Planctomyces stranskae (ex Wawrik 1952) sp. nov., nom. rev. and *Planctomyces guttaeformis* (ex Hortobágyi 1965) sp. nov., nom. rev.

MORTIMER P. STARR¹* AND JEAN M. SCHMIDT²

Department of Bacteriology, University of California, Davis, California 95616,¹ and Department of Botany and Microbiology, Arizona State University, Tempe, Arizona 85287²

Two related but recognizably different forms belonging to morphotype V of the *Blastocaulis-Planctomyces* group of budding bacteria were observed during the summer of 1983 in two eutrophic man-made ponds in Tempe, Ariz. Each of these forms can be assigned to previously described species of the genus *Planctomyces*; because these forms were not included in the 1980 *Approved Lists of Bacterial Names* (Skerman et al., ed., Int. J. Syst. Bacteriol. 30:225–420), they need to be formally revived. One of these forms (morphotype Vb) is assigned to *Planctomyces stranskae* (ex Wawrik 1952) sp. nov., nom. rev.; the other form (morphotype Va) is assigned to *Planctomyces guttaeformis* (ex Hortobágyi 1965) sp. nov., nom. rev. Neither species has been cultivated axenically; hence, both are based on type descriptive material.

In 1924, Gimesi (4) established the genus *Planctomyces* to accommodate the peculiar aquatic “fungus” (*Planctomyces bekefii*) he had observed in a pond (Lake Lágymányos) near the Technical University in Budapest, Hungary. Later, additional species were assigned to this “fungal” genus (11, 24). “*Blastocaulis sphaerica*” was independently established in 1935 by Henrici and Johnson (6) for unusual (budding and appendaged) bacteria, which later were found (9) to be identical to *P. bekefii*. Thus, *Blastocaulis* (a bacterial genus) is an exact later synonym of *Planctomyces* (for some 50 years believed to be a fungal genus). Some members of the genus *Planctomyces* have been cultivated axenically (1, 15, 20, 22), although many of them, including *P. bekefii* (the type species of the genus), have never been brought into pure culture. This rather heterogeneous assemblage of budding and nonprosthecately appendaged bacteria is called by us (17, 20) and others (1) the *Blastocaulis-Planctomyces* group; we have divided the group into taxonomically noncommittal morphotypes (17, 20).

Both bacteria under consideration here, “*Planctomyces stranskae*” Wawrik 1952 (24) and “*Planctomyces guttaeformis*” Hortobágyi 1965 (11), were originally described as fungi. Neither has been cultivated axenically. Neither was included in the 1980 *Approved Lists of Bacterial Names* (21). Confusion exists about the relationships of these two organisms to each other. At one extreme, “*P. guttaeformis*” is considered to be a later synonym of “*P. stranskae*” (F. Wawrik, personal communication). Others suggest that “*P. stranskae*” is (i) within the limits of variability of *P. bekefii* (3, 12), (ii) unlike *P. bekefii* (24), (iii) probably identical to “*P. guttaeformis*” but with the latter epithet (a junior synonym) retained (5, 8), or (iv) a member of the bacterial genus *Gallionella* (10).

The fortuitous occurrence, during the summer of 1983, of these two organisms side-by-side in two Arizona ponds we regularly study (15, 17, 19) provided an opportunity for us to clarify some of the pertinent taxonomic issues. On the basis of an examination of this Arizona material, samples collected in Austria and Hungary (18), and chemically preserved type material from a Hungarian repository, we believe that

“*P. stranskae*” and “*P. guttaeformis*” are related but recognizably different organisms and that both are budding bacteria rather than fungi.

MATERIALS AND METHODS

Sources of water samples. Water samples containing the budding bacteria described in this report were collected in June and July 1983 from the top 15 cm of water at the edge of a eutrophic, shallow man-made pond in The Lakes, a residential development in Tempe, Ariz. Observations similar to those reported here were made (but are not presented here) on samples from another eutrophic, shallow man-made pond (in Kiwanis Park, Tempe, Ariz.). Both ponds are fed via reservoirs and canals with water from the Salt River Project. Some of the illustrative material for morphotype Va is based on laboratory enrichments prepared from water samples collected in August 1981 from a pond located in the Buda section of Budapest, Hungary, just north of the railroad bridge spanning the Danube River and southwest of the Technical University; this pond is the last remnant of the type locality of the genus *Planctomyces* (16, 19).

“*Planctomyces guttaeformis*” type material. Type material of “*P. guttaeformis*” Hortobágyi 1965 (11), in the form of pond water microflora preserved in Formalin (as is customary with “mycological” specimens), collected in 1964 by T. Hortobágyi at Buzák, Hungary, was obtained from L. J. Hajdu, Curator of the Algal Herbarium, Museum of Natural History, Budapest, Hungary.

Microscopic methods. Samples were prepared for phase-contrast light microscopy and for negative-contrast transmission electron microscopy by previously described methods (15, 17, 20). Stained preparations (13), examined by light microscopy, were sometimes used to emphasize spikes, bristles, and other features.

For preparation of thin sections for transmission electron microscopy, 500-ml samples of pond water containing ca. 2×10^4 rosettes of the relevant bacteria per ml were concentrated by centrifugation ($8,000 \times g$; 15 min; refrigerated centrifuge). The pellets (containing rosettes of the budding bacteria together with many algae, cyanobacteria, and other bacteria) were fixed by the procedure of Burdett and Murray (2) with 5.0% acrolein (Eastman Kodak Co., Rochester, N.Y.) plus 0.25% glutaraldehyde (prepared from ampoules

* Corresponding author.

of 8.0% glutaraldehyde stock solution obtained from Ted Pella, Inc., Tustin, Calif.). A 5-min pre-fixation in a 1:10 dilution of this fixative was followed by a 3-h treatment in the full-strength fixative buffered at pH 7.4 with 0.05 M sodium cacodylate. A 1-h secondary fixation with 1.0% osmic acid (also buffered at pH 7.4 with 0.05 M sodium cacodylate) followed. The fixed material was enrobed in agar (2.0% Special Agar; Difco Laboratories, Detroit, Mich.), dehydrated in an ethanol series followed by propylene oxide, and embedded in Maraglass (Ted Pella, Inc.). After polymerization, thin sections were cut with a diamond knife (Bio-medical Division, Du Pont Co., Wilmington, Del.). Electron-microscopic observations were made with a Philips model EM-300 instrument operated at 80 kV.

RESULTS AND DISCUSSION

More than one form of morphotype V. The various budding and nonprosthecately appendaged bacteria have been sorted into morphotypes of the *Blastocaulis-Planctomyces* group (17, 20). In our initial categorization (18), morphotype V was represented only by those bacteria assigned to "*Planctomyces guttaeformis*" Hortobágyi 1965, that is, the bulbiform, budding bacteria that bear spikes and form rosettes (see figures). Up to now, the existence of two similar, yet distinguishable, bulbiform, budding bacteria has not generally been realized. The aforementioned form, with a prominent spike at its globose end, is widely distributed and quite well known (5, 7, 8, 11, 18). The other form, which lacks a spike, was probably sighted by us earlier (see, for example, Fig. 1B and C of reference 18) but not recognized as a separate entity until its fortuitous occurrence during the summer of 1983, while we were seeking "*Planctomyces gracilis*" (23). Two distinguishable populations of bulbiform, budding bacteria were then seen repeatedly in both Arizona ponds.

Both forms are shown in the same microscopic fields in Fig. 1A, a transmission electron micrograph, and in Fig. 1B, a stained (13) preparation examined by light microscopy. One form (morphotype Va) possesses an apical spike and thin pili on the globose hemisphere. The other form (morphotype Vb) lacks the spike, but its globose hemisphere is covered by numerous rigid, multifibrillar, and tapered appendages, thicker and more substantial than pili; we call them bristles. In stained preparations, the bristles of morphotype Vb appear as a halo not more than 1 to 2 μm in length or diameter, whereas the individual spikes of morphotype Va are thicker and 5 to 10 μm long. Each rosette is homogeneous with regard to the appendages on the cells that make up the rosette; i.e., either every cell of a given rosette has a spike or every cell of a given rosette lacks a spike but has a beard of bristles at its globose end. An examination of over 100 rosettes revealed none with a mixture of morphotype Va and Vb cells, although both forms were abundant in the samples. Assuming rosettes are formed by attachments of individual cells by their holdfasts, this homogeneity speaks for some kind of uniqueness recognized by the

FIG. 1. Demonstrations in the same fields of the two different kinds of bulbiform, rosette-forming, budding bacteria in material from the pond in The Lakes, Tempe, Ariz. Pg, *Planctomyces guttaeformis* (ex Hortobágyi 1965) sp. nov., nom. rev.; Ps, *Planctomyces stranskae* (ex Wawrik 1952) sp. nov., nom. rev. (A) Negative-contrast transmission electron micrograph (1.0% uranyl acetate stain). sp, Spike; br, bristles. $\times 8,000$. (B) Light micrograph of a stained (13) preparation showing a *P. guttaeformis* rosette, with a long spike (sp) on each of several cells, and a *P. stranskae* rosette, with no spikes at all but with a prominent halo caused by staining of the bristles (br). $\times 4,400$.

FIG. 2. Reproductions of archival line drawings of *Planctomyces guttaeformis* (ex Hortobágyi 1965) sp. nov., nom. rev. and *Planctomyces stranskae* (ex Wawrik 1952) sp. nov., nom. rev. (A) After Wawrik's 1952 drawings (24); part of the type descriptive material of *P. stranskae*. (B) After Heynig's 1961 drawings (7) of *P. stranskae*. (C) After Hortobágyi's 1965 drawings (11) of *P. guttaeformis*; part of the type descriptive material of *P. guttaeformis*, although no spikes are depicted (see text). (D) After Hortobágyi's 1968 drawings (12) of *P. guttaeformis*. (E) Selected from Heynig's 1979 drawings (8), all labeled as *P. guttaeformis*, although both spiked and spikeless forms are shown.

bacteria, even if bacterial taxonomists have been slow to recognize the distinction!

Archival illustrations and preserved type material. Much confusion between the two forms (morphotypes Va and Vb) is evident in the literature (5, 7, 8, 11, 12), especially with respect to the spikes. Relevant archival illustrations are reproduced in Fig. 2. Wawrik's drawings (Fig. 2A) accompanied her original description of "*P. stranskae*" (24). Other drawings of both forms (Fig. 2B–E) by Heynig (7, 8) and Hortobágyi (11, 12) showed either no spikes or mixtures of spiked and spikeless cells. The only bulbiform, rosette-forming, budding bacterium seen by phase-contrast microscopy in Hortobágyi's preserved type material of "*P. guttaeformis*" (Fig. 3) was the spiked form.

Hortobágyi's description of "*P. guttaeformis*" and clarification of its cellular shape. Hortobágyi (11) described "*P. guttaeformis*" as a new species of truly planktonic fungi

("euplanktonische Pilze"), in the following terms, as translated by us (18) from his Latin diagnosis (the mycological terminology is retained): three to seven drop-shaped [guttiform], spore-bearing arms [i.e., conidiophores]; one pole [of each arm] is gradually tapered to a point, [several] points [of the three to seven arms] come together at the center of the thallus; the other pole [of each arm] is broadly rounded; the arms bear spores, also drop shaped and contacting the arms by their rounded poles; mature cells are 2.8 to 3.7 μm long, 1 to 1.6 μm wide, and straight or slightly bent. Hortobágyi's sketches (11, 12), reproduced here as Fig. 2C, were based on conventional light microscopy; they depict a drop-shaped (i.e., guttiform) organism arranged in rosettes.

Whether Hortobágyi's "*P. guttaeformis*" is bulbiform or drop shaped has been discussed (5, 18). On the basis of transmission electron microscopy and phase-contrast microscopy of material from the same Hungarian sources as Hortobágyi's, Hajdu (5) described this bacterium as "pear shaped" (during an interview in Budapest, Hungary, L. J. Hajdu explained that he used the term "pear shaped" for the shape we call "bulbiform"). We (18) and Hajdu (5) agree that Hortobágyi was understandably unable to resolve the junction between the globose and cylindrical portions of the bulbiform cell by conventional light microscopy and, hence, interpreted what he saw as the smoothly tapered transition of a globose end to a pointed end (i.e., drop shaped). This assumption is supported by our phase-contrast (light) micrographs of Hortobágyi's preserved type material of "*P. guttaeformis*" (Fig. 3), which unmistakably show rosettes of bulbiform cells. It is, of course, possible that Hortobágyi actually saw drop-shaped cells in his material in 1964 but that they were no longer visible in the preserved type material when examined 2 decades later. However, until evidence of a drop-shaped organism comes to light, we must believe that Hortobágyi's "*P. guttaeformis*" is bulbiform.

Assignment of Hortobágyi's organism to *Planctomyces guttaeformis* (ex Hortobágyi 1965) sp. nov., nom. rev. Although the foregoing points are historically interesting, they are taxonomically moot because "*P. guttaeformis*" Hortobágyi 1965 was not included in the 1980 *Approved Lists of Bacterial Names* (21). We now formally revive the name of Hortobágyi's organism (our morphotype Va), using the same name, *Planctomyces guttaeformis* (ex Hortobágyi 1965) sp.

FIG. 3. Two phase-contrast (light) micrographs made by us from Hortobágyi's 1964 chemically preserved type material (11) of *Planctomyces guttaeformis* (ex Hortobágyi 1965) sp. nov., nom. rev. Each of the bulbiform bacteria in this material has the spike characteristic of this species. $\times 2,100$.

nov., nom. rev. Rule 28a of the *International Code of Nomenclature of Bacteria* allows revived names to "be used whether or not the new taxon is related in any way to the taxon to which the name was originally applied" (14). However, the "ex" in our designation (see Provisional Rule B3 of the *International Code of Nomenclature of Bacteria* [14]) indicates our belief that we are dealing here with Hortobágyi's organism. *P. guttaeformis* has not been isolated in axenic cultures; it is known only from natural freshwater samples and derivatives held in laboratories. Hence, there are no type cultures, and "a description, a preserved specimen, or an illustration" may serve as the type according to Rule 18a of the *International Code of Nomenclature of Bacteria* (14).

Description of *Planctomyces guttaeformis* (ex Hortobágyi 1965) sp. nov., nom. rev. *Planctomyces guttaeformis* [gutt. ae. form'is. L. gen. noun *gutta(e)* a drop; L. suffix *-formis* in the form or shape of; M.L. adj. *guttaeformis* drop shaped]. Cells are relatively large (2.9 to 3.0 μm in length, 1.15 to 1.3 μm in diameter at the globose end, and 0.6 to 0.7 μm in diameter at the cylindrical end) and bulbiform (i.e., bulb shaped; a cylinder blending into a spherical terminal dilatation; shaped like a common screw-in incandescent light bulb). A prominent multifibrillar appendage, a spike, extends from the globose (spherical) end of the cell. The spike is not a stalk, as it lacks the function of connecting the cell to other cells or to a substrate via a terminal holdfast. Division is by budding, with a mirror-image bud formed at the globose end of the cell. The bud is often slightly off-center with respect to the longitudinal axis of the mother cell, whereas the spike is usually exactly polar. Numerous crateriform surface structures and fine pili are present on the globose end of the cell. The fine structure is that of a typical bacterium, except for the rather thin cell envelope, the crateriform surface structures, and the spike and its basal attachment site. Resistant to beta-lactam antibiotics. Occur in rosettes, consisting of as many as 12 cells attached via holdfasts at the narrower ends of the several cells. Neither motility nor flagella have been observed. Common in eutrophic freshwater habitats, usually accompanying phototrophs (algae and cyanobacteria). Has not been cultivated axenically, although blooms occur in laboratory enrichments. The type material consists of the present description and illustrations (Pg in Fig. 1; Fig. 3 made from Hortobágyi's preserved type material; and Fig. 4; see also Fig. 2 of reference 18 and Fig. 2 of reference 20). The type locality is a eutrophic man-made pond in a residential district (The Lakes) in Tempe, Ariz. Frequently confused with *Planctomyces stranskae* (ex Wawrik 1952) sp. nov., nom. rev., from which it can be distinguished on the basis of cellular size and shape, the presence of a multifibrillar spike in *P. guttaeformis* and its absence in *P. stranskae*, and the absence of numerous multifibrillar bristles in *P. guttaeformis* and their presence in *P. stranskae*.

Wawrik's description of "*P. stranskae*". In 1952, Wawrik (24) described "*P. stranskae*" as a new fungal species. Her German text and Latin diagnosis, translated and paraphrased here rather freely (and with the mycological terminology retained), distinguished the new species from *P. bekefii* (which accompanied it in the pond water) on the basis of the gradually tapering (i.e., club-shaped) conidiophores [of "*P. stranskae*"]. The daughter spores were reported to arise from the most strongly refractile end of the conidiophore, in a shallow concavity thereof. The diameter of the thallus was given as 8.8 to 12 μm , the diameter of the daughter spore was given as 1.5 μm ; and the diameter of the

conidiophore was given as 1.0 μm . Iron encrustation was observed. Her description of "*P. stranskae*" included sketches, which are reproduced here as Fig. 2A.

Assignment of Wawrik's organism to *Planctomyces stranskae* (ex Wawrik 1952) sp. nov., nom. rev. We believe that the spikeless organism from our Arizona samples (morphotype Vb) is the same as the one described in 1952 as "*P. stranskae*" by Wawrik (24). Transmission electron micrographs of negatively stained preparations (Fig. 1A, 5A–C, and 6A) and of a thin section (Fig. 5D) of morphotype Vb, as well as light micrographs (Fig. 1B and 6B), are presented (for a comparison with morphotype Va, see Fig. 1 through 4). Invoking Rule 28a and Provisional Rule B3 of the *International Code of Nomenclature of Bacteria* (14), we now apply to morphotype Vb the name *Planctomyces stranskae* (ex Wawrik 1952) sp. nov., nom. rev. No type cultures are available because *P. stranskae* has not been cultured axenically; hence, type descriptive material must suffice.

Description of *Planctomyces stranskae* (ex Wawrik 1952) sp. nov., nom. rev. *Planctomyces stranskae* (stran'skae. M.L. adj. *stranskae* of Stransky; named originally by F. Wawrik [24] in honor of her biology teacher, M. L. Stransky) cells are relatively large (3.0 to 3.5 μm in length, 1.5 to 1.7 μm in diameter at the globose end, ca. 1.3 to 1.4 μm in initial diameter at the conical end, and 1.0 to 1.1 μm in diameter at the terminus of the cell) and bulbiform (i.e., bulb shaped; a truncated cone blending into a spherical terminal dilatation; shaped like a common screw-in incandescent light bulb). Numerous multifibrillar appendages, termed bristles, extend from the globose (spherical) end of the cell. Numerous bacteria are associated with the bristles, especially in preparations made directly from natural samples. Division is by budding, with a mirror-image bud formed at the globose end of the cell. Numerous crateriform surface structures are present on the globose end of the cell; the presence of pili is uncertain. The fine structure is typically bacterial, except for the rather thin cell envelope, the crateriform surface structures, and the many multifibrillar bristles. Resistant to beta-lactam antibiotics. Occur in rosettes, consisting of as many as 12 cells attached via holdfasts at the narrower ends of the several cells. Neither motility nor flagella have been observed. Common in eutrophic freshwater habitats, usually accompanying phototrophs (algae and cyanobacteria). Metallic oxide encrustations of the cells have been observed in material from Austria (24) and from San Carlos Reservoir in Ariz. (unpublished observations). Has not been cultivated axenically, although blooms occur in laboratory enrichments. The type material consists of the present description and illustrations (Ps in Fig. 1; Fig. 5; and Fig. 6). The type locality is a eutrophic man-made pond in a residential district (The Lakes) in Tempe, Ariz. Frequently confused with *Planctomyces guttaeformis* (ex Hortobágyi 1965) sp. nov., nom. rev., from which it can be distinguished on the basis of cellular size and shape, the absence of a multifibrillar spike in *P. stranskae* and its presence in *P. guttaeformis*, and the presence of numerous multifibrillar bristles in *P. stranskae* and their absence in *P. guttaeformis*.

Distinctions between *P. stranskae* and *P. guttaeformis*. F. Wawrik (personal communication) has maintained quite firmly that the two organisms are identical and, hence, that *P. guttaeformis* (first described in 1965) is a later synonym of *P. stranskae* (first described in 1952). Before our recognition of morphotype Vb in the Arizona material, we would have accepted her opinion. However, these two budding bacteria are discernibly different in the following respects. (i) *P. guttaeformis* (morphotype Va) invariably has a prominent

FIG. 4. Morphology and fine structure of morphotype Va, *Planctomyces guttaeformis* (ex Hortobágyi 1965) sp. nov., nom. rev. (A) Five-membered rosette in material from a pond near the Budapest railroad bridge, with one cell bearing a smaller, mirror-image daughter cell, a bud (Bu). Each of the five mature cells bears a prominent multifibrillar spike (sp) extending outward from the globose end of the cell. Negative contrast; 1.0% uranyl acetate stain. $\times 8,580$. (B) Budding cell of morphotype Va in material from a pond near the Budapest railroad bridge, showing the crateriform surface structures (arrowheads) and fine pili (p) on the globose end of the cell. The bud (Bu) is slightly off-center with respect to the longitudinal axis of the parent cell, whereas the spike is centrally located. Negative contrast; 1.0% uranyl acetate stain. $\times 26,000$. (C) Thin section of a morphotype Va cell in material from the pond in The Lakes, Tempe, Ariz., showing typical bacterial organization, the thin cell envelope, and the basal attachment site (arrowhead) of the spike protruding from the globose end of the cell (cf. with Fig. 5D). The fixation method used was that described by Burdett and Murray (2). $\times 48,600$.

FIG. 5. Morphology and fine structure of morphotype Vb, *Planctomyces stranskae* (ex Wawrik 1952) sp. nov., nom. rev., in material from the pond in The Lakes, Tempe, Ariz. (A) Mature cell, showing a young bud (Bu) and numerous multifibrillar bristles (br). Negative contrast; 1.0% uranyl acetate stain. $\times 27,000$. (B) Budding cell of morphotype Vb with mirror-image bud (Bu) at a later stage of development than in (A); note the prominent bristles (br). Negative contrast; 1.0% uranyl acetate stain. $\times 19,375$. (C) Six-membered rosette of morphotype Vb. No cell has a spike, but all have prominent bristles (br). Negative contrast; 1.0% uranyl acetate stain. $\times 11,480$. (D) Thin section of a morphotype Vb cell showing its bacterial ultrastructure; no spike can be seen (cf. with Fig. 4C). The fixation method used was that described by Burdett and Murray (2). $\times 51,300$.

FIG. 6. Some details of morphotype Vb, *Planctomyces stranskae* (ex Wawrik 1952) sp. nov., nom. rev., in material from the pond in The Lakes, Tempe, Ariz. (A) Numerous multifibrillar bristles (br) extend from the globose end of the cell. Multiple crateriform surface structures (arrowheads) are discernible over the globose end of the cell. Negative contrast; 1.0% uranyl acetate stain. $\times 68,000$. (B) Phase-contrast (light) micrograph of a rosette, showing the association of numerous bacteria with the bristles of *P. stranskae*; such associations are particularly evident in preparations made directly from natural samples.

multifibrillar spike at the globose (spherical) end of the cell; *P. stranskae* (morphotype Vb) does not have a spike but does have a large number of bristles covering much of the globose end. (ii) The cellular shape of *P. stranskae* is a sphere merging gradually into a truncated cone; in contrast, the cellular shape of *P. guttaeformis* usually is a sphere merging into a cylinder fairly uniform in diameter. (iii) In natural material, *P. stranskae* cells are larger than *P. guttaeformis* cells. Cell size is dependent upon nutrient conditions and the age of samples or enrichments, but the dimensions

given above are typical for organisms observed in natural samples. (iv) *P. guttaeformis* has prominent pili; in *P. stranskae*, the presence of pili is suspected (although the situation is confused by the plethora of bristles and fibrils shed from them); in any case, piliation of *P. stranskae* is not the prominent feature it is in *P. guttaeformis*.

ACKNOWLEDGMENTS

This work was supported by Public Health Service grant AI-08426 from the National Institutes of Health and grant DEB-78-23281 from the National Science Foundation.

We thank L. J. Hajdu for providing a sample of the preserved type material of "*P. guttaeformis*" and for much useful advice. We appreciate very much having had opportunities for extended discussions with F. Wawrik.

LITERATURE CITED

1. Bauld, J., and J. T. Staley. 1976. *Planctomyces maris* sp. nov.: a marine isolate of the *Planctomyces*/*Blastocaulis* group of budding bacteria. J. Gen. Microbiol. 97:45-55.
2. Burdett, I. D. J., and R. G. E. Murray. 1974. Septum formation in *Escherichia coli*: characterization of septal structure and the effects of antibiotics on cell division. J. Bacteriol. 119:303-324.
3. Fott, B., and J. Komárek. 1960. Das Phytoplankton der Teiche im Teschner Schlesien. Preslia (Prague) 32:113-141.
4. Gimesi, N. 1924. Hydrobiologiai Tanulmányok [Hydrobiologische Studien]. I. *Planctomyces Békefi* Gim. nov. gen. et sp. [Ein neues Glied des Phytoplanktons.], p. 1-8. Kiadja a Magyar Ciszterci Rend, Budapest. (In Hungarian, with partial German translation.)
5. Hajdu, L. 1974. Observations on the bacterium species *Planctomyces guttaeformis* Hortob. (Caulobacteriales) [sic]. Arch. Hydrobiol. 74:172-185.
6. Henrici, A. T., and D. E. Johnson. 1935. Studies of freshwater bacteria. II. Stalked bacteria, a new order of Schizomycetes. J. Bacteriol. 30:61-93.
7. Heynig, H. 1961. Zur Kenntnis des Planktons mitteleuropäischer Gewässer. Arch. Protistenkd. 105:407-416.
8. Heynig, H. 1979. Einige Bemerkungen und Beobachtungen zur Gattung *Planctomyces* Gimesi, 1924 (Caulobacteriales) [sic]. Arch. Protistenkd. 122:275-281.
9. Hirsch, P. 1972. Two identical genera of budding and stalked bacteria: *Planctomyces* Gimesi 1924 and *Blastocaulis* Henrici and Johnson 1935. Int. J. Syst. Bacteriol. 22:107-111.
10. Hirsch, P., and H. Skuja. 1974. Genus *Planctomyces* Gimesi 1924, 4, p. 162-163. In R. E. Buchanan and N. E. Gibbons (ed.), *Bergey's manual of determinative bacteriology*, 8th ed. The Williams & Wilkins Co., Baltimore.
11. Hortobágyi, T. 1965. Új *Planctomyces* fajok. [Neue *Planctomyces*-Arten.] Bot. Közl. 52:111-115. (In Hungarian, with German resume.)
12. Hortobágyi, T. 1968. *Planctomyces* from Vietnam. Acta Phytopathol. Acad. Sci. Hung. 3:271-273.
13. Kodata, H., A. Y. Armfield, G. L. Lombard, and V. R. Dowell, Jr. 1982. Practical procedure for demonstrating bacterial flagella. J. Clin. Microbiol. 16:948-952.
14. Lapage, S. P., P. H. A. Sneath, E. F. Lessel, V. B. D. Skerman, H. P. R. Seeliger, and W. A. Clark (ed.). 1975. International code of nomenclature of bacteria. 1975 Revision. Published for the International Association of Microbiological Societies by the American Society for Microbiology, Washington, D.C.
15. Schmidt, J. M. 1978. Isolation and ultrastructure of freshwater strains of *Planctomyces*. Curr. Microbiol. 1:65-71.
16. Schmidt, J. M., W. P. Sharp, and M. P. Starr. 1982. Metallic-oxide encrustations of the nonprosthecae stalks of naturally occurring populations of *Planctomyces bekefi*. Curr. Microbiol. 7:389-394.
17. Schmidt, J. M., and M. P. Starr. 1978. Morphological diversity of freshwater bacteria belonging to the *Blastocaulis*-*Planctomyces* group as observed in natural populations and enrichments. Curr. Microbiol. 1:325-330.
18. Schmidt, J. M., and M. P. Starr. 1979. Morphotype V of the

- Blastocaulis-Planctomyces* group of budding and appendaged bacteria: *Planctomyces guttaeformis* Hortobágyi (*sensu* Hajdu). *Curr. Microbiol.* **2**:195–200.
19. Schmidt, J. M., and M. P. Starr. 1980. Current sightings, at the respective type localities and elsewhere, of *Planctomyces bekefii* Gimesi 1924 and *Blastocaulis sphaerica* Henrici and Johnson 1935. *Curr. Microbiol.* **4**:183–188.
 20. Schmidt, J. M., and M. P. Starr. 1981. The *Blastocaulis-Planctomyces* group of budding and appendaged bacteria, p. 496–504. In M. P. Starr, H. Stolp, H. G. Trüper, A. Balows, and H. G. Schlegel (ed.), *The prokaryotes. A handbook on habitats, isolation, and identification of bacteria*. Springer-Verlag, Berlin.
 21. Skerman, V. B. D., V. McGowan, and P. H. A. Sneath (ed.). 1980. Approved lists of bacterial names. *Int. J. Syst. Bacteriol.* **30**:225–420.
 22. Starr, M. P., R. M. Sayre, and J. M. Schmidt. 1983. Assignment of ATCC 27377 to *Planctomyces staley* sp. nov. and conservation of *Pasteuria ramosa* Metchnikoff 1888 on the basis of type descriptive material. Request for an opinion. *Int. J. Syst. Bacteriol.* **33**:666–671.
 23. Starr, M. P., K. A. Short, and J. M. Schmidt. 1984. Exclusion of the filamentous and rosette-forming bacterium “*Planctomyces gracilis*” Hortobágyi 1965 from the *Blastocaulis-Planctomyces* group. *Int. J. Syst. Bacteriol.* **34**:465–469.
 24. Wawrik, F. 1952. *Planctomyces*—Studien. *Sydowia Ann. Mycol.* **6**:443–452.