Nomenclature for "*Micrococcus radiodurans*" and Other Radiation-Resistant Cocci: *Deinococcaceae* fam. nov. and *Deinococcus* gen. nov., Including Five Species

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The data assembled by Brooks et al. (Int. J. Syst. Bacteriol. **30**:627-646, 1980) suggest that the radiation-resistant, red, gram-positive, tetrad-forming cocci exemplified by "*Micrococcus radiodurans*" (not on Approved Lists of Bacterial Names [Skerman et al., Int. J. System. Bacteriol. **30**:225-420, 1980]) are a distinct natural group separate from *Micrococcus*. The nomenclature proposed here for these organisms utilizes specific epithets used in the original names of these organisms, which names were made illegitimate by omission from the Approved Lists. One species is added to those named before 1 January 1980. The proposals are as follows:

Deinococcaceae fam. nov.

Deinococcus gen. nov. (type genus)

D. radiodurans nom. nov. (type species)

D. radiophilus nom. nov.

D. proteolyticus nom. nov.

D. radiopugnans sp. nov.

Species *incertae sedis*

D. erythromyxa nom. nov.

Descriptions of the taxa are provided.

"*Micrococcus radiodurans*" (19) (names in quotation marks were not included on the Approved Lists of Bacterial Names [21]) was the name given to a remarkable radiation-resistant coccus isolated by Anderson et al. (1) from irradiated meat. Most of the detailed studies of this organism have used the R₁ strain of Anderson et al. or the Sark strain (R. G. E. Murray and C. F. Robinow, Abstr. 7th Int. Congr. Microbiol., p. 427, 1958), which was later shown to be closely related (5). Structural and biochemical analysis of the cell walls of these two strains showed distinct differences from *Micrococcus* species: a complex profile in sections (15, 22, 25) and L-ornithine with di- or triglycine as the interpeptide bridge in the peptidoglycan (5, 20, 26). Furthermore, the predominant fatty acid in lipid extracts of these cells was a 16:1 component (5, 10, 12), which is commonly associated with gram-negative bacteria.

Hill (11) aligned the radiation-resistant, red-pigmented, catalase-positive micrococci with other similarly pigmented, gram-positive organisms such as *Micrococcus roseus* and *M. agilis*. Subsequent taxonomic analysis by Baird-Parker

(2, 3) suggested that these strains should be excluded from the genus *Micrococcus* because of the nature of the cell wall (20, 27) and lipid (12) constituents in addition to radiation resistance. These strains, under the common name "*Micrococcus radiodurans*," were placed in *Bergey's Manual* (4) in the *incertae sedis* section appended to *Micrococcus* for determinative purposes. The recent taxonomic study by Feltham (9) also suggests that "*M. radiodurans*" and its relatives are distinct from conventional *Micrococcus* species. This distinction has been confirmed by Brooks et al. (5), with additional evidence supporting and amplifying the earlier recognition by Davis et al. (8), Lewis (17), and Kobatake et al. (13) of distinctive organisms within the radiation-resistant group. Recent structural observations on these organisms (15, 22, 23) emphasize the unique features of their cell walls and membranes. The application of ribosomal ribonucleic acid oligonucleotide sequence catalog data provides the best evidence in support of the thesis that these organisms are unrelated or are very distantly related to *Micrococcus* (5).

The situation is made the more complex because the name "*M. radiodurans*," as well as "*M. radiophilus*" (17) and "*M. radioproteolyti-*

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cus" (13), which may be considered relatives, were omitted from the Approved Lists of Bacterial Names (21). Therefore, it is the intent of this paper to establish a nomenclature and appropriate descriptions of the taxa to provide a legitimate basis for referring to these organisms and to stimulate studies of this unique group. No disrespect is intended toward the original authors of the specific epithets proposed in this paper; the provisions of the Bacteriological Code (1976 revision) do not allow their inclusion as contributions to new combinations of names.

The taxonomic treatment put forward in this paper is based on the comparative data published by Brooks et al. (5) and on their more detailed studies of representative strains of the apparent phenotypic clusters. It is clear that the red-pigmented micrococci, *M. roseus* and *M. agilis*, are species of *Micrococcus* Cohn 1872 (14) and are quite separate from the radiation-resistant "*M. radiodurans*" (Table 1) and the organisms that resemble it. Therefore, we hereby conserve the elegant and effective specific epithet "*radiodurans*" associated with this organism (19) in the new name *Deinococcus radiodurans*. The new generic name *Deinococcus* implies that these cocci have remarkable properties. The appropriate descriptions follow.

Description of the type strain of *D. radiodurans* nom. nov. M.L. adj. ra·di·o·du·rans. L.n. *radiatio* radiation; L. part. adj. *durans* enduring; *radiodurans* resisting radiation.

Spheres, 1.5 to 3 μm in diameter, occurring singly and in pairs and dividing in two planes to form tetrads or tablets of cells. Nonmotile.

The peptide subunit of the cell wall contains L-alanine, D-glutamic acid, and L-ornithine. The interpeptide bridge contains glycine. Teichoic acids are absent. The cell wall consists of at least four layers and has a total thickness of 130 to 140 nm. The peptidoglycan-containing layer is fenestrated. The outermost layer consists of hexagonally packed protein subunits.

The predominant fatty acid component is palmitoleate. No branched-chain fatty acids are present.

Colonies are red, smooth, and convex with a regular edge. Multiple carotenoids are present.

Chemoorganotrophic; metabolism is strictly respiratory. Acid production from some carbohydrates (glucose and fructose) is variable. Fructose, glycerol, glucose, and mannose are utilized, but no acid is produced in standard broth.

Strictly aerobic. Optimal growth temperature is 30°C. All strains grow in the presence of 1% NaCl and most grow in 5% NaCl in media. Nitrates are not reduced to nitrites.

Resistant to 1.5 Mrad of gamma radiation and exposure to 1,800 ergs/cm² per s of ultraviolet radiation for 10 min.

Guanine-plus-cytosine (G+C) content of the deoxyribonucleic acid (DNA) is 67 mol% (by T_m).

Type strain: ATCC (American Type Culture Collection) 13939 (=UWO [Collection in the Department of Microbiology and Immunology, University of Western Ontario] 288).

Variations in cell wall structure, reduction of nitrates, tolerance to sodium chloride, proportion of fatty acid components, and loss of pigmentation have been observed in strains included in *D. radiodurans*. Some greater variations among strains assigned to *D. radiodurans* e.g., strains 1083, G+C = 70 mol%; see Table 2) will demand detailed study in the future in terms of relatedness and species assignment of the strains.

Description of *Deinococcus* gen. nov. *Dei·no·coc'cus*. Gr. adj. *deinos* strange or unusual; Gr. n. *coccus* a grain or berry; M.L. masc. n. *Deinococcus* unusual coccus.

Cells spherical, 0.5 to 3.5 μm in diameter, occurring singly and in pairs and dividing in two planes to form tetrads or tablets of cells. Nonmotile. No resting stages known. Gram positive.

Chemoorganotrophic; metabolism is respiratory. Glucose may be metabolized, but acid is produced from only a limited number of carbohydrate substrates, if at all. Catalase is produced. Carotenoid pigments usually are present, and colonies are usually pink to brick red.

Aerobic. Optimal growth temperature is 25 to 35°C.

Several distinct cell wall layers are visible in thin sections, and the walls may contain lipoprotein. The interpeptide bridge of the peptidoglycan contains glycine, and the peptide subunit contains L-alanine, D-glutamic acid, and L-ornithine. Teichoic acids are absent.

Many strains are resistant to 1.5 Mrad of gamma radiation and to exposure to 1,800 ergs/cm² per s of ultraviolet radiation for 10 min.

The fatty acid component palmitoleate accounts for at least 25% of the total fatty acid composition.

The G+C content of the DNA ranges from 62 to 70 mol% (by T_m).

Type species: *Deinococcus radiodurans*.

Family relationship of the genus *Deinococcus*. Results of comparative cataloging of 16S ribosomal ribonucleic acid taken together with the results of DNA homology, the analysis of fatty acid composition, and the analysis of cell wall structure and composition indicate a very distant relationship between *D. radiodurans*

TABLE 1. Characters useful in differentiating *M. roseus*, *M. agilis*, and *D. radiodurans*

Strain	mol% G + C in DNA ^a	Character											
		Growth on 5% NaCl	Growth at 37°C	Nitrate reduction	Esculin hydrolysis	ONPG ^b	Peptidoglycan type in cell wall ^c	Motility	Lipoprotein in cell wall ^c	Predominant fatty acid	Fenestrated peptidoglycan-containing layer	Resistance to 1.5 Mrad of radiation	
<i>M. roseus</i>	74	+	(100%)	+	(100%)	Variable (+ 71%)	— (0%)	L-Lys-L-Ala ₃₋₄ ^d	— (0%)	Not sought	15:0 branched	Absent	No
<i>M. agilis</i>	64 ^e	—	(0%)	—	(0%)	— (0%)	— (0%) ^f	L-Lys-L-Thr-L-Ala ₃ ^e	— (0%) ^f	Not sought	15:0 branched	Absent	No
<i>D. radiodurans</i>	67	Variable (+ 25%)	+	(+ 96%)	Variable (+ 25%)	— (0%)	— (0%)	L-Orn, di- or triglycine ^g	— (0%)	Present	16:1	Present	Yes

^a Determined on type strain.
^b o-Nitrophenyl-β-D-galactosidase. These results do not support those of Kocur and Schliefer (14).
^c This is a potentially useful character. Work and Griffiths (27) and Lancy and Murray (15) have detected lipoprotein in the cell wall of "*M. radiodurans*." Cell walls of *M. roseus* have not been analyzed specifically for lipoprotein.
^d Schliefer and Kandler (20).
^e Kocur and Schliefer (14).
^f All strains were nonmotile but were previously reported as motile (14).
^g Work (26).

TABLE 2. *Differential characters of miscellaneous strains of red-pigmented cocci*

Strain	Character								
	Nitrate reduction	Acid from glucose in standard medium	mol% G + C in DNA	Resistance to gamma radiation	Cell size (μ m)	Peptidoglycan type in cell wall	Growth in presence of 5% NaCl	Predominant fatty acid	Branched-chain fatty acid
<i>D. radiophilus</i> UWO 1055	—	—	62	Yes ^a	1.0–2.0	L-Orn-Gly ₂ ^b	+	16:1	Not detected
<i>D. proteolyticus</i> UWO 1056	—	+	65	Yes ^c	1.0–2.0	L-Orn-Gly ₂ ^b	—	16:1	Not detected
<i>D. radiopugnans</i> UWO 293	+	—	70	Yes ^d	1.0–2.0	Orn-Gly ₂	—	16:1, 17:0	15:0
<i>D. erythromyxa</i> UWO 1045	+	—	71	Yes ^e	1.0–2.5	L-Lys-L-Ala ₃₋₄ ^f	+	16:0, 18:1	Not present
<i>D. radiodurans</i> UWO 1083	+	—	70	Yes ^g	1.5–3.0	Orn-Gly ₂	—	15:1, 16:1	Not present

^a Lewis (17).^b Sleytr et al. (23).^c Kobatake et al. (13).^d Davis et al. (8).^e $D_{10} = 0.127$ to 0.254 Mrad (R. G. E. Murray, D. G. Storey, and J. L. Whitby, unpublished data).^f Schliefer and Kandler (20).^g E. A. Christensen, Statens Seruminstitut, Copenhagen, Denmark, personal communication.

and *M. roseus* (5). For these multiple reasons, we believe that these organisms should not be assigned to the same family.

In the eighth edition of *Bergey's Manual* (6), three families (*Micrococcaceae*, *Streptococcaceae*, and *Peptococcaceae*) are included in part 14, Gram-Positive Cocci. The inclusion of *D. radiodurans* in any of these three families is not appropriate. Therefore, *Deinococcaceae* fam. nov. is proposed with *Deinococcus* as the type genus. For determinative reasons ("gram-positive cocci" being a convenient assembly) and until strong phylogenetic or other data demand some other alignments, this new family should remain in Part 14 of *Bergey's Manual*, or its equivalent.

Description of the family *Deinococcaceae* fam. nov. Dei-no-coc-ca'ce-ae. M.L. masc. n. *Deinococcus* type genus of the family; -aceae ending to denote family; M.L. fem. pl. n. *Deinococcaceae* the *Deinococcus* family.

Cells spherical, 0.5 to 3.5 μ m in diameter, characteristically dividing in more than one plane to form tetrads or tablets. Nonmotile. Resting stages are not produced. Gram positive.

Chemoorganotrophic; metabolism is respiratory. Acid without gas is produced from glucose, when attacked.

Nutritional requirements are variable.

Catalase positive.

Aerobic.

The fatty acid component palmitoleate accounts for at least 25% of the fatty acid composition.

Several distinct cell wall layers are visible in thin section, and the cell wall contains lipoprotein. L-Ornithine is present in the peptide subunit of the peptidoglycan; exceptions may occur.

Many strains are resistant to high levels of gamma and ultraviolet radiation.

The G+C content of the DNA ranges from 62 to 70 mol% (by T_m).

Type genus: *Deinococcus*.

Taxonomic status of other radiation-resistant, red-pigmented strains. On the basis of fatty acid composition, in terms of both components detected and relative percentage of individual components, Brooks et al. (5) distinguished eight strains (formerly known as *M. roseus* UWO 293, *M. roseus* UWO 294, "*M. radiophilus*" UWO 1055, "*M. radioproteolyticus*" UWO 1056, *M. roseus* UWO 1045, *M. roseus* UWO 1088, "*M. radiodurans*" UWO 1083, and "*M. radiodurans*" UWO 1085) from *M. roseus*, *M. agilis*, and "*M. radiodurans*" (now *D. radiodurans*). At the same time, the fatty acid compositions and the analyses of the cell wall profiles of these eight strains indicate that these organisms can be divided into five clusters (Table 2). The strains formerly known as "*M. radiophilus*" (UWO 1055) and "*M. radioproteolyticus*" (UWO 1056) were distinct from each other and from the other six strains. *M. roseus* strains UWO 293 and 294 were similar to each other, as were *M. roseus* strains UWO 1045 and UWO 1088 and "*M. radiodurans*" strains UWO 1083 and UWO 1085.

Determination of cell wall profiles and of fatty

acid composition has provided differential characters for taxonomic purposes at the level of family or genus, but these are of limited value for species identification. Unfortunately, the chemistry of the cell walls of the eight strains, beyond establishing the peptidoglycan type, has not been studied in detail.

Taxonomic status of the organism formerly known as "*M. radiophilus*." The organism formerly known as "*M. radiophilus*" UWO 1055 was isolated by Lewis (17), who described it as a new species which differed from "*M. radiodurans*" in size, tolerance to sodium chloride, and degree of resistance to gamma radiation. No type strain was designated, but Lewis described only a single strain (ATCC 27603); according to Rule 18c of the Bacteriological Code (16), this strain must be accepted as the type. The name *Deinococcus radiophilus* nom. nov. is proposed for this organism.

Description of the type strain of *D. radiophilus* nom. nov. Ra·di·o·phil·us. M.L. n. *radiatio* radiation; Gr. adj. *philos* loving; M.L. adj. *radiophilus* radiation loving.

Spheres, 1.0 to 2.0 μm in diameter, occurring singly and in pairs and dividing in two planes to form tetrads. Nonmotile.

The peptide subunit of the cell wall contains L-ornithine, and the interpeptide bridge contains glycine. The cell wall consists of at least three distinct layers.

The predominant fatty acid component is palmitoleate. No branched-chain fatty acids are present.

Colonies are orange-red, smooth, and convex with a regular edge. Multiple carotenoids are present.

Chemoorganotrophic; metabolism is strictly respiratory. No acid is produced in standard broth containing glucose or fructose.

Strictly aerobic. Optimal growth temperature is 30°C. Grows in the presence of 5% NaCl. Nitrates are not reduced to nitrates. Catalase positive.

Resistant to 1.5 Mrad of gamma radiation.

G+C content of the DNA is 62 mol% (by T_m).

Type strain: ATCC 27603 (= UWO 1055).

Taxonomic status of the organism formerly known as "*M. radioproteolyticus*." "*M. radioproteolyticus*" was isolated by Kobatake et al. (13) and was described as a new species. No type strain was designated, but because only a single strain was described (Czechoslovak Collection of Microorganisms [CCM] strain 2703), it is the type strain by monotypy (Rule 18c). The specific epithet is illegitimate (Rule 12a) because it expresses more than a single concept. Kobatake et al. (13) recognized

that this organism was more active in digesting proteins (milk, soya, and gelatin) than was "*M. radiodurans*" and expressed this in forming the epithet. We retain this approach.

Brooks et al. (5) and Sleytr et al. (23) reported additional characters for this organism: the fatty acid composition of this strain and the cell wall profile are similar to those of *D. radiodurans* and *D. radiophilus*. Acid production from glucose and fructose in the standard medium, non-specific esterase banding patterns, and results from studies on DNA homology support the recognition of this organism as a separate species. The name *Deinococcus proteolyticus* nom. nov. is proposed for this organism.

Description of the type strain of *D. proteolyticus* nom. nov. Pro·te·o·ly·ti·cus. M.L. m. adj. *proteolyticus* proteolytic.

Spheres, 1.0 to 2.0 μm in diameter, occurring singly and in pairs and dividing in two planes to form tetrads. Nonmotile.

The peptide subunit of the cell wall contains L-ornithine, and the interpeptide bridge contains glycine. The cell wall consists of at least three distinct layers.

The predominant fatty acid component is palmitoleate. No branched-chain fatty acids are present.

Colonies are orange-red, smooth, and convex with a regular edge. Multiple carotenoids are present.

Chemoorganotrophic; metabolism is respiratory. Acid but no gas is produced from glucose and fructose in standard broth. Milk is peptonized and gelatin is liquefied.

Strictly aerobic. Optimal growth temperature is 30°C. Grows in the presence of 1% NaCl. Nitrates are not reduced to nitrates. Catalase positive.

Resistant to 1.5 Mrad of gamma radiation.

G+C content of the DNA is 65 mol% (by T_m).

Type strain: CCM 2703 (= UWO 1056).

Taxonomic status of the organism formerly known as the "Davis" or "haddock" strain of *M. roseus*. In 1964, Davis et al. (8) reported the isolation of a radiation-resistant coccus from haddock tissue (UWO 293). It was distinguished from "*M. radiodurans*" by size, nitrate reduction, and gelatin hydrolysis. Davis et al. did not identify their isolate, but Girard (10) studied it and included it with *M. roseus* despite the findings of Davis et al. It is evident from the study of Brooks et al. (5) that the Davis strain is a member of neither *M. roseus* nor the genus *Micrococcus*.

The fatty acid composition of the Davis isolate is distinct from that of *D. radiodurans* in terms of the components and, in particular, their rela-

tive proportions. A 15:0 branched-chain fatty acid, not detected in *D. radiodurans*, is present in the Davis isolate. The profile of the cell wall of the Davis isolate consists of at least three distinct layers and is thus similar to that observed in *D. radiophilus* and *D. proteolyticus*. This information as well as DNA homology data (5) supports the recognition of this isolate as a distinct species. *Deinococcus radiopugnans* is suggested as an appropriate name for this organism, and UWO 293 is proposed as the type strain.

Description of the type strain of *D. radiopugnans* sp. nov. Ra·di·o·pug'nans. L. n. *radiatio* radiation; L. part. adj. *pugnans* fighting or resisting; M.L. adj. *radiopugnans* radiation resisting.

Spheres, 1.0 to 2.0 μm in diameter, occurring singly and in pairs and dividing in two planes to form tetrads or tablets of cells. Nonmotile.

The cell wall consists of at least three layers, and the peptidoglycan-containing layer is fenestrated.

Two fatty acid components, palmitoleate and heptadecanoate, present in approximately equal proportion, together account for at least 50% of the total fatty acid composition. A 15-carbon, branched-chain, saturated fatty acid component is present.

Colonies are orange-red, smooth, and convex with a regular edge. Multiple carotenoids are present.

Chemoorganotrophic; metabolism is strictly respiratory. No acid is produced from glucose in standard medium. Catalase positive.

Strictly aerobic. Optimal growth temperature is 30°C.

Grows in the presence of 1% NaCl. Nitrate is reduced to nitrite.

Resistant to 1.5 Mrad of gamma radiation.

G+C content of the DNA is mol% (by T_m).

Type strain: ATCC 19172 (= UWO 293).

Smooth and rough variants, as well as variants with less pigment, may occur. The 15-carbon, saturated, branched-chain fatty acid component may be absent.

Taxonomic status of strains formerly identified as members of *M. roseus* (UWO 1045 and UWO 1088). *M. roseus* strains UWO 1045 and 1088 have similar cell wall profiles and fatty acid compositions but differ in both respects from the type strain of *M. roseus*, ATCC 186. On the basis of these two complex characters and DNA homology (5), *M. roseus* strain UWO 1045 is recognized as belonging to a species separate from *M. roseus*. Because *M. roseus* UWO 1045 was formerly called "*Sarcina erythromyxa*" (7), the name *Deinococcus erythromyxa* is suggested. The type strain of *D. ery-*

thromyxa is ATCC 187 (= UWO 1045). Strain UWO 1088 will have to be left out of consideration for this taxon because repeated assessment of its peptidoglycan constitution reveals the presence of *m*-diaminopimelic acid and no trace of either ornithine or lysine (E. Stackebrandt, Technische Universität, Munich, West Germany, personal communication). However, in other respects the phenotypes of these two organisms, including the fatty acid constituents, are remarkably similar (5).

Description of the type strain of *D. erythromyxa* nom. nov. E·ry·thro·my'xa. Gr. adj. *erythros* red; Gr. n. *myxa* slime or mucus; M.L. n. *erythromyxa* red slime.

Spheres, 1.0 to 2.0 μm in diameter, occurring singly and in pairs and dividing in two planes to form tetrads. Nonmotile.

The cell wall consists of two layers. The peptidoglycan is of the L-Lys-L-Ala₃₋₄ type. The peptidoglycan-containing layer is not fenestrated.

Two fatty acid components, palmitate and oleate, are present in approximately equal proportion and together account for at least 60% of the total fatty acid composition. No branched-chain fatty acids are present.

Colonies are red, smooth, and convex with a regular edge. Multiple carotenoids are present.

Chemoorganotrophic; metabolism is strictly respiratory. No acid is produced from glucose in standard medium. Catalase positive.

Aerobic. Optimal growth temperature is 30°C. Grows in the presence of 5% NaCl. Nitrates are reduced to nitrites.

Resistant to gamma radiation; the level is uncertain, but it is in the region of 1 Mrad.

G+C content of the DNA is 71 mol% (by T_m).

Type strain: ATCC (= UWO 1045).

Intragenetic relationship of *D. radiophilus*, *D. proteolyticus*, *D. radiopugnans*, and *D. erythromyxa*. *D. radiophilus*, *D. proteolyticus*, and *D. radiopugnans* have complex cell walls with several obvious layers and a fatty acid component, palmitoleate, which accounts for at least 25% of the total fatty acid composition. All three strains have features characteristic of the genus *Deinococcus*; they are resistant to 1.5 Mrad of gamma radiation and have a peptidoglycan of the L-Orn-Gly₂ type.

However, results of DNA homology studies (5) between *D. radiodurans* UWO 298 and *D. radiophilus*, *D. proteolyticus*, and *D. radiopugnans* indicate only low homologies (4, 10, and 12%, respectively). Similarly, results of DNA homology studies between *D. radiopugnans* and *D. radiodurans* UWO 298, *D. radiophilis*, and *D. proteolyticus* also indicate low homologies

(17, 4, and 8%, respectively). Results of comparative cataloging of 16S ribosomal ribonucleic acid (5) indicate that there are 320 common bases between *D. radiodurans* UWO 298 and *D. radiopugnans*, which indicates that these two strains are related.

This information indicates that *D. radiophilus*, *D. proteolyticus*, and *D. radiopugnans* should be aligned with the genus *Deinococcus*. However, the low DNA homology values and the small number of positive characters used for description make it likely that some or all of these will have to be reassessed as members of the genus *Deinococcus* at some time in the future.

The generic relationship of *D. erythromyxa* is difficult to assess, because there is limited information suggesting distinction from both *Micrococcus* and *Deinococcus*. The cell wall profile is distinct from those of strains included in *M. roseus*, but the cell wall of *D. erythromyxa* does not have as many obvious layers as are seen in other species included in the genus *Deinococcus*. The peptidoglycan of *D. erythromyxa* is of the L-Lys-L-Ala₃₋₄ type found in *M. roseus* strains. However, the fatty acid profiles of *M. roseus* (type strain) and *D. erythromyxa* are distinctly different. We find that the resistance of strains to gamma radiation is different but overlapping (*M. roseus* UWO 1057, type strain, $D_{10} = 0.075$ to 0.157 Mrad; *D. erythromyxa* UWO 1045, $D_{10} = 0.127$ to 0.254 Mrad, according to unpublished data of R. G. E. Murray, D. G. Storey, and J. L. Whitby). Unfortunately, there are no homology data or comparative cataloging of 16S ribosomal ribonucleic acid of *M. roseus* and *D. erythromyxa* strains available. So, in the absence of a more appropriate niche, the species *D. erythromyxa* is included in the genus *Deinococcus* as a species *incertae sedis* awaiting further study and a more informed assignment. We can hope for a bigger collection of anomalous strains for a comparative study.

Regarding radiation resistance. It is worth noting that there is little consistency in the methods applied to determining radiation resistance and providing an effective comparison of organisms in this regard. Until some effective approach to comparable data is agreed upon, we are not prepared to provide figures that are different from those expressed in the literature. Our preliminary data (unpublished) confirm that all of the organisms selected as representative strains of *Deinococcus* species are remarkably resistant to gamma radiation and show a range of D_{10} values of 0.100 to 0.547 Mrad, which probably corresponds to a sterilizing dose (^{60}Co ; in air) approximating six times those values.

However, the values vary by as much as 20 to 100% according to the method used, notably cells dried on glass versus cells dried on a paper strip.

Radiation resistance is an attractive and selective character but, as discussed in the previous publication (5), it is mutable (13) and may not serve to distinguish all the near or distant relatives of this unusual family of bacteria.

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REPRINT REQUESTS

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