Using Bergey’s Manuals

If you are using Bergey’s for BSCI 223, you should have already entered your sequences into the Ribosomal Database Project (RDP, http://rdp.cme.msu.edu) in order to identify your bacteria. Using the phylogenetic tree information, you can then go to the various Bergey’s Manuals to get additional information.

Note: there are two types of Bergey’s Manuals: Bergey's Manual of Systematic Bacteriology and Bergey's Manual of Determinative Bacteriology.

<table>
<thead>
<tr>
<th>Bergey’s Manual of...</th>
<th>Organized by...</th>
<th>Content</th>
<th>Level of Detail</th>
<th>Ease of Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>Determinative Bacteriology</td>
<td>Phenotypic characteristics</td>
<td>Identification information (Shape and size of cells, Gram stain results, motility, optimal growth temperature, etc.); differentiation tables</td>
<td>Basic; Genus level information</td>
<td>Good place to start; only one volume to search.</td>
</tr>
<tr>
<td>Systematic Bacteriology, 1st ed.</td>
<td>Phenotypic characteristics</td>
<td>Detailed information on bacterial classification and detailed characteristics of taxa and species</td>
<td>More detailed than Determinative manual; Species level information</td>
<td>Use index in volume 4 to search across all 4 volumes</td>
</tr>
<tr>
<td>Systematic Bacteriology, 2nd ed.</td>
<td>Similarity of 16s rRNA sequences</td>
<td>Detailed information on bacterial classification and detailed characteristics of taxa and species</td>
<td>More detailed than Determinative manual; Species level information</td>
<td>Multiple volumes to search; need to search each volume’s index.</td>
</tr>
</tbody>
</table>

For example, let us say for my unknown sequence I obtain the following information from RDP. My unknown is *Hyphomicrobium vulgare*. 

![Table and RDP output]
First, getting basic information at the Genus level from Bergey’s Manual of Determinative Bacteriology

The Chemistry library has a number of editions of this work, the most recent being the 9th edition (1994). Finding the Genus of your bacteria is simpler here than in Bergey’s Manual of Systematic Bacteriology - however there is less information in this work, in fact there is no species-level information.

1. Once you have the phylogenetic tree for your bacteria in hand, open to the index in the back of the single volume.
2. Look up your Genus in the index and note the page number(s). In my case, I would look for “Hyphomicrobium” and see:

   Hyphomicrobium, 430, 440, 461, 470, 473
   aestuarii, 473
   coagulans, 473
   facilis, 473
   hollandicum, 473
   methyllovorum, 473
   vulgare, 461, 473
   zavarzinii, 462, 473

The page number in BOLD is the main page to find information for this particular Genus. There is little detail at the Species level in this title, though there may be some tables of differentiation characteristics available.

Therefore, to find information about Genus Hyphomicrobium, I would turn to page 461.
If I wanted limited information on Hyphomicrobium vulgare, I would check pages 461 and 473.


---

**Genus Hyphomicrobium**

Rod-shaped, oval, or bean-shaped cells, 0.3–1.2 × 1–3 μm, have polar prosthecae of varying lengths and 0.2–0.3 μm in diameter. Prosthecae may be branched and may extend from both poles of the cell. Cells reproduce by budding at the tip of a prostheca. Mature buds, which separate from the mother cell, are motile by one to three polar to subpolar flagella. Buds may produce holdfasts on the cell surface and aggregate to form rosettes. Motility is rare in older cultures. PHB is stored in cells, usually at one pole. Aerobic, chemoorganotrophic, oligocarbophilic, and methylo-
trophic (i.e., grow best with one-carbon compounds, e.g., methanol or methylamine as carbon source and ammonia or amino acids as nitrogen source). May denitrify. Carbon dioxide is required for growth. Habitat is soil and fresh water.

**Type species:** *Hyphomicrobium vulgare.*

**Differentiation of the genus Hyphomicrobium** from closely related genera: The genera, Hyphomicrobium, Hyphomonas, and Hirschia all share the same general morphological features (Figure 13.6). However, they differ physiologically (see Table 13.1).

**Differentiation of the species of the genus Hyphomicrobium:** See Table 13.5.
---
Next, getting detailed information at the **Species** level from *Bergey's Manual of Systematic Bacteriology*

*Bergey's Manual of Systematic Bacteriology* is a more exhaustive work with detailed information for each Genus, including information about specific Species. In the first edition of *Bergey's*, bacteria are classified by phenotypic characteristics, whereas in the second edition they are mostly grouped by similarity of their 16s rRNA sequences. Each of these editions consists of several volumes:

**First Edition**
- **Volume 1**: Gram-Negative Bacteria of General, Medical, or Industrial Importance (1984)
- **Volume 2**: Gram-Positive Bacteria Other than Actinomycetes (1986)
- **Volume 3**: Archaeobacteria, Cyanobacteria, and Remaining Gram-Negative Bacteria (1989)
- **Volume 4**: Actinomycetes (1989)

***Index in back of Volume 4 covers all 4 volumes.***

**Second Edition** (Chemistry Library has volumes 1-3 in print; volumes 2-4 are available online)
- **Volume 1**: The Archaea and the Deeply Branching and Phototrophic Bacteria (2001)
- **Volume 2**: The Proteobacteria (2005)
  - **2a**: Introductory Essays (2005)
  - **2b**: The Gammaproteobacteria (2005)
  - **2c**: The Alpha-, Beta-, Delta-, and Epsilonproteobacteria (2005)
- **Volume 3**: The Firmicutes
- **Volume 4**: The Bacteroidetes, Spirochaetes, Tenericutes (Mollicutes), Acidobacteria, Fibrobacteres, Fusobacteria, Dictyoglomi, Gemmatimonadetes, Lentisphaerae, Verrucomicrobia, Chlamydiae, and Planctomycetes (2010)
- **Volume 5**: The Actinobacteria, Part A (2012)

<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Go to the index in the back of <strong>volume 4</strong> (this index covers all 4 volumes; page numbers continue on to each volume and do not restart).</td>
<td>1. Go to the index in each separate volume to search. I suggest <strong>starting with volume 2c</strong>, then volumes 2b, 3 and 4 (4 is online only), in that order.</td>
</tr>
<tr>
<td>2. Look up your <strong>Genus</strong> in the index and note the page number(s) for your <strong>species</strong>. In my case, I would look for “Hyphomicrobium,” then “vulgare” underneath, and see:</td>
<td>2. Look up your <strong>Genus</strong> in the index and note the page number(s) for your <strong>species</strong>. In my case, I would look for “Hyphomicrobium,” then “vulgare” underneath, and see:</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Hyphomicrobium, 1677, 1837, 1873, 1891-1893, <strong>1895</strong>, 1896-1904...</th>
<th>Hyphomicrobium, 93, 176-178, 180, 182, 183, 193, 297-299, 397...</th>
</tr>
</thead>
<tbody>
<tr>
<td>aestuarii, 1898-1900, <strong>1901</strong></td>
<td>aestuarii, 478, 487-489, <strong>490</strong></td>
</tr>
<tr>
<td>coagulans, 1898-1900, <strong>1903</strong></td>
<td>coagulans, 489, 490, <strong>491</strong></td>
</tr>
<tr>
<td>...</td>
<td>...</td>
</tr>
<tr>
<td>variabile, 1899</td>
<td>variabile, 486</td>
</tr>
<tr>
<td>vulgare, 1895, 1897-1900 <strong>1901</strong>, 1909</td>
<td>vulgare, 187, 475, 478, 486, <strong>487</strong>, 488-490, 530...</td>
</tr>
<tr>
<td>zavarzinii, 462, 473</td>
<td>zavarzinii, 478, 487-491, <strong>493</strong></td>
</tr>
</tbody>
</table>

The page number in **BOLD** is the main page to find information for a particular Species, so I would go to page 1901 (in volume 3) for *Hyphomicrobium vulgare*.

*Note, other page numbers listed in the index will lead you to either differentiation/characteristic tables or bacteria entries where your bacteria is mentioned.*

The differential characteristics of the species of *Hyphomicrobium* are indicated in Table 21.3. Morphological characteristics of the species are listed in Table 21.4, and physiological properties are listed in Table 21.5.

**List of species of the genus Hyphomicrobium**


   Mother cells oval, pear, or drop-shaped, 0.5–1.2 × 1–3 μm, with hyphae of varying lengths and a diameter of 0.2–0.3 μm (up to 0.4 μm when stained). In fluids, cells do not form rosettes; growth may occur on turbidity or finely dispersed yellowish-brown colonies or on turbidity and turbidity. Swarmer cells with one to three subpolar flagella. Colonies remain small even after long incubation, colorless or beige, in transmitted light brown. Colony surface shiny but granular, the edge is wavy.

Chemosynthetic, aerobic, oligotrophic phototrophic. Grow well with methanol, methylamine-HCl, formate, acetate, β-methylisobutyrate, isovalerate, propionate, lactate (except for *MC-750*), isobutanol, glycerol, L-arabinose, D-mannose, 3-methylpyruvate, raffinose, dextrin, amygdalin, ascorbic, D-glucosamine, N-acetylglucosamine, dilute human urine, succinate and some carbonyl compounds. Growth is slow but stimulated by pyruvate, α-methylglutarate, β-hydroxybutyrate, oxalate, galacturonate, chitin, lactose, and α-maltose. Most amino acids are inhibitory. The type strain grew well with propionate, iso- and valerate, and succinate. It did not grow with fructose or sucrose.

Nitrates sources utilized (in order of growth stimulation) are NH₄⁺, NO₂⁻, NO₃⁻, and urea. Do not use urea or fix NO₃⁻ although slow oligotrophic growth has been observed. Do not nitrate. Anaerobic growth occurs in the presence of NO₃⁻ but NO₃⁻ has not been detected. Small growth on sheep blood agar.

Strain MC-750 is inhibited by 30 μg disks of kanamycin, neomycin, and novobiocin and by 10 μg of streptomycin. It tolerates 5.5% NaCl, but growth is retarded at this concentration. The pH optimum is between 6.5 and 7.5; the temperature range for growth is 15–37°C. *MC-750* is catalase and cytochrome oxidase positive, but sheep's blood is hemolyzed (de-hemolysis), and most cells form poly-β-hydroxybutyrate as a storage product, MC-750 is not pathogenic for mice and guinea pigs.

Habitat: soil. The type strain came from construction soil. The mol% G + C of the DNA is 61.4 (EMMC 750); 61.9 (EMMC 751). Genome size: 21.3 × 10⁶ (Köhlh-Boelke et al., 1985).

Type strain: the original type strain no longer exists, a separate culture is being proposed: IFAM MC-760 (ATCC 25700).

2. *Hyphomicrobium vulgare* (neotype strain IFAM MC-760; ATCC 27600).

3. *Hyphomicrobium aestuarii* sp. nov. *aestuarii* L. aestuarium estuary, M.L. gen. n. aestuarii of the estuary.

   Mother cells bean-shaped, often with short hyphae; the bud is also bean-shaped, but bent at a 90° angle from the mother cell. Cell sizes: mother cell 6.0 (0.5–1.6) μm wide and 1.6 (0.5–5.0) μm long. Older hyphae branched. Swarmer cells with one to three subpolar flagella. Cells do not form rosettes but clump easily and grow as parent cells in liquids.


**Differential of the species of the genus Hyphomicrobium**

The differential characteristics of the species of *Hyphomicrobium* are given in Table BXIIa.163, morphological characteristics of the species are listed in Table BXIIa.165, and physiological properties are listed in Table BXII.184.

**List of species of the genus Hyphomicrobium**


   The following description is based on characteristics given by Stutzer and Hartlib (1888) and those of the neotype strain, IFAM MC-750. Mother cells are oval, pear, or drop-shaped, 0.5–1.2 × 1–3 μm, with pseudohyphae (hyphae) of varying lengths and a rather constant diameter (0.2–0.3 μm, up to 0.4 μm when stained). In liquids, growth occurs as turbidity or finely dispersed yellowish-brown colonies or turbidity and turbidity. Cells do not form rosettes. Swarmer cells with one to three subpolar flagella. Colonies remain small even after long incubation; they are colorless or beige, and brownish in transmitted light. Colony surface shiny but granular, the edge is wavy.

Chemosynthetic, aerobic, oligotrophic phototrophic. Grow well with methanol, methylamine-HCl, formate, acetate, β-methylisobutyrate, iso-valerate, propionate, lactate (except for IFAM MC-750), isobutanol, glycerol, L-arabinose, D-mannose, 3-methylpyruvate, raffinose, dextrin, amygdalin, ascorbic, D-glucosamine, N-acetylglucosamine, dilute human urine, succinate and some carbonyl compounds. Growth is slow but stimulated by pyruvate, α-methylglutarate, β-hydroxybutyrate, oxalate, galacturonate, chitin, lactose, and α-maltose. Most amino acids are inhibitory. The type strain grew well with propionate, iso- and valerate, and succinate. It did not grow with fructose or sucrose.

Nitrates sources utilized (in order of growth stimulation) are NH₄⁺, NO₂⁻, NO₃⁻, and urea. Do not use urea or fix NO₃⁻ although slow oligotrophic growth has been observed. Do not nitrate. Anaerobic growth occurs in the presence of NO₃⁻ but NO₃⁻ has not been detected. Slow growth on sheep blood agar.

Strain IFAM MC-750 is inhibited by 30 μg disks of kanamycin, neomycin, and novobiocin and by 10 μg of streptomycin. It tolerates 5.5% NaCl, but growth is retarded at this concentration. The pH optimum is between 6.5 and 7.5; the temperature range for growth is 15–37°C. *MC-750* is catalase and cytochrome oxidase positive, but sheep's blood is hemolyzed (de-hemolysis), and most cells form poly-β-hydroxybutyrate as a storage product, MC-750 is not pathogenic for mice and guinea pigs.

The genome size is 2.13 × 10⁶ Da (Köhlh-Boelke et al., 1985).

Habitat: soil. The neotype strain came from construction soil. The mol% G + C of the DNA is 61.4 (Em. 1936) or 61.1 (EPLC) (Ukamni et al., 1995).

GenBank accession number (16S RNA): Y14392.

Additional Remarks: IFAM MC-750 (ATCC 27600) is recommended as the neotype strain; the original type strain no longer exists.


   Mother cells bean-shaped, often with short hyphae; the terminal bud on a hypha is also bean shaped, but is turned at a 90° angle from the mother cell. Mother cells 0.6 ×...