GENUS "*ANABAENOTHRIX*" AND PARALLELISM IN EVOLUTION IN FRESHWATER ALGÆ.

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During my investigations of the Panjab Freshwater Algæ, I came across two *Anabæna*-like species of Blue Green Algæ, which, however, differed from the typical specimens of *Anabæna* in having a number of trichomes enclosed in a single mucilaginous sheath. Recently Dr. F. E. Fritsch described a species of *Anabæna* with a mucus sheath, from South Africa which he calls *Anabæna vaginicola* sp. nov.* This so-called *Anabæna vaginicola* Fritsch resembles *Anabæna cylindrica* Lemmer in essential features and the only vital difference is the occurrence of a number of trichomes within a single sheath. The two species which I discovered differ from *Anabæna vaginicola* Fritsch in the size of the filaments, the shape and size of the vegetative cells, and the form and size of spores and heterocysts. Following is a detailed description of these three species of *Anabæna*, like Blue-Green Algæ.

I. *Anabænothrix vaginicola* Fritsch (nov. comb.).—Numerous trichomes in a single sheath, rarely a single one in single sheath. Cells elongate cylindrical or sub-cylindrical 4 to 5 μ broad, 6 to 10 μ long. Spores oblong, barrel-shaped, contiguous to the heterocysts in series 4–5, 6.5 to 10 μ broad and 12 to 17.5 μ long.

II. *Anabænothrix cylindrica* Randhawa and Ghose.—Numerous trichomes enclosed in a single sheath, breadth of filaments 60–75 μ inclusive of the sheath, cells rounded or constricted, dumb-bell-shaped, 5 μ broad, 6–7 μ long with homogeneous contents. Heterocysts rounded 9 to 10 μ in diameter. Spores in pairs contiguous to the heterocysts, cylindrical in shape 4 to 5 μ broad, 18–20 μ long. Found attached in mud of a pond in long cylindrical columns of blue-green colour, which later on become detached, and the alga becomes free floating. Fig. 2 shows a filament of *Anabænothrix cylindrica* with numerous trichomes enclosed in a single

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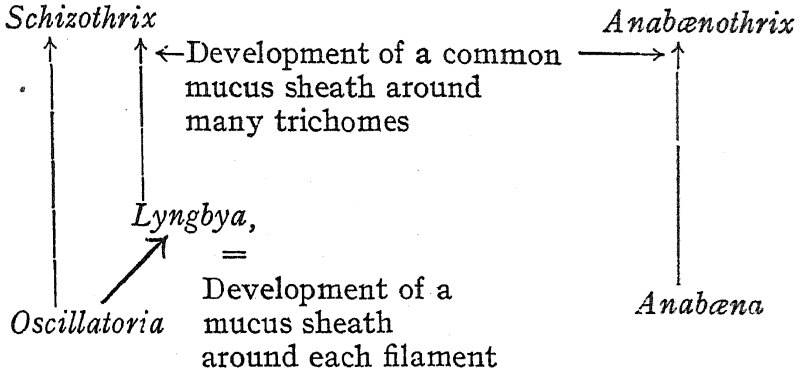
sheath. In Fig. 2 is shown a part of a trichome highly enlarged with a heterocyst surrounded by a chain of spores on both sides.

III. *Anabænothrix epiphytica* Randhawa and Ghose.—Numerous trichomes enclosed in a single sheath or a single one in a single sheath. Cells rounded with homogeneous contents. 3.5 μ in diam. Heterocysts ellipsoid-rounded, always away from the spores. 5–6 μ broad, 14–18 μ long. Always found epiphytic on other algæ especially *Sirogonium*. In Fig. 3 is shown a typical filament of *Anabænothrix epiphytica* with a number of trichomes enclosed in a single sheath. Sometimes we come across filaments of this species, showing a single trichome enclosed in a sheath as in Fig. 4. In Fig. 5 is shown a part of a trichome with a spore and a heterocyst.

So here are three species of *Anabæna*-like Blue-Green Algæ which have acquired in the course of their evolutionary progress, the same character of enclosure of a number of trichomes in a single sheath. This case clearly illustrates, as suggested by Miss Agnes Arber in her excellent monograph on Monocotyledons, that a genus is an evolutionary platform on which species of a different origin are assembled together. In the case of these algæ, three different species of *Anabæna* independently acquired the habit of grouping of numerous trichomes in a single sheath. Obviously we are justified in establishing a new genus, which I call *Anabænothrix*, for the same reasons as we have in establishing *Schizothrix* as a separate genus from *Lyngbya* or *Lyngbya* from *Oscillatoria*. This genus *Anabænothrix* is an expression of a tendency parallel to that of *Schizothrix*, *viz.*, the enclosure of a number of trichomes within a common sheath. This parallelism in evolution is very interesting and shows how the habit of secretion of a common mucus sheath by a number of filaments, developed in different families of Myxophyceæ; by *Schizothrix* in Oscillatoriaceæ and *Anabænothrix* in Nostocaceæ. Members of genus *Lyngbya* are nothing but *Oscillatorias* enclosed in a mucus sheath. Here the individual filaments developed the habit of secreting separate mucus sheaths around themselves, possibly as a protection against drought and desiccation. In *Schizothrix* which marks the next stage, possibly higher in the evolutionary progress we see a number of filaments secreting a common sheath, which means a greater economy of material. This tendency towards collective secretion of a sheath has also expressed itself in *Anabænothrix*, the various species of which developed from different species of *Anabæna*. Though *Anabæna* is structurally on a higher scale than *Oscillatoria* or *Lyngbya*, we find it treading the same evolutionary path as some species of the later two genera of Myxophyceæ. Different species of *Oscillatoria* and *Lyngbya* developed into *Schizothrix* and different species of *Anabæna* into *Anabænothrix*, but both followed

independent roads in reaching the same goal. Following is the possible evolutionary course among these algæ.



We also note similar parallelism in evolution between a dichotomously divided species of *Botrydium* from Madras called *Botrydium divisum*, described by Dr. M. O. P. Iyengar some years ago and *Dichotomosiphon*. The dichotomous nature of the branching of *B. divisum* suggested to Dr. Iyengar some distant connection with *Dichotomosiphon*, a member of Isokontæ. However, these resemblances of form between *Botrydium divisum* Iyengar and *Dichotomosiphon* are purely superficial and comparable to resemblances shown by certain members of Euphorbiaceæ, *e.g.*, *Euphorbia royleana* to *Cereus triangularis*, a member of Cactaceæ. As a result of similar dry and hot environment these plants, phylogenetically far apart, have developed similar physical characteristics like succulence of stem and reduction of leaves. *Dichotomosiphon*, a member of Isokontæ, is characterised by starch metabolism, presence of pyrenoids and presence of carotin and xanthophyll in the same proportion as in higher plants, while *Botrydium*, a member of Heterokontæ, is characterised by absence of pyrenoids coupled with oil metabolism and excess of xanthophyll in its chloroplasts. Differences between Isokontæ and Heterokontæ are regarded as so fundamental that prominent algologists hold that Isokontæ and Heterokontæ had an independent origin among the primitive Flagellates. Most probably the ancestors of *Botrydium* were some dichotomously branched filamentous cœnocytic Heterokontæ, possibly some cœnocytic Tribonemaceæ. Such structure in this hypothetical member of Tribonemaceæ and *Dichotomosiphon* developed quite independently due to a similar response to some unknown environmental conditions and does not mean any phylogenetic relationship between the two, for their differences are more fundamental than their resemblances.

Another striking instance of parallelism in evolution is seen in the case of *Protosiphon*, a globular member of Isokontæ and the common roundish species of *Botrydium*, which belong to Heterokontæ. In this

case the resemblance in external appearance is so great that species of *Botrydium* are often mistaken for those of *Protosiphon* and *vice versa* especially when the chloroplasts have disappeared. The spherical form has been independently evolved in these two algæ to reduce evaporation of water, especially as they subsist on dry mud and they have to economise their water content. These two terrestrial algæ find their parallel in globular Cactaceæ of Mexico and South America.

Species have a tendency to evolve along parallel lines when they are subjected to similar environmental stimuli, *e.g.*, the same degree of temperature, similar hygroscopic conditions and similar soil constituents. This is clearly seen in the case of *Botrydium* and *Protosiphon*. However, in some cases the resemblance may be purely fortuitous and may be due to some unknown changes in the chromomeres of the chromosomes of the nuclei of cells taking place independently in different species of different genera but resulting in similar external physical appearance of the plant.

The discovery of the fact that species have a tendency to evolve along parallel lines has made it abundantly clear that external physical appearance is no index of phylogenetic relationship and we should avoid the fallacy of deducing pedigrees and relationships merely on the occurrence of a few common external characteristics. The realisation of the fact of parallelism in evolution has also influenced our concept of genus. The species of *Anabænothrix* clearly illustrate that genus is an evolutionary platform on which species which have evolved independently from different levels gather together for they have acquired some common characteristics.

LITERATURE CITED.

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EXPLANATION OF FIGURES.

Anabænothrix cylindrica.

FIG. 1.—Numerous trichomes enclosed in a sheath. (× 360.)

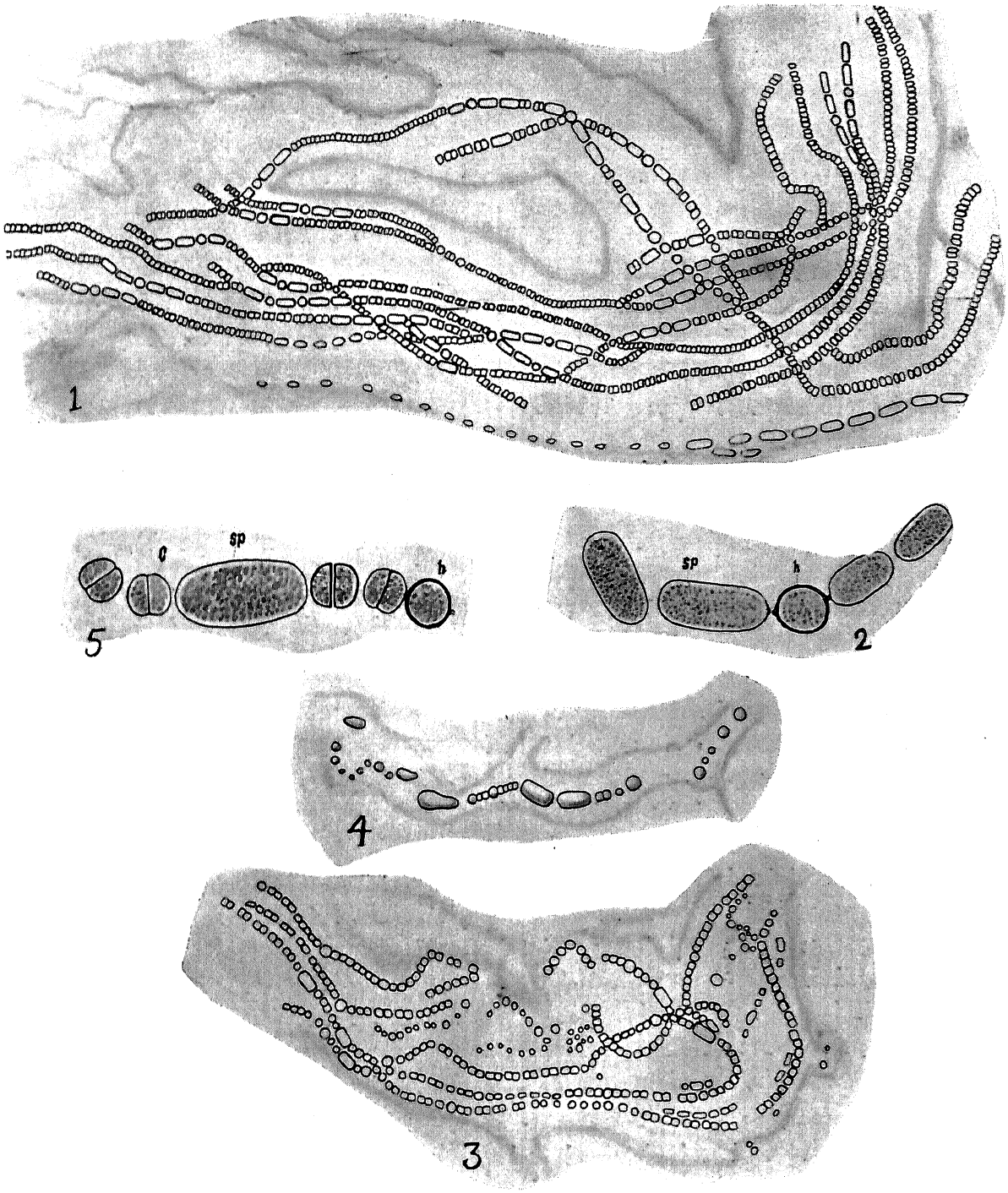
FIG. 2.—*h*, heterocyst; *sp*, spore. (All × 1000.)

Anabænothrix epiphytica.

FIG. 3.—Numerous trichomes enclosed in a sheath. (× 360.)

FIG. 4.—Single trichome enclosed in a sheath. (× 360.)

FIG. 5.—*h*, heterocyst; *sp*, spore; *c*, vegetative cell. (All × 1000.)


1
sp
c
b
5
sp
h
2
4
3