

Two Identical Genera of Budding and Stalked Bacteria: *Planctomyces* Gimesi 1924 and *Blastocaulis* Henrici and Johnson 1935

PETER HIRSCH

Institut für Allgemeine Mikrobiologie, Universität Kiel, Germany

Planctomyces bekefii Gimesi 1924 was originally described as a planktonic, freshwater fungus. Its spherical bodies on thin stalks were interpreted as sporangia. Colonies of this organism were compared to pine needles whose pointed ends were attached to a common base. *Blastocaulis sphaerica* Henrici and Johnson 1935 is a planktonic, freshwater bacterium of a morphology and size identical to that of the former organism; both organisms occur in the same habitat and at the same time. Because of their rather unique morphology, the organisms are easily recognized. Depositions of ferric hydroxide occasionally thicken the stalks of the two forms. Recent observations on living material have confirmed the original descriptions. As a result of a comparison of the characteristics of the organisms, both are here considered to be identical. Although *Planctomyces bekefii* has been described as a fungus and its description lacks physiological details, priority must be given to this name, of which *B. sphaerica* must be considered a later subjective synonym. Because these organisms are the type species of their respective genera, the generic names are also regarded as subjective synonyms, and *Planctomyces* Gimesi 1924 has priority over *Blastocaulis* Henrici and Johnson 1935. An amended description of *Planctomyces* is presented. Besides *P. bekefii* Gimesi 1924, the following species are currently recognized as belonging to *Planctomyces* and are described herein: *P. gracilis* Horrothbágyi 1965, *P. condensatus* Skuja 1964, and *P. kljasmensis* comb. nov. (basionym: *Gallionella kljasmensis* Razumov 1949). A key to these species is given. The taxonomic placement of other named organisms which either are or have been associated with the genus *Planctomyces* is discussed.

A study of the September plankton of Lake Lágymányos (Budapest, Hungary) led to the discovery of *Planctomyces bekefii* Gimesi 1924 (2). According to the description, the organism was thought to belong to the sporulating fungi. Spherical "thalli" were thought to be formed by organisms resembling a group of pine needles radiating out of a common center. In the mature state the diameter of such a structure (group) was 18.2 to 21.5 μm . The spherical heads had a diameter of 1.66 μm and were interpreted by Gimesi to be fungal spores formed on the 0.89- μm -diameter filaments (sporophores). Other spores, usually smaller, were often attached to the main spore. The spore-bearing filaments were unbranched, of uneven length, and appeared to be joined at a common base. There were no connections to other structures. The whole thallus was thus composed of only filaments and spores. New

thalli were thought to develop by germination of spores that had detached from their filaments. Up to four "germination tubes" were observed. The organisms were colorless and probably grew at the expense of dissolved organic matter in the lake. A rather unclear micrograph (two sizes) accompanied this vague description. Growth was not obtained in artificial media.

P. bekefii seems to be widely distributed and usually occurs during the late summer and early fall in lakes and shallow fish ponds (1, 5-7, 10, 12, 13, 15-17). The present author (1968/1970) and G. Saunders (1968/70, personal communication) have made similar observations. Most of the authors who have described this organism noted the presence on the stalks of iron depositions which rendered the stalk base wider than the tip.

In their famous study of freshwater bacteria

which attach themselves to surfaces, Henrici and Johnson (4) observed several budding and stalked bacteria which now appear to be identical to *P. bekefii*. One of these organisms, *Blastocaulis sphaerica*, was chosen as the type species for a new genus, *Blastocaulis*. The description of this new organism was thorough and clear, although based mainly upon morphological observations. Pure cultures on artificial media were not obtained, but drawings and a micrograph were published. The original photomicrographs used for this publication, as well as several other unpublished ones, are still available for comparison.

Because of the similarity of the two organisms, a detailed study of both original descriptions was made; a list of the distinguishing characters is given in Table 1. It can be seen by comparison that the differences that seem to exist are unimportant. Moreover, observations on living material from enrichment cultures and from bacterial plankton of some Michigan marl

lakes and ponds allowed an evaluation of the importance of characteristics for the accurate description of these organisms. *P. bekefii* and *B. sphaerica* are identical organisms, and their names must be considered subjective synonyms. Inasmuch as these organisms are the type species of their respective genera, the generic names are also regarded as subjective synonyms, and *Planctomyces* Gimesi 1924 has priority over *Blastocaulis* Henrici and Johnson 1935. However, from a practical standpoint, *Blastocaulis* would appear to be preferable to *Planctomyces* for the following reasons.

(i) The original description of *Planctomyces* was vague and short, whereas that of *Blastocaulis* was precise and pertinent; clear illustrative material exists only for the latter organism.

(ii) The generic name *Planctomyces* was formally claimed for an organism believed to be a fungus.

(iii) At the time of naming, the presumed relationship of *Planctomyces* to fungi was based

TABLE 1. Comparison of *Planctomyces bekefii* Gimesi 1924 with *Blastocaulis sphaerica* Henrici and Johnson 1935

Property	<i>P. bekefii</i>	<i>B. sphaerica</i>
Cell shape	Spherical ^a	Spherical
Cell diameter	1.66 μm	1.4-1.6 μm ^a
Bud morphology	Spherical ^a	Spherical
Budding site	Distal cell pole	Distal cell pole ^a
Immature budding	Frequent	Not mentioned
No. of buds per cell	One (?)	One
Germination of buds	With 4 radial tubes	Not mentioned, but one stalk only per cell ^a
Staining of buds	Not mentioned	Gram-positive; evenly dense
Staining of mature cells	Not mentioned	Gram-negative; uneven
Diameter of stalks	0.89 μm	0.5-0.7 μm
Stalk thickness	Even ^a	Even
Fe-depositions on stalk	Not mentioned	Occasionally present ^a
Cells falling off from stalks	Occasionally	Not mentioned
Stalks flexible	Occasionally	Occasionally
Stalks branching	Never	Never
Cell color	None	None
Diameter of colony	Up to 21.5 μm	Up to 16 μm ^a
No. of stalks per colony	Eight ^a	Up to eight
Habitat	Phytoplankton	Phytoplankton
Source	Lake Lágymányos (Hungary)	Lake Alexander (U.S.A.)
Maximal development	September 1922	Fall 1933
Temperature optimum	Not mentioned	23 C
Nutrition	Not mentioned	Heterotrophic
Taxonomic position	"Probably fungus"	Bacterium
Illustrations	One poor micrograph	Excellent micrographs and drawings

^a Deduced or measured on illustrations of the original publication.

TABLE 2. Stalked and budding bacteria described in the literature and related to the genus *Planctomyces*

Original name	Current name
<i>Actinothrix globulifera</i> Nováček 1938	<i>Planctomyces bekefii</i> Gimesi
<i>Blastocaulis kljasmensis</i> (Raz- umov) Zavarzin 1961, 780	<i>P. kljasmensis</i> comb. nov.
<i>B. sphaerica</i> Henrici and Johnson 1935, 84	<i>P. bekefii</i> Gimesi
<i>Gallionella kljasmensis</i> Raz- umov 1949	<i>P. kljasmensis</i> comb. nov.
<i>G. planctonica</i> Krasil'nikov 1949	<i>P. kljasmensis</i> comb. nov.
<i>P. bekefii</i> Gimesi 1924, 5	<i>P. bekefii</i> Gimesi
<i>P. condensatus</i> Skuja 1964, 16	<i>P. condensatus</i> Skuja
<i>P. crassus</i> Hortobágyi 1965, 111	<i>P. bekefii</i> Gimesi
<i>P. ferrimorula</i> Wawrik 1956, 296	New genus?
<i>P. gracilis</i> Hortobágyi 1965, 112	<i>P. gracilis</i> Hortobágyi
<i>P. guttaeformis</i> Hortobágyi 1965, 111	New genus?
<i>P. stranskae</i> Wawrik 1952, 448	<i>Siderophacus?</i>
<i>P. subulatus</i> Wawrik 1952, 448	<i>P. bekefii</i> Gimesi

merely upon assumptions; the exact life cycle was not known; germination of a "spore" was not directly followed, and the origin of the "spore-bearing" filaments remained unclear. The concept that the stalk may be excreted appears to be far more acceptable.

(iv) Characteristics used for the description of *Planctomyces* are no longer pertinent for bacteria, as can be seen from a few examples: the number of spore-bearing filaments per sphere (coenobium), the length of these filaments, etc. Unfortunately several other, unrelated bacteria were subsequently described as *Planctomyces* species on the basis of these characteristics (Table 2). By comparison, characteristics given for *B. sphaerica* are still sufficient for identification of members of this genus despite the fact that pure cultures do not yet exist. Some properties that can be used in the case of these morphologically distinct bacteria are: size of cells, diameter of stalks, staining properties, life cycle, growth temperature, habitat, and season of appearance in large numbers.

(v) The only illustration given for *P. bekefii* is too unclear to be useful (7). For *Blastocaulis*, original photographs still exist for several of its forms. It follows that it would be more advantageous to use both the description and name of *Blastocaulis*.

Nevertheless, both *Planctomyces* and *Blastocaulis* have been validly published according to the rules of the International Code of Nomenclature of Bacteria (8). Because knowledge of these organisms is still scant and only a few

publications on them have appeared, neither name can be considered more widely used or accepted than the other, and the choice of names must be determined by priority, as stated above.

A listing of all organisms known to have been associated with either genus or now thought to be related to them is given in Table 2. As a result of a study of the original descriptions associated with these names, four species are recognized as members of the genus. Two named planctomycetes are regarded as identical to *P. bekefii*, and two other named planctomycetes are removed from the genus.

Genus *Planctomyces* Gimesi 1924 (Subj. Syn.: *Blastocaulis* Henrici and Johnson 1935). Spherical, oblong, or pear-shaped bacteria with long and slender stalks when in the mature state. The stalks are often attached to a common holdfast. Iron depositions occur on older parts of the stalks and thus render these thicker at the base. Multiplication is characteristically by budding; only immature cells may produce terminal or lateral buds. Type species: *P. bekefii* Gimesi 1924. Key to the species is as follows.

- (1) Cell diameter larger than 0.7 μm .
 - (a) Cells spherical; stalks up to 10 μm long and 0.4 to 0.9 μm wide, often encrusted with iron depositions: *P. bekefii* Gimesi.
 - (aa) Cells globose, stalks short or absent; cells attached to a central and iron-containing material; buds terminal: *P. condensatus* Skuja.

(2) Cell diameter less than $0.7 \mu\text{m}$.

(a) Cells small, spherical to oblong; in the latter case the long axis is perpendicular to the main stalk axis; stalks straight or only slightly curved, attached to form a rosette; iron depositions occur: *P. kljasmensis* (Razumov) comb. n.

(aa) Cells small, globose; stalks thin and crescent-shaped, up to $11 \mu\text{m}$ long; rosettes are formed; iron deposition not reported: *P. gracilis* Hortobágyi.

Description of species is as follows.

(i) *P. bekefii* Gimesi. Mature cells globular in form, colorless, 1.4 to $1.7 \mu\text{m}$ in diameter, attached to long, slender stalks which radiate from a common center to form rosettes (coenobia) (Fig. 1). Multiplication by terminal or lateral budding. Immature cells (buds) spherical, occasionally oblong, sometimes growing stalks and budding before reaching maturity. Smaller cells stain evenly and are gram-positive. Larger, older cells are gram-negative and stain deeply at the distal regions while the part from which the stalk originates stains faintly. Stalks approximately 0.4 to $0.9 \mu\text{m}$ in diameter, slightly flexible, and of varying lengths; cells may fall off from the stalks. Lengthening occurs from the site of stalk origin; older parts may be heavily encrusted

with iron-containing depositions. Diameter of coenobia up to $22 \mu\text{m}$. Heterotrophic, psychrophilic. Occur in open freshwater lakes or ponds in depths up to 33 cm ; most abundant in the fall (September). Illustrations: Henrici and Johnson, Plate 3, Fig. 2, and Plate 2, Fig. 14 in reference 4. Subjective synonyms: *B. sphaerica* Henrici and Johnson 1935, 84; *Actinothrix globulifera* Nováček 1938; *P. subulatus* Wawrick 1952, 448; *P. crassus* Hortobágyi 1965, 111.

(ii) *P. kljasmensis* (Razumov) comb. nov. Cells spherical to oblong, 0.3 to $0.5 \mu\text{m}$ wide, occasionally larger. Slender stalks may be encrusted with ferric hydroxide depositions. Oblong cells attached with their long axis perpendicular to the axis of the main stalk. Rosettes are formed by up to 50 cells. Multiplication by budding is assumed. Found in the bacterial plankton of reservoirs near Moscow, USSR, where it comprised up to 6% of the total number of organisms. Objective synonyms: *Galionella* (sic) *kljasmensis* Razumov 1949; *B. kljasmensis* Zavarzin 1961. Subjective synonym: *Galionella planctonica* Krasil'nikov 1949.

(iii) *P. gracilis* Hortobágyi 1965, 112. Cells small, 0.3 to $0.6 \mu\text{m}$ wide, globose. Stalks of almost the same diameter (0.3 to $0.4 \mu\text{m}$), up to $11 \mu\text{m}$ long, usually bent, joining at the base

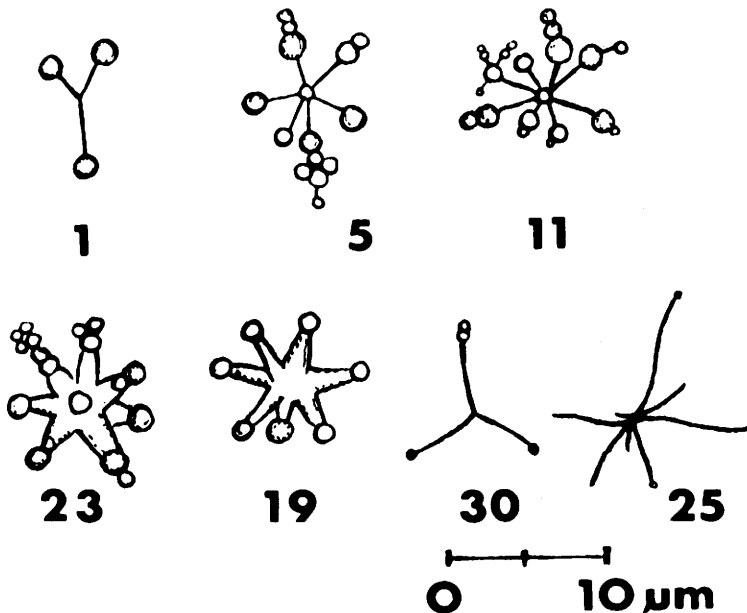


FIG. 1. Morphology of *Planctomyces* species as drawn by Hortobágyi (1965), 114. Numbers 1, 5, and 11: "*Planctomyces bekefii* Gimesi." Numbers 19 and 23: "*Planctomyces crassus* Hort." Numbers 25 and 30: "*Planctomyces gracilis* Hort." Redrawn from the original.

to form a small rosette (Fig. 1; references 25, 30).

(iv) *P. condensatus* Skuja 1964, 16. Cells 0.7 to 1.7 μm wide, globose, colorless, in groups attached to a common, central concretion containing iron compounds. Stalklets very short and thin, gel-like, mostly lacking. Buds terminal. Originally found in a lake in Swedish Lapland at a depth greater than 10m.

Some additional organisms originally placed in *Planctomyces* cannot be retained in this genus because they lack stalks completely (*P. ferrimorula* Wawrik 1956, 296) or because their cells do not appear to be differentiated into the more or less spherical part and the thinner, distinct stalk. The drop-shaped and budding organism described as *P. guttaeformis* (5) will have to be placed in a new genus. An organism named *P. stranskae* Wawrik 1952, 448 shows many similarities with *Siderophacus corneolus* Dorff 1934.

ACKNOWLEDGMENTS

I gratefully acknowledge the generous help of B. Fott (Prague, CSSR), T. Hortobágyi (Budapest, Hungary), G. Saunders (Ann Arbor, Mich.), H. Skuja (Uppsala, Sweden), F. Wawrik (Scheibbs, Austria), and G. A. Zavarzin (Moscow, USSR). The original photomicrographs of budding bacteria used by A. T. Henrici for the description of *Blastocaulis* species were kindly made available by E. McCoy, Madison, Wis.

LITERATURE CITED

1. Fott, B., and I. Komárek. 1960. Das Phytoplankton der Teiche im Teschner Schlesien. *Preslia* 32:113-141.
2. Gimesi, N. 1924. Hydrobiologiai talmányok (Hydrobiologische Studien). I. *Planctomyces Bekefii* Gim. nov. gen. et sp. Budapest, Kiadja a Magyar Ciszterci Rend, p. 1-8.
3. Guseva, K. A. 1956. On two planktonic microorganisms participating in the iron turnover (Russian). *Trudy Biolog. Stanzii "Borok"* 2:24-31.
4. Henrici, A. T., and D. E. Johnson. 1935. Studies of fresh water bacteria. II. Stalked bacteria, a new order of *Schizomycetes*. *J. Bacteriol.* 30:61-93.
5. Hortobágyi, T. 1944. Ein neues Vorkommen des *Planctomyces bekefii*. *Kőferago Gyelnik Budapest Borbasia Nova* 20:1-6.
6. Hortobágyi, T. 1965. Neue *Planctomyces*-Arten. *Botaniki Közlemények* 52:111-119.
7. Huber-Pestalozzi, G. 1938. Das Phytoplankton des Süßwassers. I. Teil. Die Binnengewässer, vol. 16. Stuttgart, Schweizerbarth.
8. International code of nomenclature of bacteria. 1966. *Int. J. Syst. Bacteriol.* 16:459-490.
9. Krasil'nikov, N. A. 1949. Manual of bacteria and actinomycetes. *Izd. Akad. Nauk USSR, Moscow.*
10. Nováček, G. 1938. cit. Fott and Komárek (1960).
11. Razumov, A. S. 1949. *Galionella Kljasmensis* sp.n., a component of the bacterial plankton (Russian). *Mikrobiologiya* 18:442-446.
12. Ruttner, F. 1952. Planktonstudien der Deutschen Limnologischen Sunda-Expedition. *Arch. Hydrobiol. Suppl.* 10.
13. Skuja, H. 1956. Taxonomische und biologische Studien über das Phytoplankton schwedischer Binnengewässer. *Nova Acta Reg. Soc. Sci. Upsaliensis Ser. IV* 16:1-404.
14. Skuja, H. 1964. Grundzüge der Algenflora und Algenvegetation der Fjeldgegenden um Abisko in Schwedisch-Lappland. *Nova Acta Reg. Soc. Sci. Upsaliensis Ser. IV* 18.
15. Teiling, E. 1942. Schwedische Planktonalgen. *Botan. Notiser.*
16. Utermoehl, H. 1925. Limnologische Phytoplanktonstudien. *Arch. Hydrobiol. Suppl.* 5:1-527.
17. Wawrik, F. 1952. *Planctomyces-Studien*. *Sydowia Ann. Mycol. Ser. II* 6:443-452.
18. Wawrik, F. 1956. Neue Planktonorganismen aus den Waldviertler Fischteichen. I. *Oesterr. Bot. Z.* 103:291-199.
19. Zavarzin, G. A. 1961. Budding bacteria. Survey (Russian). *Transl. Microbiol.* 30:774-791.