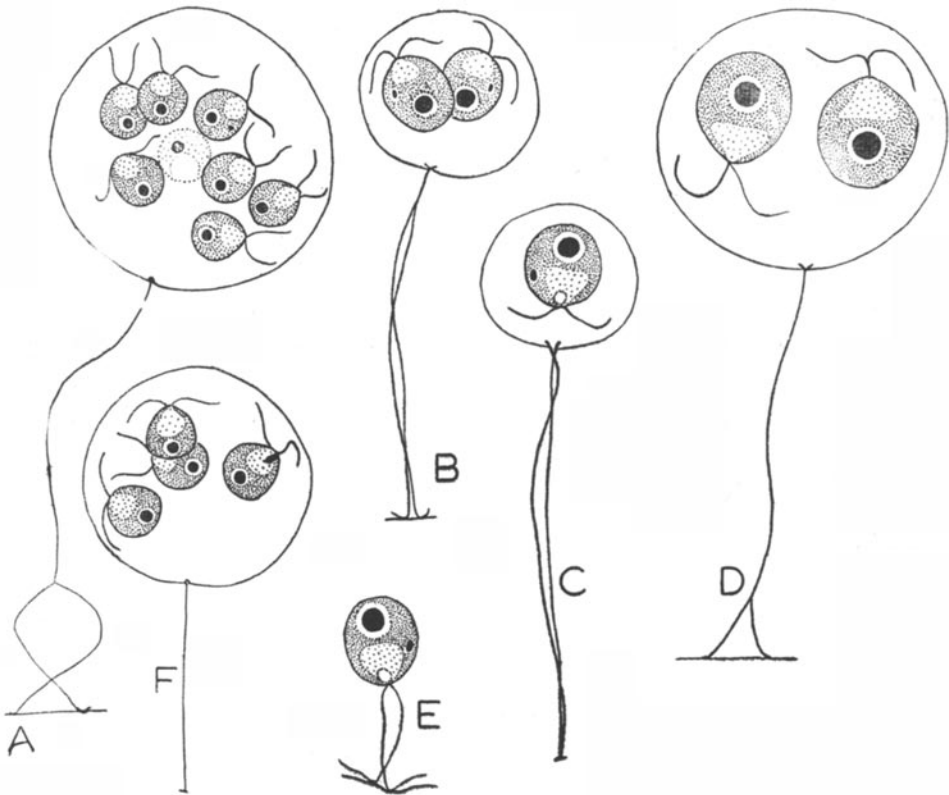


FIG. 9. *Physocytium indicum* Iyengar (after Balakrishnan).

stigma medianum; vacuolae contractilis binae, anticae, subflagello; reproduction sexualis isogama vel anisogama.

Habitat.—In marginibus vadosis irriguorum stagnorum, Vandalur, prope Madras (26-8-1933 etiam 23, 28-8-1933; 10-8-1949, etc.).

Typus.—Fig. 1, A-N.

***Gloeococcus lateralis* Iyengar sp. nov.**

Cellulae chlamydomonadinae, inclusae in muco; colonia brevis, cylindrica, mucosa vel lumbricalis, viridis; cellulae 4-5.7 μ latae et 6-7.3 μ longae, asymmetricae et dorsiventralis, papillatae; biflagellatae, flagella leviter longiora vel aequantia corpus longitudine; chloroplastus campanulatus vel laminaris et lateralis, parietalis, dissectus vel fere reticulatus; pyrenoides singula, lateralis; stigma non-facile visum, lineatum, medianum; divisione cellulae in duabus.

Habitat.—In lacunis aquae lutosae, Nekkundram, Madras 1-10-1950; etiam in lacunis aquae lutosae, Tambaram, prope Madras 21-1-1936.

Typus.—Fig. 4, A-I.

***Gloeococcus simplex* Iyengar sp. nov.**

Planctonica Colonia sphaerica, 1, 2, 4, vel 8 cellulis, 39-52 μ diametro; cellulae cylindricae, papillatae, 9-13.5 μ latae, 17-20 μ longae erraticae intra limites coloniae; chloroplastus costatus vel striatus, generatim 6-7 costis; pyrenoides singula, mediana; stigma lineatum, anticum vel fere medianum; vacuolae contractiles binae, anticae, ad basim flagellorum; nucleus intra cavum chloroplasti; flagella dua, antica, aequantia corpus longitudine.

Habitat.—Planctonica in parva temporaria lacuna, Litore Elliotis, Madras (27-12-1960, 16-12-1960, 28-12-1960).

Typus.—Fig. 5 A.

***Hypnomonas indicus* Iyengar sp. nov.**

Cellulae chlamydomonadinae, non-flagellatae, papillatae, inclusae in gelatinoso involucre saepe lamellato; chloroplastus cupulatus, pyrenoides singula, basalis; stigma visum in aliquibus cellulis, longum, lineatum, anticum; vacuolae contractiles duae, anticae; divisio cellulae oblique longitudinalis; cellulae 5.5-7 μ latae et 9-10 μ longae.

Habitat.—In humido humo horti, A.H. Hortis. Madras. 7-9-1934.

Typus.—Fig. 6.

Physocytum indicum Iyengar sp. nov.

Alga similis vesiculae globosae affixa stipitibus duobus gracilibus similibus flagellis, variantibus longitudinibus; cellulae, 1, 2, 4 vel 8 vel etiam 16, inclusae in singulis vesiculis; biflagellate, erraticae intra vesiculam; chloroplastus cupulatus, pyrenoide basali, stigmatate mediano; vacuola contractilis singula, antica; reproductio asexualis divisione cellulae in duabus, utraque formanti zoosporam; zoosporae liberatae rumpenti vesicula, collocantes se extremo flagellato, secernentes vesiculam et duos stipites flagellatos; utraque zoospora formans coloniam 8 vel 16 cellulis, inclusam in vesicula gelatinosa gradatim accrescenti, aliquando unumquidque par cellularum circumcinctum vesiculis vel involucris propriis filialibus, sed generatim involucra filialia evadentia indistincta et gelatinosa; cellulae globosae 18–20 μ latae et 20–26 μ longae.

Habitat.—Epiphytica in flumine, Vaiyampatti, prope Tiruchirapalli, S. India; etiam in algis in stagnis et temporariis lacunis (leg. Iyengar; etiam K. R. Ramanathan); in *Tetrasporidio jacanico*, in flumine, Saugar, M. P. (leg. T. V. Desikachary) Fig. 8; in alga, Poona (leg. M. S. Balakrishnan) Fig. 9.

Typus.—Fig. 7, A–K.

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