Thermus ruber sp. nov., nom. rev.

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The name *Thermus ruber* Loginova, Egorova, Golovacheva, and Seregina 1975 is revived for the same organism on which the original description was based. The temperature range for growth on a potato-peptone-yeast extract medium is 37 to 70°C, and the optimum temperature for growth is 60°C. *T. ruber* is characterized by the production of an intracellular bright red (or occasionally bright orange) carotenoid pigment with an absorption spectrum similar to that of retro-dehydro- γ -carotene (or occasionally neurosporaxanthine). The type strain is strain 1258 in the All-Union Collection of Microorganisms, Moscow, USSR.

The bacterial species *Thermus ruber* was not included on the Approved Lists of Bacterial Names (15) although its description was published in 1975 (10). In this paper we revive the name *Thermus ruber* Loginova, Egorova, Golovacheva, and Seregina 1975 for the same organism on which the original description was based (10).

The morphological, physiological, and biochemical properties of *T. ruber* have been described in detail by Loginova et al. (10). The potato-peptone-yeast extract broth used contained 20 ml of potato broth, 0.5 g of peptone, 0.1 g of yeast extract, and distilled water to 100 ml. The minimal medium used contained 0.2 g of KCl, 3 g of K_2HPO_4 , 1 g of KH_2PO_4 , 0.2 g of $MgSO_4 \cdot 7H_2O$, and distilled water to 1 liter (pH 8.0).

The intracellular pigment was studied by the method of Jackson et al. (6). Absorption spectra of acetone, methanol-acetone (1:1), and hexane extracts of the bacterial pigment were recorded with a spectrophotometer (Specord, Jena, German Democratic Republic). The methods used for studying the fatty acid composition of *T. ruber* have been described previously (2). The description below is based on five strains.

Description of *Thermus ruber* sp. nov., nom. rev. *Thermus ruber* (ru'ber. M.L. adj. *ruber* red) cells are gram-negative nonmotile rods that are 3 to 6 by 0.5 to 0.8 μ m, have rounded ends, and are nonsporeforming. In potato-peptone-yeast extract broth incubated at 60°C with shaking (260 rpm), filamentous forms (20 to 40 μ m in length) are observed along with shorter rods after a few hours. No filamentous forms are seen after 16 h of incubation. Obligately thermophilic. On potato-peptone-yeast extract medium, the temperature range for growth is 35 to 40°C (minimal) to 70°C (maximal), and the optimum temperature is 60°C (the generation time is then 60 min). A bright red intracellular carotenoid pigment is produced, which resembles retro-dehydro- γ -carotene (neo A, neo B) in spectral properties (5, 8). The absorption spectra of acetone, methanol-acetone (1:1), and hexane extracts show three maxima at 455, 483, and 513 nm. One strain (strain INMI-a) contains a bright yellow pigment (12) resembling neurosporaxanthine in its spectral properties (4).

Obligately aerobic. Growth occurs in minimal medium supplemented with 0.15% (wt/vol) peptone as an N source, 0.05% (wt/vol) yeast extract, and one of the following carbon sources at a concentration of 0.25% (wt/vol): D-glucose, sucrose, maltose, D-galactose, D-mannose, rhamnose, D-cellobiose, glycerol, D-mannitol, acetate, pyruvate, succi-

nate, fumarate, or DL-malate (sodium salts) (10, 11). No growth occurs if the concentration of D-glucose in the medium is raised to 0.5% (wt/vol). Only moderate growth occurs when ammonium phosphate (0.1%, wt/vol) is substituted for peptone as the N source. No growth occurs in control medium without a carbon source.

No growth occurs on minimal medium supplemented with 0.25% (wt/vol) D-glucose, 0.05% (wt/vol) yeast extract and one of the following nitrogen sources at a concentration of 0.1% (wt/vol): L-alanine, glycine, L-asparagine, L-tyrosine, L-glutamate, ammonium sulfate, nitrate, or urea.

Nitrates are not reduced; milk is not peptonized.

The major cellular fatty acids are as follows (expressed as percentages of the total fatty acids): isopentadecanoic acid, 30.6%; isoheptadecanoic acid, 15.8%; anteisopentadecanoic acid, 8.3%; and anteisoheptadecanoic acid, 7.3% (2).

The guanine-plus-cytosine content of the deoxyribonucleic acid is 66 mol% (1).

Habitat: hot springs.

The type strain is All-Union Collection of Microorganisms strain 1258 (= Loginova strain 21) (10).

Description of the type strain. The type strain has all of the characteristics listed above for the species. A bright red intracellular carotenoid pigment is produced. This strain was isolated from a hot spring (70 to 93°C, pH 6.5 to 7.3) in the Kamchatka Peninsula. The original culture was at 60°C.

Differentiation from other species. Gram-negative, nonmotile, heterotrophic bacteria growing aerobically at a neutral pH and high temperatures are usually assigned to the genus *Thermus* (9). To date, only one species of *Thermus*, *Thermus aquaticus*, has been validly published (15). Two other species, "*Thermus flavus*" (14) and "*Thermus thermophilus*" (13), have been published, but they did not appear in the Approved Lists of Bacterial Names (15). These three species (*T. aquaticus*, "*T. flavus*," and "*T. thermophilus*") produce a bright orange intracellular pigment of the α -carotene type (3, 13, 14). In addition, *T. aquaticus* utilizes ammonium sulfate and glutamate as sole nitrogen sources, reduces nitrates, and peptonizes milk. "*T. flavus*" cannot utilize D-galactose, sucrose, maltose, lactose, or glycerol; and "*T. thermophilus*" cannot utilize sucrose, maltose, or D-mannitol. Furthermore, the generation time of "*T. thermophilus*" is 18 to 20 min (13), which is much shorter than the generation time of *T. ruber*.

All of the properties described above differentiate *T. ruber* from *T. aquaticus*, "*T. flavus*," and "*T. thermophilus*."

With the addition of *T. ruber*, the genus *Thermus* now includes not only extreme thermophilic bacteria, but also obligately thermophilic bacteria.

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