Bacterial Classification and Nomenclature

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What is Taxonomy

✓ **Taxonomy is the science of the classification of organisms, with the goal of showing evolutionary relationships among organisms.**

✓ **Taxonomy includes:**

(a) Identification.

(b) Nomenclature.

(c) Classification.

Identification – is the process of studying and recording the identical and distinguishing features

Nomenclature – is the process of assigning names to the various taxonomic ranking of each living organism.

Classification – is the orderly arrangement of organisms into groups, preferably in a format, that shows evolutionary relationships.

Basis of Taxonomy

✓**Phenetic system** groups organisms based on mutual similarity of phenotypic characteristics. May or may not correctly match evolutionary grouping, e.g. motile v/s non motile bacteria

✓**Phylogenetic system** groups organisms based on shared evolutionary genetic heritage.

Taxonomy of bacteria

✓**Living organisms** were once divided into only two kingdoms: **plantae and animaliae**: bacteria, fungi, and algae were classified with plants; protozoa were classified as animals.

✓**Haeckel in 1865 proposed third kingdom Protista for unicellular microorganisms such as bacteria, algae, fungi and protozoa.**

✓ **Bacteria were separated into the Kingdom Procaryotae or Monera in 1969 by Whittaker – five kingdoms**

Whittaker 5 Kingdom classification

Based on cellular organization and nutritional patterns:

Procaryotae or Monera - prokaryotic, unicellular, variable nutrition patterns – bacteria.

Protista- eukaryotic, unicellular or colonial, heterotrophic – protozoa, slime molds, some algae.

Myceteae or Fungi - eukaryotic, unicellular or multicellular, heterotrophic or absorptive – molds, yeasts, mushrooms.
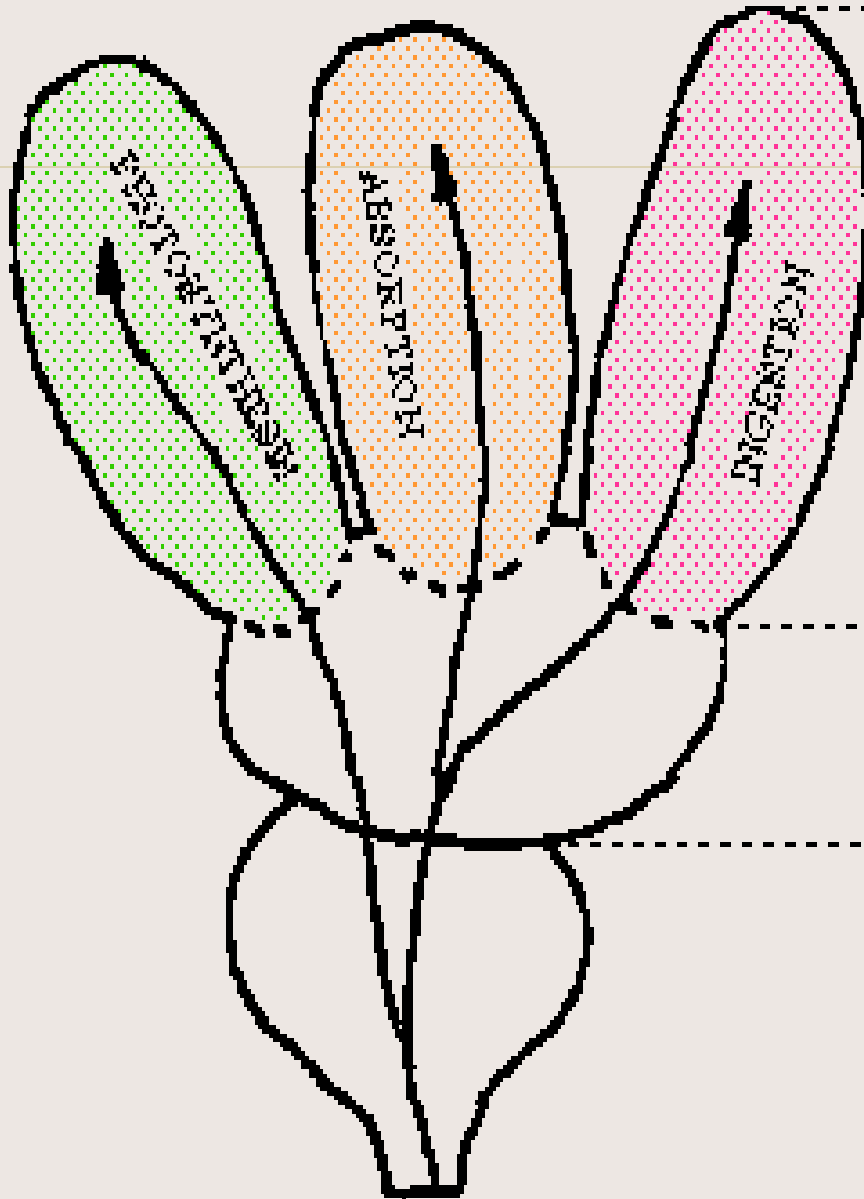
Plantae - eukaryotic, multicellular or colonial, autotrophic – plants, some algae, mosses, ferns.

Animalia - eukaryotic, multicellular, heterotrophic or ingestive – animals.

Plantae   Fungi   Animalia

PHOTOSYNTHESIS   ABSORPTION   INGESTION

Eukaryotic, multicellular

Protista (Eukaryotic, unicellular

Monera (Prokaryotic)
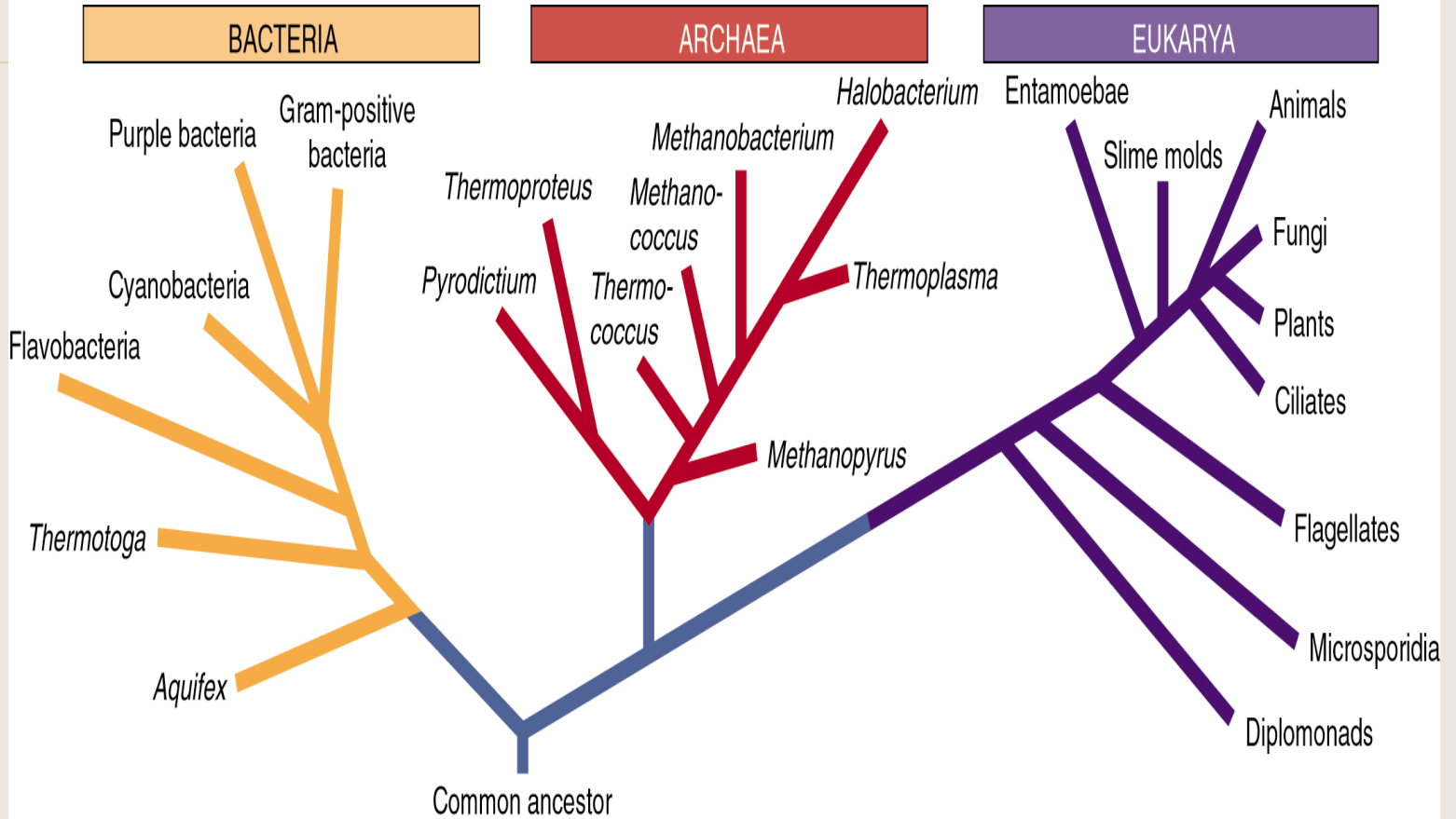
The Three Domains

(Carl Woese and George Fox, 1977)

Currently, living organisms are divided into three super kingdoms,   called as **domains,**

✓ **Eukarya Domain** **include plants, animals, fungi, and protists**

✓ **Eubacteria Domain** **include bacteria with peptidoglycan in cell wall.**

✓ **Archaea Domain** **include bacteria(Archaea) with unusual cell walls**

➢ **Based on cellular rRNAs sequence primarily**

➢ **cell membrane lipid structure and sensitivity to antibiotics.**

➢ **rRNA molecules throughout nature carry out the same function and genetically stable very little over time.**

➢ **This system proposes that a common ancestor cell ("Cenancestor") gave rise to three different cell types, each representing a domain.**

Three Cellular Domains

BACTERIA   ARCHAEA   EUKARYA

Purple bacteria   Gram-positive bacteria   *Thermoproteus*   *Methanobacterium*   *Halobacterium*   Entamoebae   Animals

Pyrodictium   *Methano-coccus*   *Thermoplasma*   Slime molds   Fungi

Cyanobacteria   *Thermo-coccus*   Plants

Flavobacteria   Ciliates

Methanopyrus   Flagellates

Thermotoga

Aquifex   Microsporidia

Diplomonads

Common ancestor
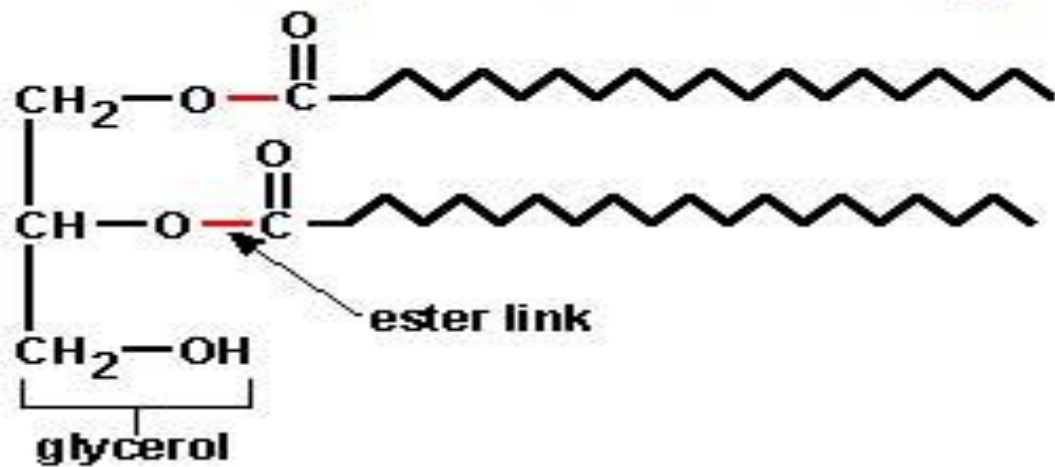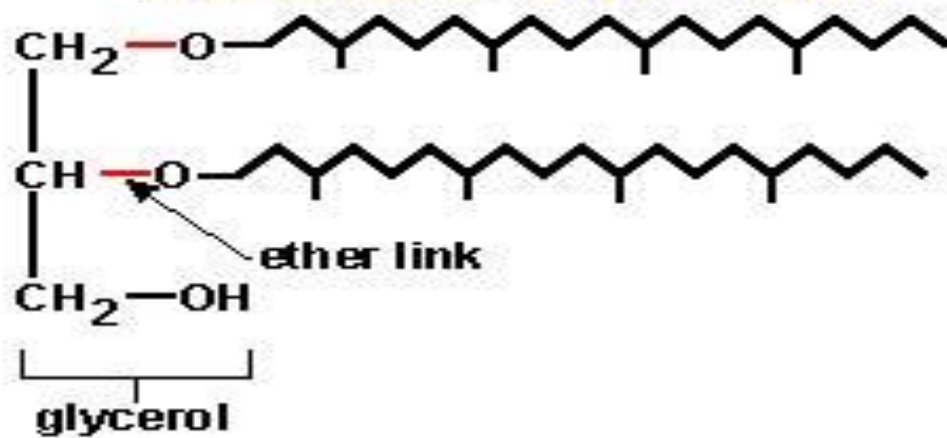
The *Archaea* (archaebacteria)

- *Archaea* are prokaryotic cells.

- contain rRNA that is unique to the *Archaea* distinctly different from the rRNA of *Bacteria* and *Eukarya*.

- cell membranes composed of branched hydrocarbon chains attached to glycerol by ether linkages.

- cell walls of *Archaea* does not have peptidoglycan.

- *Archaea* are not sensitive to some antibiotics that affect the *Bacteria*, but are sensitive to some antibiotics that affect the *Eukarya*.

Membrane Lipids of *Bacteria* and *Eukarya*

ester link

glycerol

Membrane Lipids of *Archaea*

ether link

glycerol

The *Bacteria* (eubacteria)

- *Bacteria* are prokaryotic cells.

- contain rRNA that is unique to the *Bacteria* distinctly different from the rRNA of *Archaea* and *Eukarya*.

- celll membranes composed of unbranched fatty acid chains attached to glycerol by ester linkages .

- cell walls contain peptidoglycan.

- *Bacteria* are sensitive to traditional antibacterial antibiotics but are resistant to most antibiotics that affect *Eukarya*.

The *Eukarya* (eukaryotes)

- *Eukarya* have eukaryotic cells.

- contain rRNA that is unique to the *Eukarya* distinctly different from the rRNA of *Archaea* and *Bacteria*.

- Cell membranes composed of unbranched fatty acid chains attached to glycerol by ester linkages .

- Not all *Eukarya* possess cell wall, but those having a cell wall does not contains peptidoglycan.

- *Eukarya* are resistant to traditional antibacterial antibiotics but are sensitive to most antibiotics that affect eukaryotic cells.

Methods of Identifying Bacteria

✓ **Morphological characteristics**

✓ **Biochemical tests**

✓ **Serological tests**

✓ **Phage typing**

✓ **Sequences of amino acids in proteins**

✓ **Percentage of G-C pairs in the nucleic acid**

✓ **Number and sizes of DNA fragments produced by restriction enzymes**

✓ **Sequence of bases in 16S rRNA (Ribotyping)**

Nomencalture of Bacteria

Scientific Nomenclature

✓ According to scientific nomenclature, each bacteria is assigned two names (**binomial nomenclature**): a genus and a species.

✓ Rules for the assignment of names to bacteria are established by the **International Committee on Systematic Bacteriology**.

Taxonomic hierachies

Linnaean hierarchy

Example for *E.coli*

Domain: Eubacteria

Kingdom: *Procaryotae*

Division/Phylum: *Gracilicutes*

Class: *Scotobacteria*

Family: *Enterobacteriaceae*

Genus: *Escherichia*

Species: *coli*

Methods of Classifying Bacteria

The Intuitive Method

In this method a microbiologist who is thoroughly familiar with the properties of the organisms decides that a particular organism represent a species or genus.

Dichotimous Key

1a	Gram-positive	Go to 2
1b	Not Gram-positive	Go to 3
2a	Cells spherical in shape	Gram-positive cocci
2b	Cells not spherical in shape	Go to 4
3a	Gram-negative	Go to 5
3b	Not Gram-negative (lack cell wall)	Mycoplasma
4a	Cells rod-shaped	Gram-positive bacilli
4b	Cells not rod-shaped	Go to 6
5a	Cells spherical in shape	Gram-negative cocci
5b	Cells not spherical in shape	Go to 7
6a	Cells club-shaped	Corynebacteria
6b	Cells variable in shape	Propionibacteria
7a	Cells rod-shaped	Gram-negative bacilli
7b	Cells not rod-shaped	Go to 8
8a	Cells helical with several turns	Spirochetes
8b	Cells comma-shaped	Vibrioids

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by Jacquelyn G. Black

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Numerical taxonomy

In this method of taxonomy of many (100 to 200) characteristics for each bacterial strain is determined, giving each characteristic equal weight. Then percentage similarity (%S) of each strain to every other known strain is calculated by the formula:
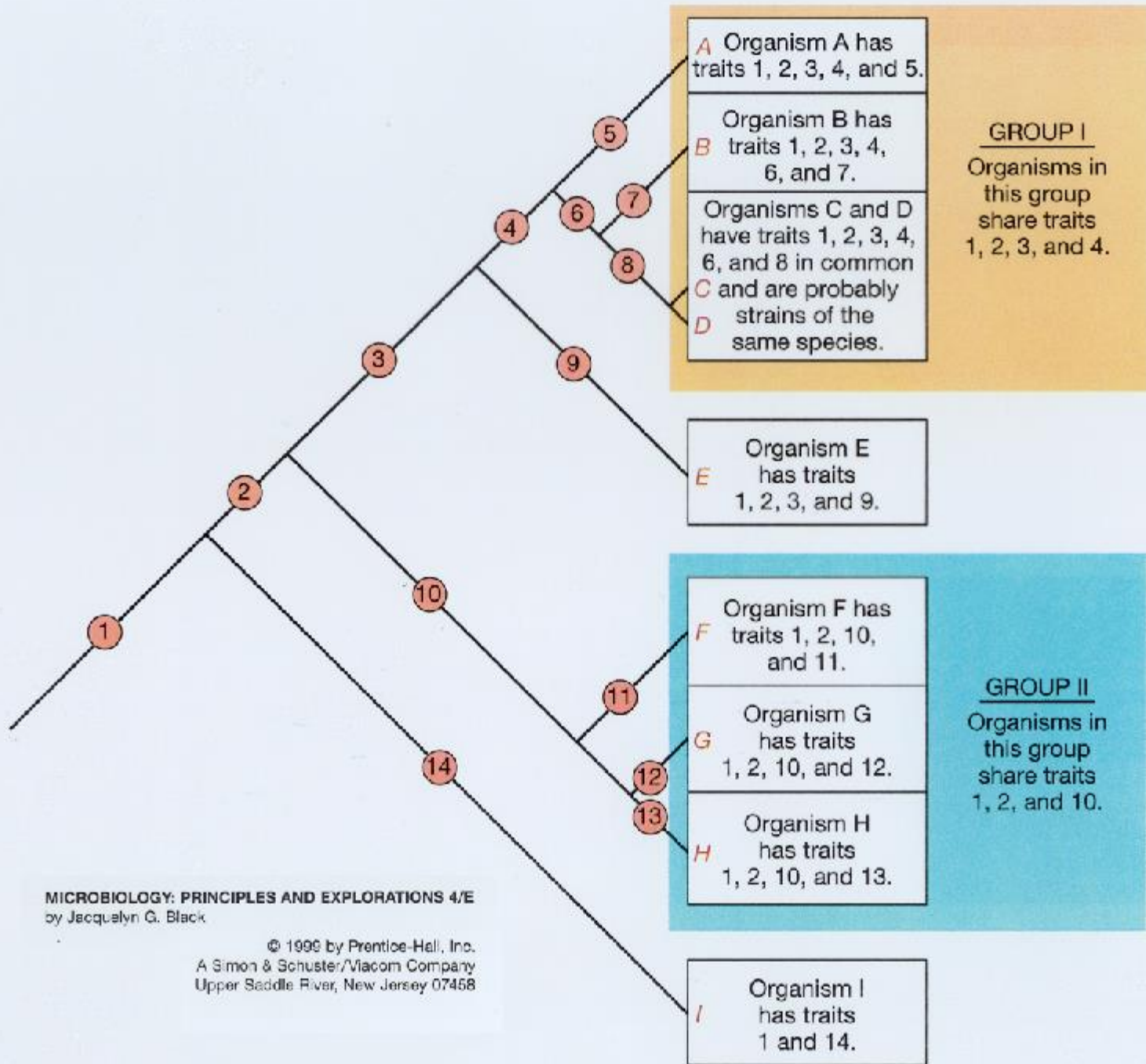
$$\%S = ND/NS + ND$$

where,

NS= number of characteristics that are same (positive or negative) for the two strains,

ND = number of characteristics that are different.

strains having a higher %S to each other are placed into same group

Numerical Taxonomy

A Organism A has traits 1, 2, 3, 4, and 5.

B Organism B has traits 1, 2, 3, 4, 6, and 7.

C Organisms C and D have traits 1, 2, 3, 4, 6, and 8 in common and are probably strains of the same species.
D

GROUP I
Organisms in this group share traits 1, 2, 3, and 4.

E Organism E has traits 1, 2, 3, and 9.

F Organism F has traits 1, 2, 10, and 11.

G Organism G has traits 1, 2, 10, and 12.

H Organism H has traits 1, 2, 10, and 13.

GROUP II
Organisms in this group share traits 1, 2, and 10.

I Organism I has traits 1 and 14.

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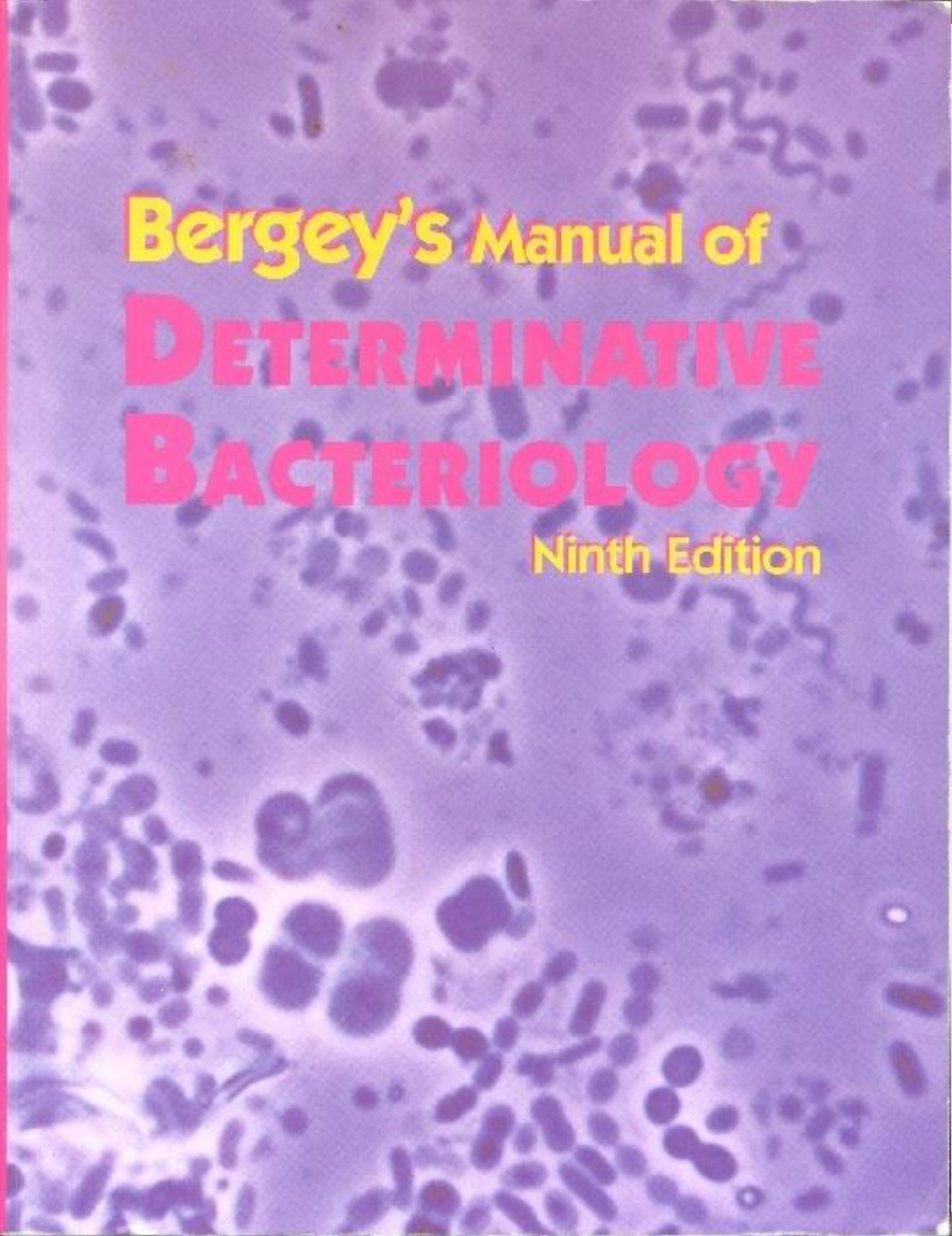Upper Saddle River, New Jersey 07458

Genetic Relatedness

➢ **most reliable method of classification**

➢ **based on the degree of genetic relatedness between organisms**

➢ **relies upon G+C content, DNA homology, ribosomal RNA homology (16S rRNA for prokaryotes and 18S rRNA for eukaryotes – ribotyping).**

Genetic homologies (similarities) can be determined by looking at:

- Base compositions

- DNA-DNA or DNA-RNA Hybridization

- DNA or RNA sequencing

Bergey's Manual

Bergey's Manual of
DETERMINATIVE
BACTERIOLOGY
Ninth Edition

The Bergey's Manual

Bergey's Manual of Determinative Bacteriology

✓ **International standard for bacterial taxonomy.**

✓ **First published in 1923.**

✓ **9 editions have been published.**

✓ **From 1980 it is renamed as Bergey's Manual of Systemic Bacteriology published as a 4 volume set from 1984.**

✓ **In 2012 – 5 volume set.**

✓ **Currently *Bergey's Manual of Systematics of Archaea and Bacteria* (2015), an online book, replaces the five-volume set.**

In the original 4 volumes of **Bergey's Manual of Systematic Bacteriology,** bacteria were classified in 33 sections based on phenotypic, not phylogenetic characteristics.

Kingdom: Procaryotae
Divisions:

- ➤ **Gracilicutes** (thin skin): Procaryotes with a Gram-negative cell wall.

- ➤ **Firmicutes** (thick skin): Procaryotes with a Gram-positive cell wall.

- ➤ **Tenericutes** (soft or tender skin): Procaryotes that lack a cell wall.

- ➤ **Mendosicutes** (skin with faults): Procaryotes with unusual cell wall.

The current 5 volumes define taxa not in terms of phenotype, but solely on 16S phylogeny