International Journal of Systematic and Evolutionary Microbiology (2013), **63**, 4354–4360 **DOI** 10.1099/ijs.0.056440-0

Designation of type strains for seven species of the order *Myxococcales* and proposal for neotype strains of *Cystobacter ferrugineus*, *Cystobacter minus* and *Polyangium fumosum*

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Ten species of the order *Myxococcales* with validly published names are devoid of living type strains. Four species of the genus *Chondromyces* are represented by dead herbarium samples as the type material. For a species of the genus *Melittangium* and two species of the genus *Polyangium*, no physical type material was assigned at the time of validation of the names or later on. In accordance with rule 18f of the International Code of Nomenclature of Bacteria the following type strains are designated for these species: strain Cm a14^T (=DSM 14605^T=JCM 12615^T) as the type strain of *Chondromyces apiculatus*, strain Cm c5^T (=DSM 14714^T=JCM 12616^T) as the type strain of *Chondromyces crocatus*, strain Sy t2^T (=DSM 14631^T=JCM 12617^T) as the type strain of *Chondromyces lanuginosus*, strain Cm p51^T (=DSM 14607^T=JCM 12618^T) as the type strain of *Chondromyces pediculatus*, strain Me b8^T (=DSM 14713^T=JCM 12633^T) as the type strain of *Melittangium boletus*, strain Pl s12^T (=DSM 14670^T=JCM 12637^T) as the type strain of *Polyangium sorediatum* and strain Pl sm5^T (=DSM 14734^T=JCM 12638^T) as the type strain of *Polyangium spumosum*. Furthermore, the type strains given for three species of the genera *Cystobacter* and *Polyangium* had been kept at one university institute and have been lost according to our investigations. In accordance with Rule 18c of the Bacteriological Code, we propose the following neotype strains: strain Cb fe18 (=DSM 14716 =JCM 12624) as the neotype strain of *Cystobacter ferrugineus*, strain Cb m2 (=DSM 14751=JCM 12627) as the neotype strain of *Cystobacter minus* and strain Pl fu5 (=DSM 14668=JCM 12636) as the neotype strain of *Polyangium fumosum*. The proposals of the strains are based on the descriptions and strain proposals given in the respective chapters of *Bergey's Manual of Systematic Bacteriology* (2005).

An exceptionally high number of myxobacterial species descriptions is not supported by the availability of formally acknowledged living type strain material. Because of this lack of material, the species could not be included, for example, in species-representing 16S rRNA gene sequence databases. These are the most frequently used guides in taxonomy currently, and for that reason, great efforts are taken to fill the sequencing gaps (Yarza *et al.*, 2013). The International Code of Nomenclature of Bacteria (Lapage *et al.*, 1992) allows for the designation of type strains in cases where descriptions or dead specimens represent the type given for species with validly published species names. The code also allows for the proposal of neotype strains if a specimen of the strain on which the original description was based cannot be found. These measures have been installed in order to clear the way for inclusion of such species in future examinations, in particular in studies including 'new' methods which had not been applied at the time of the species description. In this communication, we formally designate type strains for seven and formally propose neotype strains for three species of the order *Myxococcales*.

The present wording of Rule 18f of the International Code is: 'If a description or illustration constitutes, or a dead preserved specimen has been designated as the type of a species [Rule 18a(1)] and a later strain of this species is cultivated, then the type strain may be designated by the

†Retired.

Two supplementary tables are available with the online version of this paper.

Table 1. Myxobacterial species for which a cultivable type strain or neotype strain is formally proposed and the 16S rRNA sequences of the proposed neotype strains. AL, type strain as given in Approved Lists (Skerman *et al.*, 1980). VL, types as given in Validation List No 31 (Brockman, 1989b, c)

Species name and authors of the species description	Type strain in Approved Lists	Designated type strain	DSM number of the type strain	JCM number of the type strain	Figure No.	Accession number of the 16S rRNA gene sequence	Reference
Chondromyces apiculatus Thaxter 1897	TC 4481^T AL	Cm a14^T	DSM 14605^T	JCM 12615^T	1	AJ233938	Reichenbach (2005a)
Chondromyces crocatus Berkeley and Curtis 1874; type species of the genus	TC 601^T AL	Cm c5^T	DSM 14714^T	JCM 12616^T	2	GU207874	Reichenbach (2005a)
Chondromyces lanuginosus Kofler 1913	TC 4494^T AL	Sy t2^T	DSM 14631^T	JCM 12617^T	3	AJ233939	Reichenbach (2005a)
Chondromyces pediculatus Thaxter 1904	TC 4524^T AL	Cm p51^T	DSM 14607^T	JCM 12618^T	4	GU207875	Reichenbach (2005a)
Melittangium boletus Jahn 1924; type species of the genus	'Not cultivated' AL	Me b8^T	DSM 14713^T	JCM 12633^T	5	AJ233908	Reichenbach (2005c)
Polyangium sorediatum (*ex* Thaxter 1904) Brockman 1989	Description in Brockman VL	Pl s12^T	DSM 14670^T	JCM 12637^T	6	GU207880	Reichenbach (2005d)
Polyangium spumosum (*ex* Krzemieniewska and Krzemieniewski 1927) Brockman 1989	Description in Brockman VL	Pl sm5^T	DSM 14734^T	JCM 12638^T	7	GU207881	Reichenbach (2005d)
		Proposed neotype strain	**DSM number of the neotype strain**	**JCM number of the neotype strain**			
Cystobacter ferrugineus (Krzemieniewska and Krzemieniewski 1927) McCurdy 1970	Windsor M-203^T AL	Cb fe18	DSM 14716	JCM 12624	8	NR_025343; AJ233901; DQ768112	Reichenbach (2005b)
Cystobacter minus (Krzemieniewska and Krzemieniewski 1926) McCurdy 1970	Windsor M-307^T AL	Cb m2	DSM 14751	JCM 12627	9	AJ233903; DQ768113	Reichenbach (2005b)
Polyangium fumosum Krzemieniewska and Krzemieniewski 1930	Windsor M-257^T AL	Pl fu5	DSM 14668	JCM 12636	10	GU207879	Reichenbach (2005d)

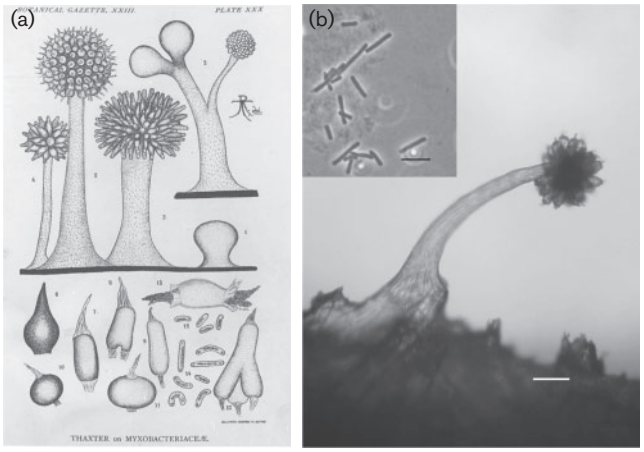

Fig. 1. *Chondromyces apiculatus*. (a) Drawing from Thaxter (1897), plate XXX on pages 405–406. (b) Fruiting body (bar, 100 μm) and vegetative cells (insert; bar, 10 μm) of Cm a14^T.

person who isolated the strain or by a subsequent author. This type strain shall then replace the description, illustration or preserved specimen as the nomenclatural type. The designation of a type strain in this manner must be published in the IJSB/IJSEM, the authorship and date of priority of publication being determined by the effective and valid publication of the name by the original authors (Rule 24b)'.

The presently designated type strains of the species *Chondromyces apiculatus* (Thaxter, 1897), *Chondromyces crocatus* (Berkeley & Curtis, 1874), *Chondromyces lanuginosus* (Kofler, 1913) and *Chondromyces pediculatus* (Thaxter, 1904) are dead herbarium specimens in the Thaxter collection (TC), housed in the Farlow Herbarium, Harvard University, Cambridge, USA (Table 1). Howard McCurdy studied myxobacteria at the University of Windsor, Ontario, Canada during the period around 1960–1970. He assigned specific samples of the Thaxter collection as the types of these species (McCurdy, 1971). The species names were included in the Approved Lists

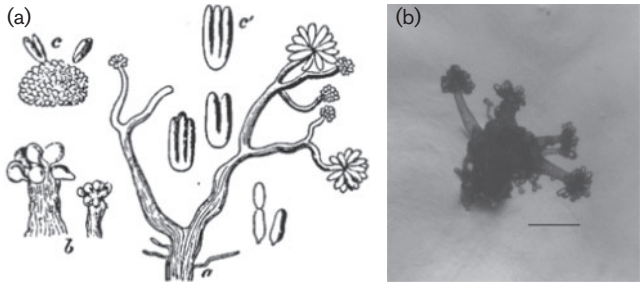

Fig. 2. *Chondromyces crocatus*. (a) Drawing from Berkeley (1857), page 313. (b) Fruiting bodies of Cm c5^T. Bar, 500 μm.

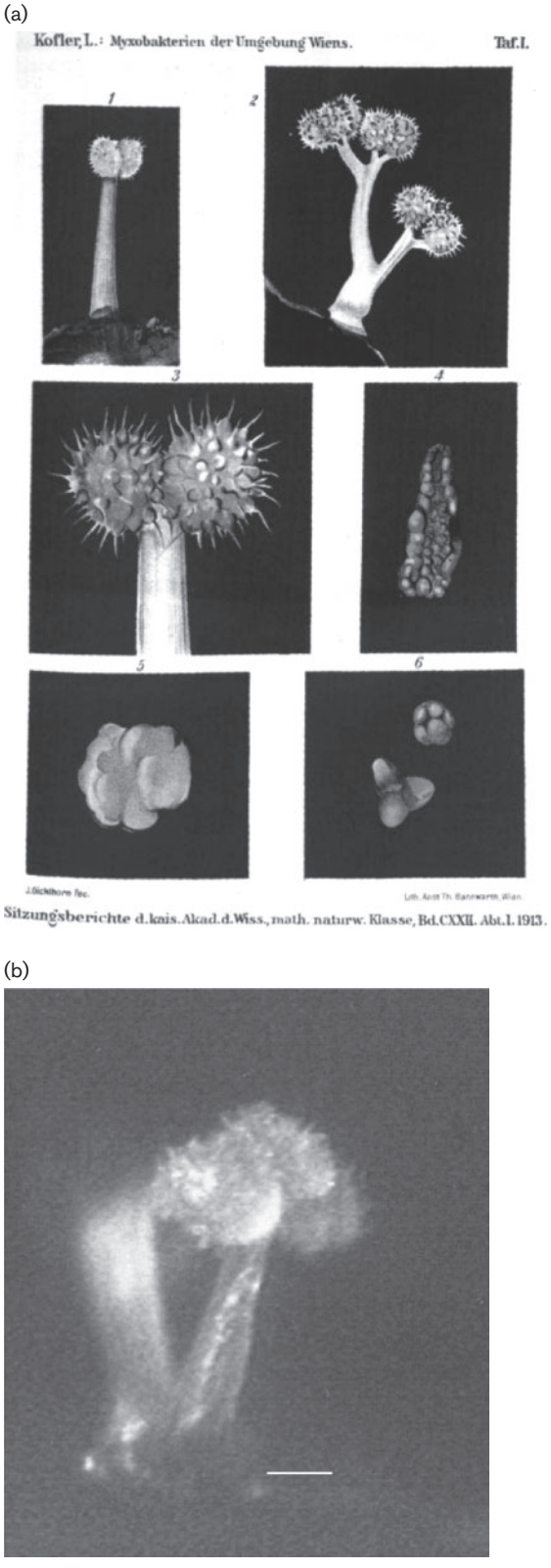

Fig. 3. *Chondromyces lanuginosus*. (a) Figures from Kofler (1913), Figs 1–3 on page 877 depict *Chondromyces lanuginosus*. Courtesy Österreichische Akademie der Wissenschaften. (b) Fruiting body of Sy t2^T. Bar, 100 μm.

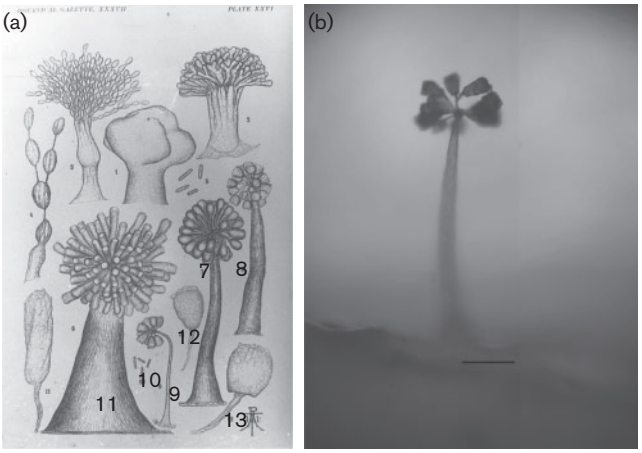

Fig. 4. *Chondromyces pediculatus*. (a) Drawing from Thaxter (1904), plate XXVI on page 411; nos 7–13 depict *Chondromyces pediculatus*. (b) Fruiting body of Cm p51^T. Bar 100 μm.

(Skerman *et al.*, 1980). According to a curator of the herbarium, the specimen for *Chondromyces lanuginosus* seems to be lost whereas the other three specimens are still there, dried on the original substrates, accompanied by some slides.

For the species *Melittangium boletus* (Jahn, 1924), *Polyangium sorediatum* (Brockman, 1989a) and *Polyangium spumosum* (Brockman, 1989a) no physical type strains were assigned in the Approved Lists (Skerman *et al.*, 1980) or in Validation List No. 31 (Brockman, 1989b,c), respectively. Instead, the descriptions of Brockman (1989a) or simply the statement 'not cultivated' are given.

Bergey's Manual of Systematic Bacteriology, second edition, includes comprehensive chapters about the members of the order *Myxococcales*. Reichenbach (2005a, b, c, d, e) are the chapters relevant to the taxa mentioned in this paper. These chapters are based on the experience and knowledge accumulated during 40 years of intense investigations on myxobacteria and were written after more than 3000 myxobacterial strains had been isolated. Based on the original species descriptions, appropriate strains were selected and described as the type strains of the respective species (Table 1). However, it has not been formally proposed in the IJSEM until now to accept these strains as the type strains.

For the reason that presently dead preserved material constitutes-, or a description has been designated-, the type strain of the mentioned species, or no type strain has been assigned, it is formally proposed that the strains selected by Reichenbach shall be designated the type strains of the respective species according to Rule 18f. The proposed type strains listed in Table 1 shall replace the dead specimen or descriptions. These are *Chondromyces apiculatus* Cm a14^T, *Chondromyces crocatus* Cm c5^T, *Chondromyces lanuginosus* Sy t2^T, *Chondromyces pediculatus* Cm p51^T, *M. boletus* Me b8^T, *P. sorediatum* Pl s12^T and *P. spumosum* Pl sm5^T. The prerequisite for the acceptance of type strains, their deposit and availability in two culture collections is achieved. The designation of the type strains is based on the descriptions given in the respective chapters of Bergey's Manual (Reichenbach 2005a, c, d). In order to facilitate the comparison of these recent descriptions with those of the authors who originally proposed, revived or emended the species these original descriptions are assembled in Table S1 available in IJSEM Online. The fatty acid composition of the proposed type strains are given in Table S2 (Garcia *et al.*, 2011). The figures from the original descriptions and of the proposed type strains are shown face to face with figures showing the proposed type strains in Figs 1–10.

The Bacteriological Code also allows for the proposal of neotype strains according to Rule 18c: 'If a strain on which the original description was based cannot be found, a neotype strain may be proposed. A neotype strain must be proposed (proposed neotype) in the IJSB, together with citation of the author(s) of the name, a description or

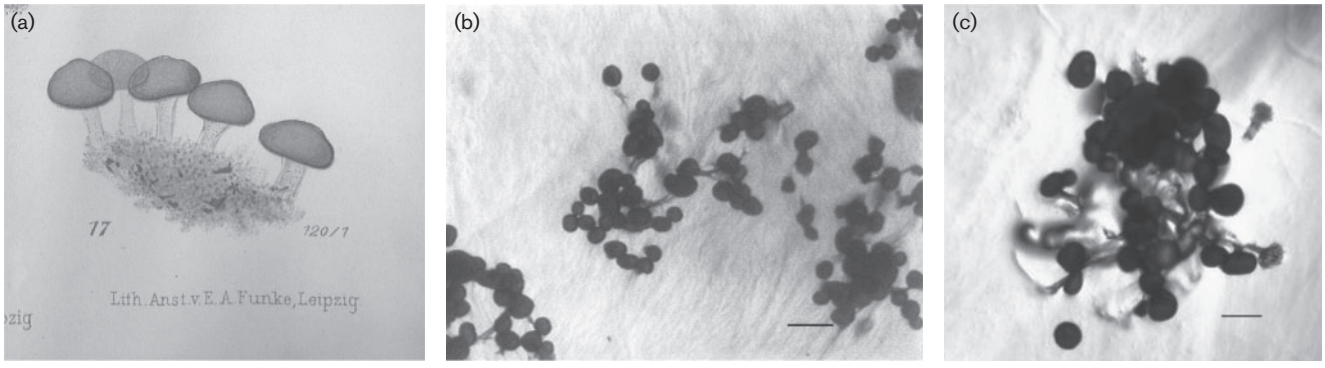

Fig. 5. *Melittangium boletus*. (a) Drawing from Jahn (1924), plate II, Fig. 17 on page 78. Courtesy Bornträger-Cramer, www.borntraeger-cramer.de. (b) and (c) Fruiting bodies of Me b8^T. Bars, 120 and 80 μm, respectively.

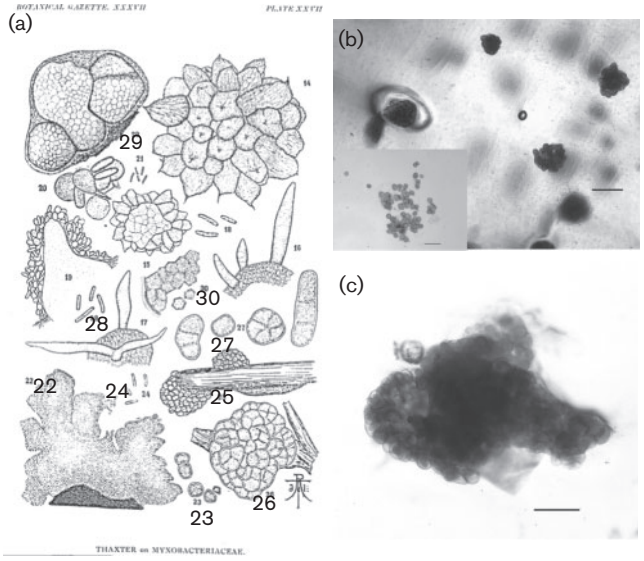

Fig. 6. *Polyangium sorediatum*. (a) Drawing from Thaxter (1904), plate XXVII. Nos 22–30 depict *P. sorediatum*. (b and c) Fruiting bodies of PI s12^T. Insert: crushed sporangium releasing the single sporangioles. Bars, 200 μm.

reference to an effectively published description and a record of the permanently established culture collection(s) where the strain is deposited (see also Note 1 to Rule 24a)'.

The species *Cystobacter ferrugineus*, *Cystobacter minus* and *Polyangium fumosum* were first described by Krzemieniewska & Krzemieniewski (1926, 1927, 1930). McCurdy assigned three of his isolates as the type strains for the above-mentioned three species (McCurdy, 1970; Table 1). The species names and type strains were included in the Approved Lists (Skerman *et al.*, 1980) but they have never been deposited in a culture collection to the best of our knowledge. In 2007, we wrote a letter to the head of the microbiology laboratory of the University of Windsor with the request for subcultures of the strains *Cystobacter ferrugineus* M-203^T, *Cystobacter minus* M-307^T and *P. fumosum* M257^T. Even though the importance for microbial taxonomy was stressed there was no response. In 2012, another attempt to contact the department at Windsor University was more successful in the respect that we received answers from two colleagues at Windsor and from H. D. McCurdy who retired several years ago. However, they informed us that they cannot find the samples. Since 1981, there have been no scientific papers originating from the

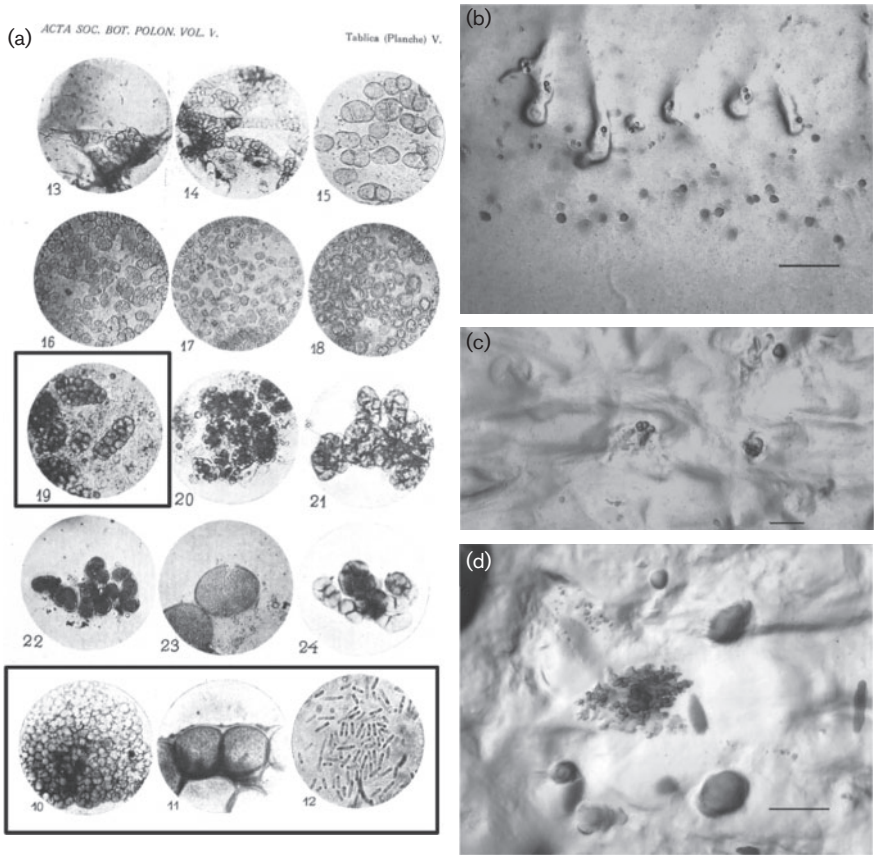

Fig. 7. *Polyangium spumosum*. (a) Figures from Krzemieniewska & Krzemieniewski (1926), plate V; no. 19 depicts *P. spumosum* and from Krzemieniewska & Krzemieniewski (1930), plate XVI; nos 10–12 depict *P. spumosum*. Courtesy of the Polish Botanical Society. (b–d) Degenerated fruiting bodies of PI sm5^T. Bars, 500, 100 and 250 μm, respectively.

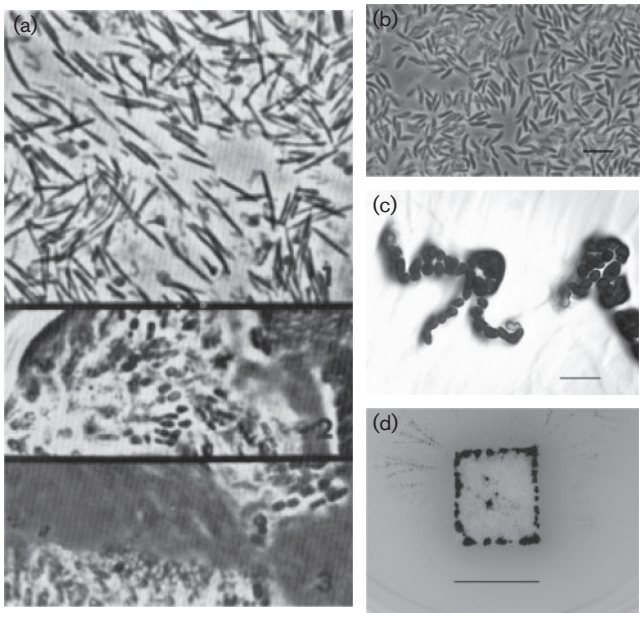

Fig. 8. *Cystobacter ferrugineus*. (a) Figures from McCurdy (1970). (b–d) Strain Cb fe18, (b) myxospores and (c) fruiting bodies on *Escherichia coli* as food bacteria and (d) on a cellulose plate. Bars, 10 μm, 1 mm and 10 mm, respectively.

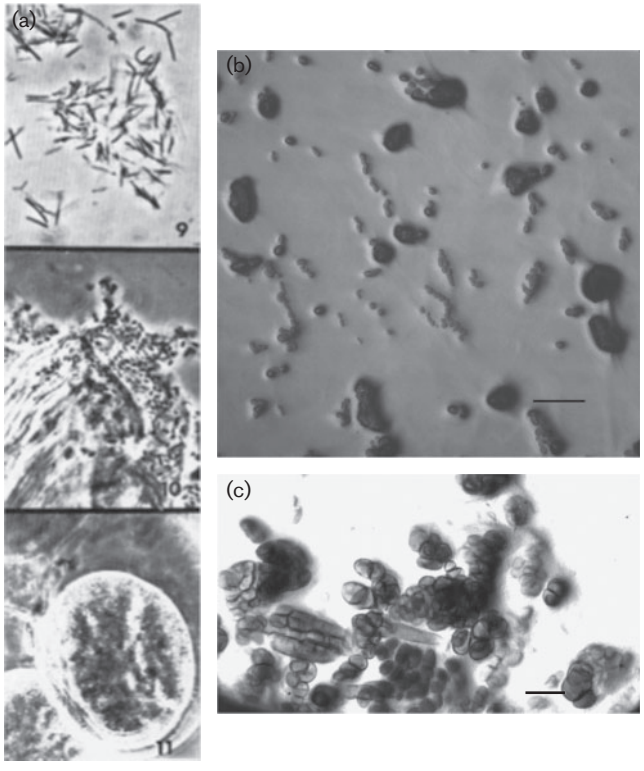

Fig. 9. *Cystobacter minus*. (a), Figures from McCurdy (1970). (b and c), Fruiting bodies of Cb m2. Bars, 500 μm and 200 μm, respectively.

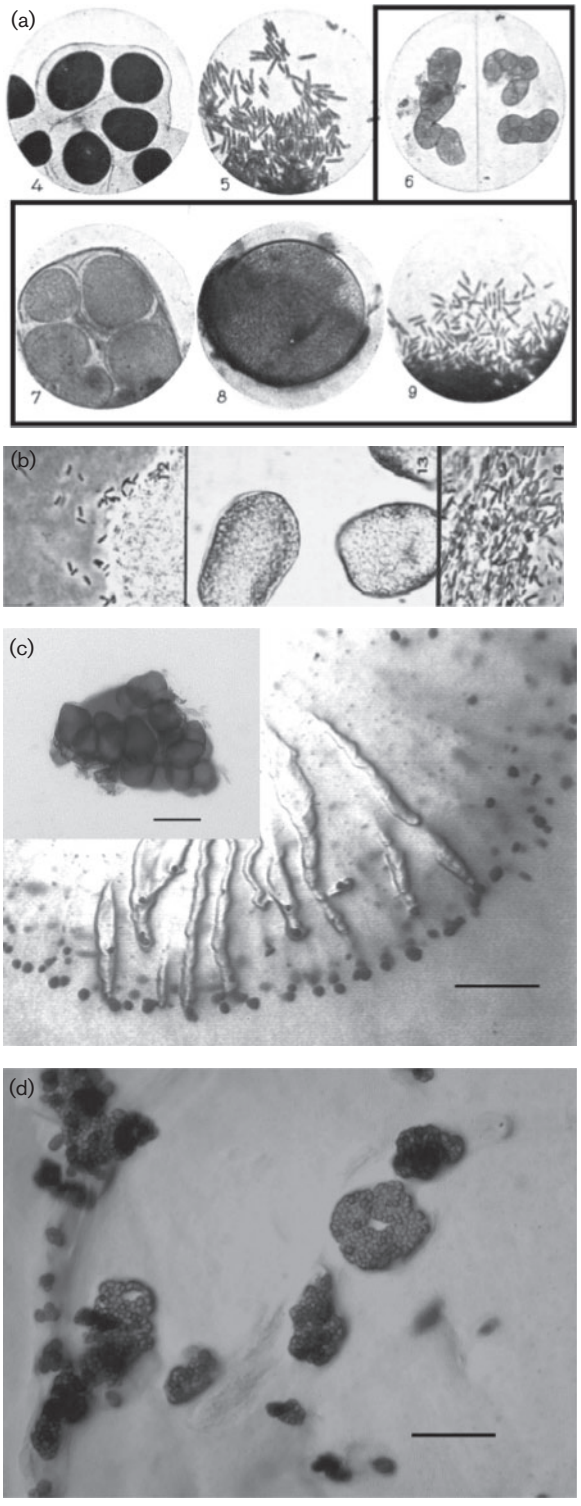

Fig. 10. *Polyangium fumosum*. (a) Drawing from Krzemieniewska & Krzemieniewski (1930), plate XVI, nos 6–9 depict *P. fumosum*. Courtesy of the Polish Botanical Society. (b) Swarm of Pl fu5 (bar, 2000 μm) and single sporangium of Pl fu5 (insert; bar, 100 μm). (c) Fruiting bodies of Pl fu5. Bar, 300 μm.

University of Windsor dealing with myxobacteria (PubMed), a fact additionally suggesting that nobody at the university had a research interest to keep the cultures alive or, at least, under surveillance. For that reasons we conclude that these cultures must have been lost.

Since the presently assigned type strains of the mentioned species are no longer available as living cultures it is formally proposed that the strains selected by Reichenbach shall be proposed as the neotype strains of the respective species in accordance with Rule 18c, as given in Table 1. The deposit and availability of the neotype strains from two culture collections is achieved. The proposals of the neotype strains are based on the suggestions in (Reichenbach (2005b, d). In these chapters, the strains *Cystobacter ferrugineus* Cb fe18, *Cystobacter minus* Cb m2 and *P. fumosum* Pl fu5 were proposed as the type strains according to the species descriptions given in the respective chapters which rely on the original species descriptions by Krzemieniewska and Krzemieniewski and McCurdy (Reichenbach 2005b, d). However, since type strains have already been assigned these strains have to be proposed as the neotype strains of the respective species according to rule 18c.

Acknowledgements

We are thankful to K. Poling and I. Churchill at Windsor University, G. Lewis-Gentry at the Harvard University Herbaria and H. D. McCurdy for taking the effort to investigate the disposition of the type materials.

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