Bergey's Manual:

Reference for Prokaryote identification

***Bergey's Manual of Determinative Bacteriology*:** Is standard reference for laboratory identification of bacteria.	Morphology, differential staining, biochemical tests to test for presence of various enzymes.
Bergey's Manual of Systematic Bacteriology Provides phylogenetic information on bacteria and archaea	Based on rRNA sequencing

Bergey's Manual of Determinative Bacteriology

First published in 1923 by **David Hendricks Bergey,** it is used to classify bacteria based on their structural and functional attributes by arranging them into specific familial orders.

9th Edition
Edited by John G. Holt

Williams & Wilkins, Baltimore
ISBN 0-683-00603-7
This book is still in print

Criteria for identification and classification

Morphology

Cell Shape & Arrangement

- Cell Size
- Staining Reaction

Chemical

Chemical Composition

- Teichoic acid
- LPS

Cultural

Nutritional Requirements

Living Host Requirement

Physical Conditions

- Temperature, Light, Gas

Metabolic

Energy Yielding Processes

- Fermentation

Energy Utilizing Processes

- Nutrient transport

Motility

Enzymes

Antigens

Stimulate the immune system

-antigens

Genetics

G-C ratio

Plasmids

Pathogenic

Cause disease

Host - plant, animal

Ecological

Habitat

Bergey's Manual of Systematic Bacteriology

1st Edition

John G. Holt, Editor-in-Chief

Williams & Wilkins, Baltimore, MD

Published in 4 volumes:

Volume 1 (1984)

Gram-negative *Bacteria* of general, medical, or industrial importance

ISBN 0-683-04108-8

Volume 2 (1986)

Gram-positive *Bacteria* other than *Actinomycetes*

ISBN 0-683-07893-3

Volume 3 (1989)

Archaeobacteria, *Cyanobacteria*, and remaining Gram-negative *Bacteria* ISBN 0-683-07908-5

Volume 4 (1989)

Actinomycetes

ISBN 0-683-09061-5

Bergey's Manual of Systematic Bacteriology
2nd Edition

Published by Springer, New York
The second edition is being published in 5 volumes

Volume 1 (2001)

The *Archaea* and the deeply branching and phototrophic *Bacteria*
Editor-in-Chief: George M. Garrity
Editors: David R. Boone and Richard W. Castenholz
ISBN 0-387-98771-1

Volume 2 (2005)

The *Proteobacteria*

Editor-in-Chief: George M. Garrity

Editors: Don J. Brenner, Noel R. Krieg and James T. Staley

ISBN 0-387-95040-0

2A: Introductory essays

2B: The Gammaproteobacteria

2C: Other classes of Proteobacteria

Volume 3 (2009)

The *Firmicutes*

Editors: Paul De Vos, George Garrity, Dorothy Jones, Noel R. Krieg, Wolfgang Ludwig, Fred A. Rainey, Karl-Heinz Schleifer and William B. Whitman

ISBN 0-387-95041-9

Volume 4 (2010)

The *Bacteroidetes*, *Spirochaetes*, *Tenericutes* (*Mollicutes*), *Acidobacteria*, *Fibrobacteres*, *Fusobacteria*, *Dictyoglomi*, *Gemmatimonadetes*, *Lentisphaerae*, *Verrucomicrobia*, *Chlamydiae*, and *Planctomycetes*

Editors: Noel R. Krieg, James T. Staley, Daniel R. Brown, Brian Hedlund, Bruce J. Paster, Naomi Ward, Wolfgang Ludwig and William B. Whitman

ISBN 0-387-95043-5

Volume 5 (2012) in two parts

The *Actinobacteria*
Editors: Michael Goodfellow, Peter Kämpfer, Hans-Jürgen Busse, Martha Trujillo, Ken-ichiro Suzuki, Wolfgang Ludwig and William B. Whitman
ISBN 0-387-95042-7

Bergey's Manual of Systematic Bacteriology

- Prokaryotes into 25 phyla
  - Archaea
    - 2
  - Bacteria
    - 23
- Consensus of experts

Microbial Phylogeny

- **Domains**
  - Based on the research of Woese and others in the 1980s and 1990s, most biologists divide all living organisms into 3 domains:
    - **Domain *Archaea***
    - **Domain *Bacteria***
    - **Domain *Eucarya***
  - rRNA sequence data suggests that *Archaea* & *Eucarya* may share a more recent common ancestor with each other than with bacteria.

- **Phylogeny of domain *Archaea* (Volume 1)**

  – Based primarily on rRNA sequence data, domain *Archaea* is divided into two phyla:

  - **Phylum *Crenarchaeota***
    – Originally containing thermophylic and hyperthermophilic sulfur-metabolizing archaea
    – Recently discovered *Crenarchaeota* are inhibited by sulfur & grow at lower temperatures

  - **Phylum *Euryarchaeota***
    – Contains primarily methanogenic archaea, halophilic archaea, and thermophilic, sulfur-reducing archaea

- **Phylogeny of domain *Bacteria***
  - The 2nd edition of *Bergey's Manual of Systematic Bacteriology* divides domain *Bacteria* into 23 phyla. Nine of the more notable phyla are described here.
    - **Phylum *Aquiflexa***
      - The earliest "deepest" branch of the *Bacteria*
      - Contains genera *Aquiflex* and *Hydrogenobacter* that can obtain energy from hydrogen via chemolithotrophic pathways

- **Phylum *Cyanobacteria***
  - Oxygenic photosynthetic bacteria

- **Phylum *Chlorobi***
  - The “green sulfur bacteria”
  - Anoxygenic photosynthesis
  - Includes genus *Chlorobium*

- **Phylum *Proteobacteria* (Volume 2)**
  - The largest group of gram-negative bacteria
  - Extremely complex group, with over 400 genera and 1300 named species
  - All major nutritional types are represented: phototrophy, heterotrophy, and several types of chemolithotrophy
  - Sometimes called the "purple bacteria," although very few are purple; the term refers to a hypothetical purple photosynthetic bacterium from which the group is believed to have evolved.
  - Divided into 5 classes: *Alphaproteobacteria*, *Betaproteobacteria*, *Gammaproteobacteria*, *Deltaproteobacteria*, *Epsilonproteobacteria*

- **Phylum *Proteobacteria* (cont.)**
  - Significant groups and genera include:
    - Photosynthetic genera such as *Rhodospirillum* (a purple non-sulfur bacterium) and *Chromatium* (a purple sulfur bacterium)
    - Sulfur chemolithotrophs, genera *Thiobacillus* and *Beggiatoa*
    - Nitrogen chemolithotrophs (nitrifying bacteria), genera *Nitrobacter* and *Nitrosomonas*
    - Other chemolithotrophs, genera *Alcaligenes*, *Methylobacilllus*, *Burkholderia*

- **Phylum *Proteobacteria* (cont.)**
  - Significant groups and genera include:
    - The family *Enterobacteriaceae*, the "gram-negative enteric bacteria," which includes genera *Escherichia*, *Proteus*, *Enterobacter*, *Klebsiella*, *Salmonella*, *Shigella*, *Serratia*, and others
    - The family *Pseudomonadaceae*, which includes genus *Pseudomonas* and related genera
    - Other medically important *Proteobacteria* include genera *Haemophilus*, *Vibrio*, *Camphylobacter*, *Helicobacter*, *Rickettssia*, *Brucella*

- **Phylum *Firmicutes* (Volume 3)**
  - "Low G + C gram-positive" bacteria
  - Divided into 3 classes
    - » Class I – Clostridia; includes genera *Clostridium* and *Desulfotomaculatum*, and others
    - » Class II – *Mollicutes*; bacteria in this class cannot make peptidoglycan and lack cell walls; includes genera *Mycoplasma*, *Ureaplasma*, and others.
    - » Class III – Bacilli; includes genera *Bacillus*, *Lactobacillus*, *Streptococcus*, *Lactococcus*, *Geobacillus*, *Enterococcus*, *Listeria*, *Staphylococcus*, and others

- **Phylum *Actinobacteria* (Volume 5)**
  - "High G + C gram-positive" bacteria
  - Includes genera *Actinomyces*, *Streptomyces*, *Corynebacterium*, *Micrococcus*, *Mycobacterium*, *Propionibacterium*

- **Phylum *Chlamidiae* (Volume 4)**
  - Small phylum containing the genus *Chlamydia*

  obligate intracellular parasites, causes sexually transmitted diseases

- **Phylum *Spirochaetes* (Volume 4)**
  - The spirochaetes
  - Characterized by flexible, helical cells with a modified outer membrane (the outer sheath) and modified flagella (axial filaments) located within the outer sheath
  - Important pathogenic genera include *Treponema*, *Borrelia*, and *Leptospira*
- **Phylum *Bacteroidetes* (Volume 4)**
  - Includes genera *Bacteroides*, *Flavobacterium*, *Flexibacter*, and *Cytophyga*; *Flexibacter* and *Cytophyga* are motile by means of "gliding motility"

- **Phylogeny of domain *Eucarya***

  - The domain ***Eucarya*** is divided into four kingdoms by most biologists:
    - Kingdom ***Protista***, including the protozoa and algae
    - Kingdom ***Fungi***, the fungi (molds, yeast, and fleshy fungi)
    - Kingdom ***Animalia***, the multicellular animals
    - Kingdom ***Plantae***, the multicellular plants

Prokaryotic Diversity And Taxonomy: Current Status Future Challenges

1. **The abundance of bacteria and archaea on Earth-** Kluvyer and Niel one half of living protoplasm on Earth is microbial

2. **The definition of bacterial species-** DNA –DNA hybridization , >70 % similarity

3. **How many prokaryotic species have been described?** ICSP, In 2003 validated names of prokaryotes described were 6205 belonging to 1174genera

4. **How many prokaryote species are there on Earth?** 16S rRNA sequencing approach, microbes from environment, limitations

5. **Are bacteria distributed ubiquitously and do endemic bacterial species exist?** Symboints and pathogens of animals and plant endemic, Antarctic region, Sea water

6. **Why are we not able to grow all living prokaryotes?** Complex nutritional requirement, microbial consortia

7. **Novel types of metabolism in prokaryotes-** ammonium oxidation, reversed methanogenesis

8. **Are there endangered Prokaryotes?**
   geogrophical areas or habitats may be endangered e.g. hot springs

9. **Development of novel isolation techniques for prokaryotes**

Laser optical tweezers-Use of infra red laser for micromanipulation of a single bacterial cell in a capillary tube.
Dilution cultures- Oligotropic marine bacteria

10. **Funding for microbial diversity studies-** 5%of living species, less funds are available as compared to research in plants and animals, DNA chip technology/ proteomics