The Most Important Bacteria

By: Dr. M. Mobini-Dehkordi

Class *Gammaproteobacteria*

- *Gammaproteobacteria* into 13 orders, 20 families, and around 160 genera.
- several deeply branching groups. One consists of the **purple sulfur bacteria**; a second includes the intracellular parasites ***Legionella.*** The two largest groups contain a wide variety of nonphotosynthetic genera: ***Vibrionaceae, Enterobacteriaceae,*** and ***Pasteurellaceae.*** Most are **facultative anaerobes.**
- These genera aere aerobic:***Pseudomonas,*** ***Azotobacter, Moraxella, Xanthomonas,*** and ***Acinetobacter.***

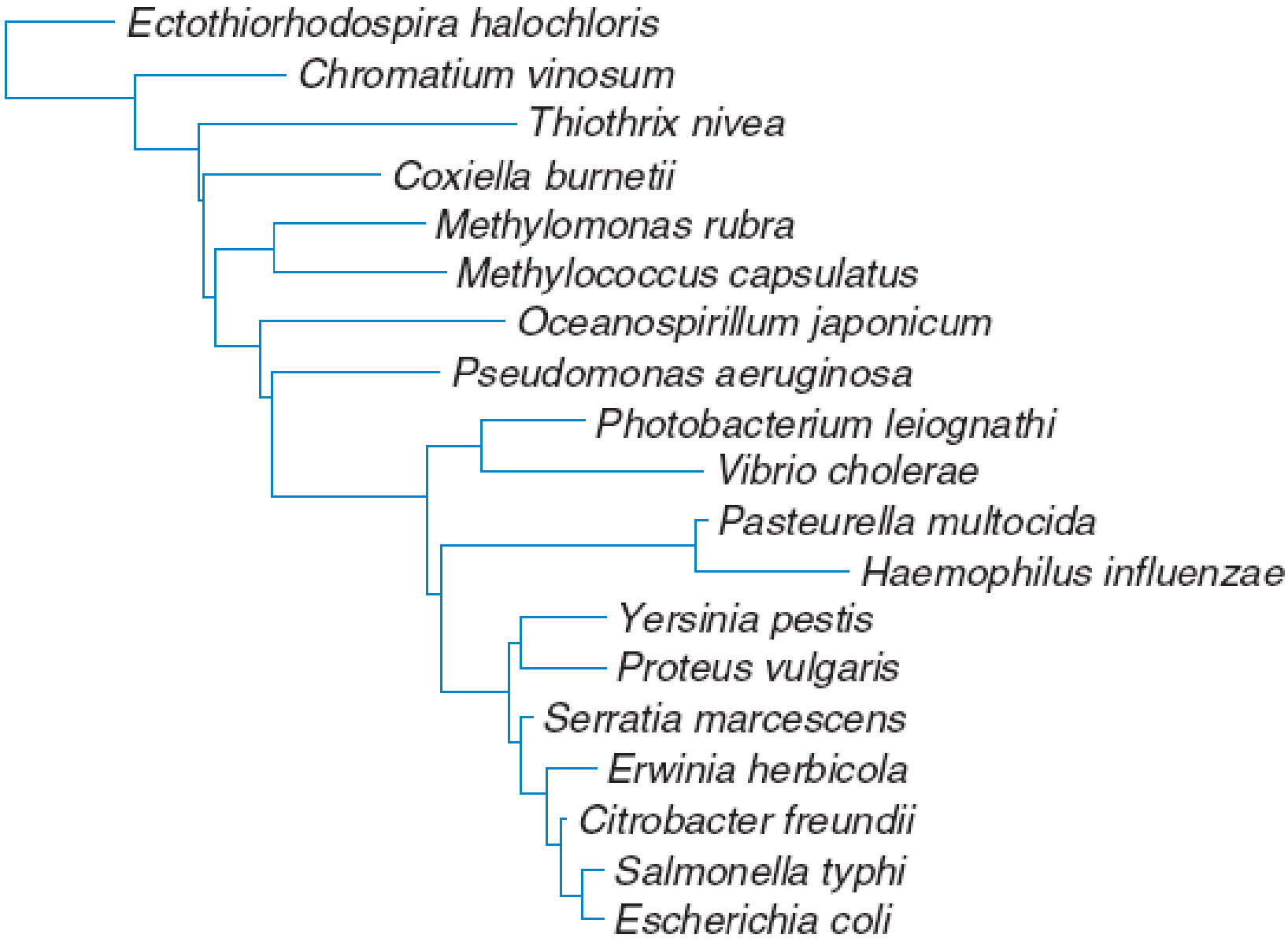

Ectothiorhodospira halochloris
Chromatium vinosum
Thiothrix nivea
Coxiella burnetii
Methylomonas rubra
Methylococcus capsulatus
Oceanospirillum japonicum
Pseudomonas aeruginosa
Photobacterium leiognathi
Vibrio cholerae
Pasteurella multocida
Haemophilus influenzae
Yersinia pestis
Proteus vulgaris
Serratia marcescens
Erwinia herbicola
Citrobacter freundii
Salmonella typhi
Escherichia coli

Table 22.5 Characteristics of Selected γ-Proteobacteria

Genus	Dimensions (μm) and Morphology	G + C Content (mol%)	Oxygen Requirement	Other Distinctive Characteristics
Azotobacter	1.5–2.0; ovoid cells, pleomorphic, peritrichous or nonmotile	63.2–67.5	Aerobic	Can form cysts; fix nitrogen nonsymbiotically
Beggiatoa	≈1–50 × ≈2–10; colorless cells form filaments, either single or in colonies	37–51	Aerobic or microaerophilic	Gliding motility; can form sulfur inclusions with hydrogen sulfide present
Chromatium	1–6 × 1.5–16; rod-shaped or ovoid, straight or slightly curved, polar flagella	48–70	Anaerobic	Photolithoautotroph that can use sulfide; sulfur stored within the cell
Ectothiorhodospira	0.5–1.5 in diameter; vibrioid- or rod-shaped, polar flagella	50.5–69.7	Anaerobic, some aerobic or microaerobic	Internal lamellar stacks of membranes; deposits sulfur granules outside cells
Escherichia	1.1–1.5 × 2–6; straight rods, peritrichous or nonmotile	48–52	Facultatively anaerobic	Mixed acid fermenter; formic acid converted to H_2 and CO_2, lactose fermented, citrate not used
Haemophilus	<1.0 in width; coccobacilli or rods, nonmotile	33–47	Facultative or aerobic	Fermentative; requires growth factors present in blood; parasites on mucous membranes
Leucothrix	Long filaments of short cylindrical cells, usually holdfast is present	46–51	Aerobic	Dispersal by gonidia, filaments don't glide; rosettes formed; heterotrophic
Methylococcus	1.0 in diameter; cocci with capsules, nonmotile	62–63	Aerobic	Can form a cyst; methane, methanol, and formaldehyde are sole carbon and energy sources
Photobacterium	0.8–1.3 × 1.8–2.4; straight, plump rods with polar flagella	40–44	Facultatively anaerobic	Two species can emit blue-green light; Na^+ needed for growth
Pseudomonas	0.5–1.0 × 1.5–5.0; straight or slightly curved rods, polar flagella	58–70	Aerobic	Respiratory metabolism with oxygen as acceptor; some are able to use H_2 or CO as energy source
Vibrio	0.5–0.8 × 1.4–2.6; straight or curved rods with sheathed polar flagella	38–51	Facultatively anaerobic	Fermentative or respiratory metabolism; sodium ions stimulate or are needed for growth; oxidase positive

The Purple Sulfur Bacteria

- The purple photosynthetic bacteria are distributed between **three** subgroups of the proteobacteria.
- They have common properties.
- *Bergey's Manual* divides the purple sulfur bacteria into two families: the ***Chromatiaceae*** and ***Ectothiorhodospiraceae.***
- ***Ectothiorhodospira*** has red, spiral-shaped, polarly flagellated cells that deposit sulfur globules externally.

Family I. *Chromatiaceae*
- Genus I. *Chromatium*
- Genus II. *Allochromatium*
- Genus III. *Halochromatium*
- Genus IV. *Isochromatium*
- Genus V. *Lamprobacter*
- Genus VI. *Lamprocystis*
- Genus VII. *Marichromatium*
- Genus VIII. *Nitrosococcus*
- Genus IX. *Pfennigia*
- Genus X. *Rhabdochromatium*
- Genus XI. *Thermochromatium*
- Genus XII. *Thioalkalicoccus*
- Genus XIII. *Thiocapsa*
- Genus XIV. *Thiococcus*
- Genus XV. *Thiocystis*
- Genus XVI. *Thiodictyon*
- Genus XVII. *Thioflavicoccus*
- Genus XVIII. *Thiohalocapsa*
- Genus XIX. *Thiolamprovum*
- Genus XX. *Thiopedia*
- Genus XXI. *Thiorhodococcus*
- Genus XXII. *Thiorhodovibrio*
- Genus XXIII. *Thiospirillum*

Family II. *Ectothiorhodospiraceae*
- Genus I. *Ectothiorhodospira*
- Genus II. *Arhodomonas*
- Genus III. *Halorhodospira*
- Genus IV. *Nitrococcus*
- Genus V. *Thioalkalivibrio*
- Genus VI. *Thiorhodospira*

Characteristic	Purple Sulfur
Major photosynthetic pigments	Bacteriochlorophyll *a* or *b*
Morphology of photosynthetic membranes	Photosynthetic system contained in spherical or lamellar membrane complexes that are continuous with the plasma membrane
Photosynthetic electron donors	H_2, H_2S, S
Sulfur deposition	Inside the cell[c]
Nature of photosynthesis	Anoxygenic
General metabolic type	Obligately anaerobic photolithoautotrophs
Motility	Motile with polar flagella; some are peritrichously flagellated
Percent G + C	45–70

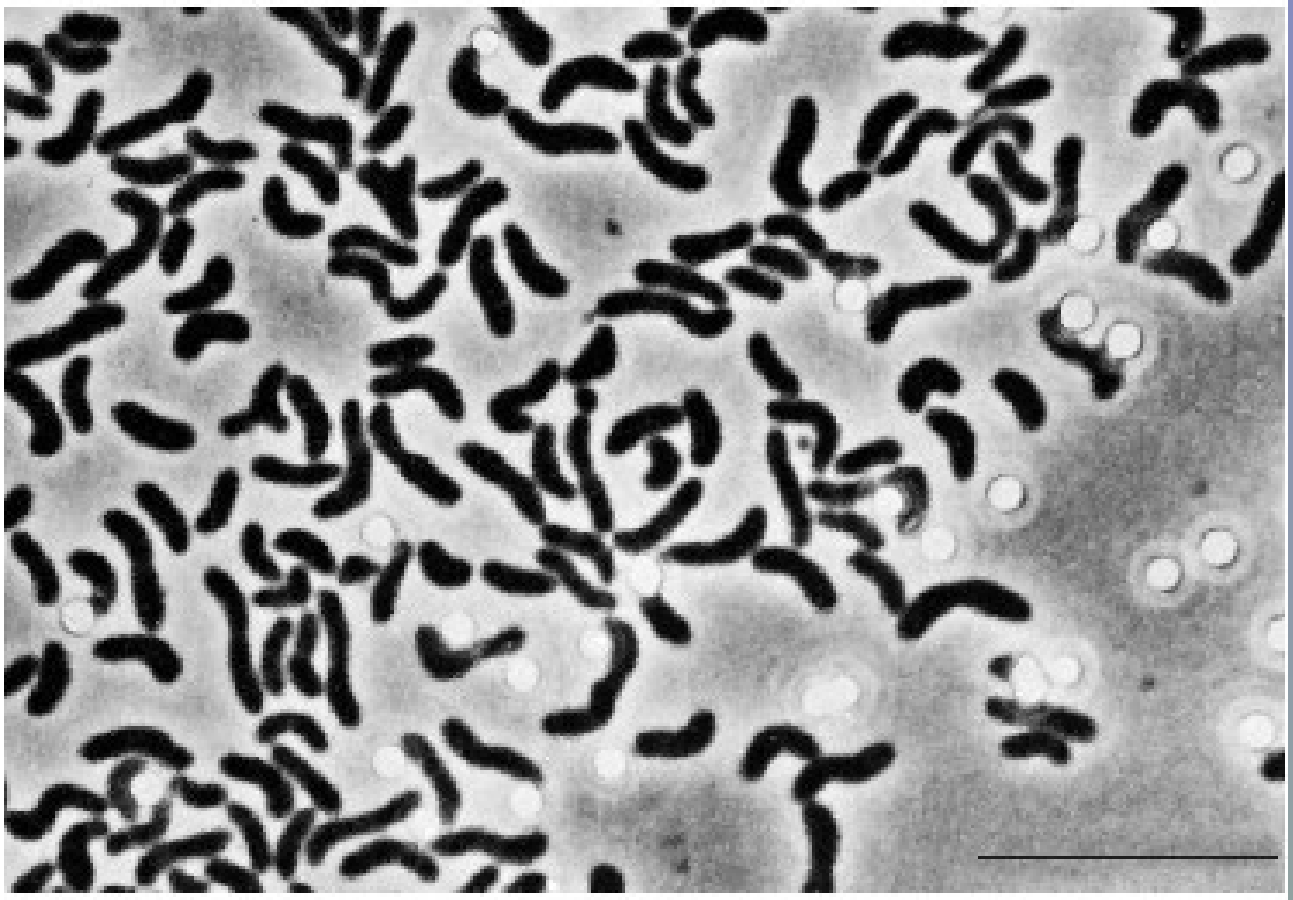
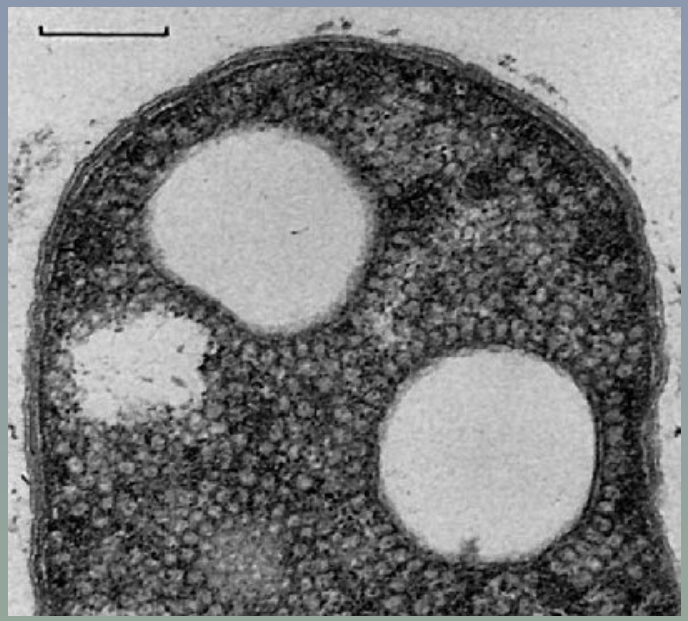
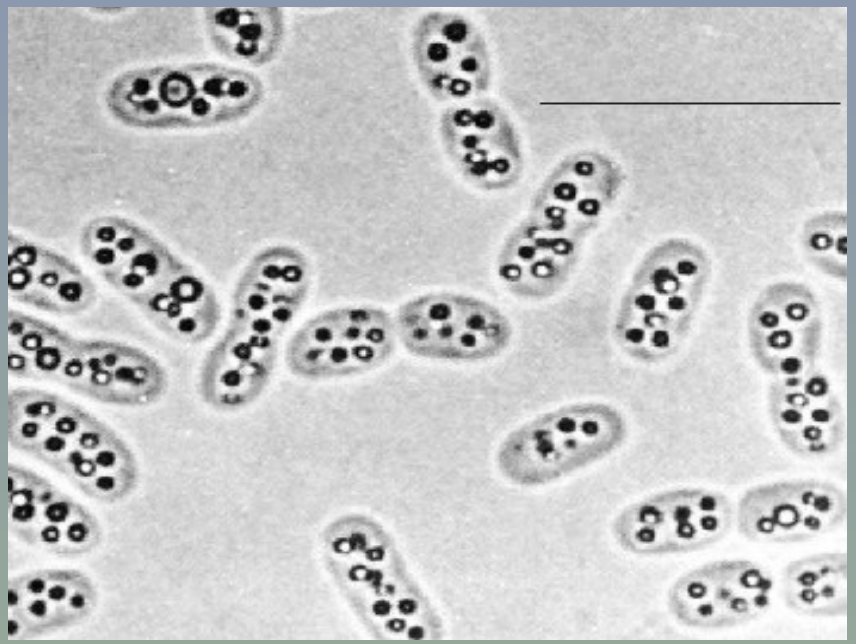


Figure 22.17 **Purple Bacteria.** *Ectothiorhodospira mobilis;* light micrograph. Bar = 10 μm.

The Purple Sulfur Bacteria

- **Internal** photosynthetic membranes are organized as lamellar stacks. The typical purple sulfur bacteria are located in the family ***Chromatiaceae***, which is much larger and contains 22 genera.





.***Chromatium vinosum*** with intracellular sulfur granules

The Purple Sulfur Bacteria

- *Thiospirillum, Thiocapsa,* and *Chromatium* are typical purple sulfur bacteria.They are found in anaerobic, sulfide-rich zones of lakes.
- Large blooms of purple sulfur bacteria occur in bogs and lagoons under the proper conditions.

Purple Photosynthetic Sulfur Bacteria. (**a**) Purple photosynthetic sulfur bacteria growing in a bog. (**b**) A sewage lagoon with a bloom of purple photosynthetic bacteria.

The family *Pseudomonadaceae* was circumscribed for this volume on the basis of phylogenetic analysis of 16S rRNA sequences; the family contains the genera *Pseudomonas* (type genus), *Azomonas*, *Azotobacter*, *Cellvibrio*, *Mesophilobacter*, *Rhizobacter*, and *Rugamonas*. *Serpens* is also included.

Aerobic chemoorganotrophs with respiratory metabolism. Most are motile by means of flagella. *Azomonas* and *Azotobacter* fix nitrogen; *Azotobacter* forms cysts.

Type genus: **Pseudomonas** Migula 1894, 237[AL.] (Nom. Cons.,

Pseudomonas

- The genus ***Pseudomonas*** contains straight or slightly gram-negative curved rods, 0.5 to 1.0 m by 1.5 to 5.0 m in length, that are motile by one or several polar flagella and lack **prosthecae or sheaths**.
- These chemoheterotrophs are aerobic and carry out respiratory metabolism with O2 (and sometimes nitrate) as the electron acceptor. All pseudomonads have a functional tricarboxylic acid cycle and can oxidize substrates to CO2.
- *Pseudomonas aeruginosa, P. fluorescens, P. putida,* and *P. syringae* are members of this group.

Pseudomonas

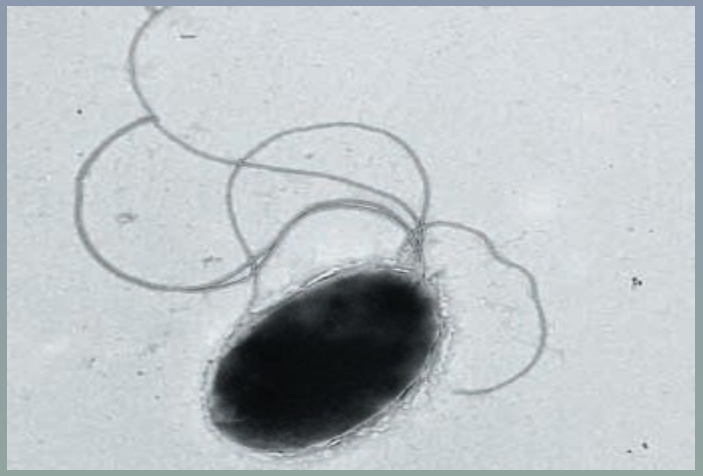
- ***P. fluorescens*** are involved in the spoilage of refrigerated milk, meat, eggs, and seafood because they grow at 4°C and degrade lipids and proteins.
- ***P. aeruginosa*** infects people with low resistance such as cystic fibrosis patients and invades burn areas or causes urinary tract infections.
- ***P. syringae*** is a plant pathogen. (Blithe)
- ***P. putida*** can do microbial breakdown of organic materials to inorganic substances. (**mineralization process).**

TABLE BXII.γ.109. Some toxins produced by phytopathogenic *Pseudomonas* species and pathovars[a]

Species	Toxins	Target or mechanism
P. syringae		
P. syringae pathovar *atropurpurea*	Coronatine	
P. syringae pathovar *coronafaciens*	Tabtoxinine-β-lactam	Glutamine synthetase
P. syringae pathovar *garcae*	Tabtoxinine-β-lactam	Glutamine synthetase
P. syringae pathovar *glycinea*	Coronatine, polysaccharide	
P. syringae pathovar *lachrymans*	Polysaccharides	
P. syringae pathovar *maculicola*	Coronatine	
P. syringae pathovar *morsprunorum*	Coronatine	
P. syringae pathovar *phaseolicola*[b]	Phaseolotoxin	Ornithine transcarbamylase
P. syringae pathovar *savastanoi*[b]	Indole acetate, cytokinins	
P. syringae pathovar *syringae*	Syringomycins	Plasma membrane
	Syringopeptins	
	Syringotoxins	Plasma membrane
P. syringae pathovar *tabaci*	Tabtoxinine-β-lactam	Glutamine synthetase
P. syringae pathovar *tagetis*	Tagetitoxin	Chloroplastic RNA polymerase
P. syringae pathovar *tomato*	Coronatine	
P. tolaasii	Tolaasin	Plasma membrane

[a]For symbols see standard definitions. Modified from Durbin (1992). The nomenclature used is the one preceding the proposal by Gardan et al. (1992).

[b] *P. syringae* pathovar *savastanoi* is described in this treatment as an independent species, *P. savastanoi*, and pathovar *phaseolicola* is considered as a pathovar of *P. savastanoi*; see description of this species in the list of species).



.Pseudomonas putida *KT2442*

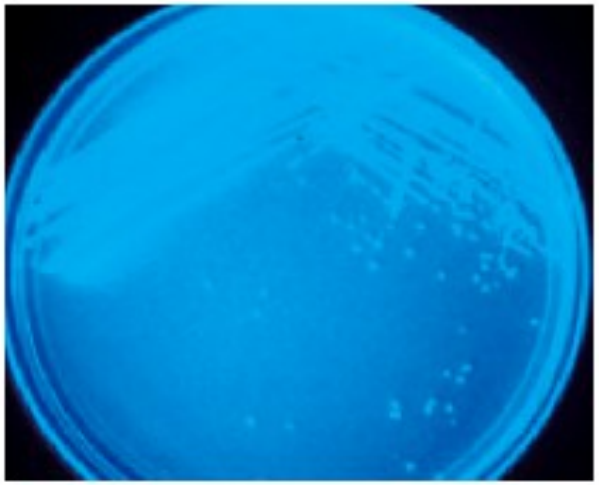


Figure 22.24 ***Pseudomonas*** **Fluorescence.** *Pseudomonas aeruginosa* colonies fluorescing under ultraviolet light.

TABLE BXII.γ.114. Characteristics differentiating *Pseudomonas aeruginosa*, *P. balearica*, *P. stutzeri*, and *P. putida*[a]

Characteristics	*P. aeruginosa*	*P. balearica*	*P. putida*	*P. stutzeri*
Type of colony:				
Smooth	+		+	
Wrinkled		+		+
Number of flagella	1	1	>1	1
Hydrolysis of:				
Gelatin	+	−	−	−
Starch	−	+	−	+
Utilization of:				
Maltose	−	+	d	+
Xylose	−	+	d	−
γ-Aminobutyrate	−	−	d	d
Malate	d	+	−	+
Suberate	d	−	−	d
Mannitol	+	−	−	d
Ethylene glycol	−	−	−	+
Denitrification	+	+	−	+
Growth at:				
42°C	+	+	−	d
46°C	−	+	−	d
Growth in media with 8.5% NaCl	−	+	−	−
Fatty acid content (%):				
$C_{17:0\ cyclo}$	0.8	4.71	>5	0.28–1.72
$C_{19:0\ cyclo}$	1.2	3.8	Traces	0.32-1.45
Mol% G + C of the DNA	67	64.1–64.4	60.7–62.5	60.9–64.9

[a]For symbols see standard definitions. Data from Bennasar et al. (1996) and Stanier et al. (1966).

Vibrionaceae

- Members of the family ***Vibrionaceae*** are gram-negative, straight or curved rods with polar flagella. Most are oxidase positive, and all use D-glucose as their sole or primary carbon and energy source.
- The majority are aquatic microorganisms, widespread in freshwater and the sea. There are six genera in the family: *Vibrio, Photobacterium, Enhydrobacter, Salinivibrio, Listonella,* and *Allomonas.*

Vibrio

- ***V. cholerae*** is the causative agent of cholera.
- ***V. parahaemolyticus*** sometimes causes gastroenteritis in humans following consumption of contaminated seafood.
- ***V. anguillarum*** and others are responsible for fish diseases.

V. cholera

- The *Vibrio cholerae genome has now been sequenced and* found to contain **3,885 open reading frames (ORF)** distributed between two circular chromosomes, **chromosome 1** (2.96 million base pairs) and **chromosome 2** (1.07 million bp).
- The larger chromosome primarily has genes for essential cell functions such as DNA replication, transcription, and protein synthesis. It also has most of the virulence genes (e.g., the cholera toxin gene is located in an integrated **CTX phage** on chromosome 1).
- Chromosome 2 also has essential genes such as transport genes and ribosomal protein genes. Copies of some genes are present on both chromosomes.

Figure 21-4. *Vibrio cholerae* growing on thiosulfate-citrate-bile salt-sucrose agar. Notice the yellow color of the colonies. Other colonies of *Vibrio* species will appear green on this medium. Image courtesy of the Centers for Disease Control and Prevention.

TREATMENT AND PREVENTION

Successful therapy of cholera requires prompt replacement of fluids and electrolytes. Oral rehydration therapy is usually the first therapy attempted; however, if the dehydration cannot be corrected by oral administration of fluids, intravenous administration of fluids can be given. Tetracycline reduces the severity and length of disease.

Family *Thiotrichaceae*

- Family ***Thiotrichaceae: Beggiatoa, Leucothrix , Thiotrix***
- Two of the best-studied **gliding** genera in this family: ***Beggiatoa and Thiothrix :*** **Internal S granule.**
- The name (gliding) is derived from the tendency of members to glide over moist surfaces. The gliding property evidently involves rotation of **filaments or fibers just under the outer membrane** of the cell wall. They do not have flagella.

Beggiatoa

- ***Beggiatoa*** is microaerophilic and grows in sulfide-rich habitats such as sulfur springs, freshwater with decaying plant material, rice paddies, salt marshes, and marine sediments.
- Its filaments contain short, **disklike** cells and lack a sheath. *Beggiatoa* is very versatile metabolically. It oxidizes **hydrogen sulfide** to form large sulfur grains located in pockets formed by invaginations of the plasma membrane.

Beggiatoa

- ***Beggiatoa*** can subsequently oxidize the sulfur to sulfate. The electrons are used by the electron transport chain in energy production. Many strains also can grow **heterotrophically** with acetate as a carbon source, and some may incorporate CO_2 **autotrophically**.

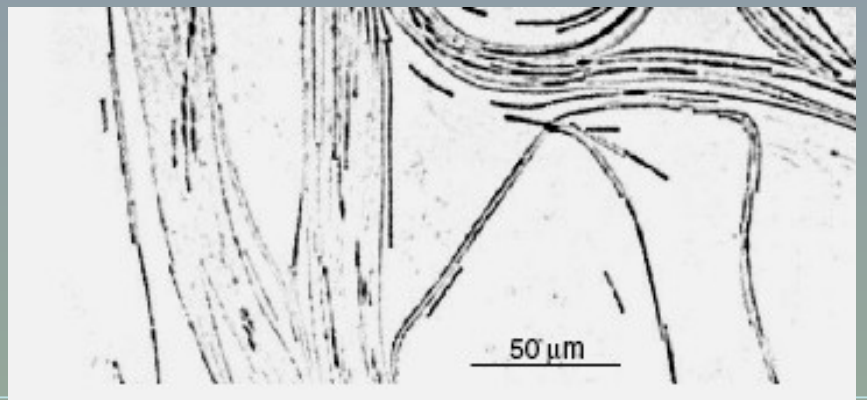
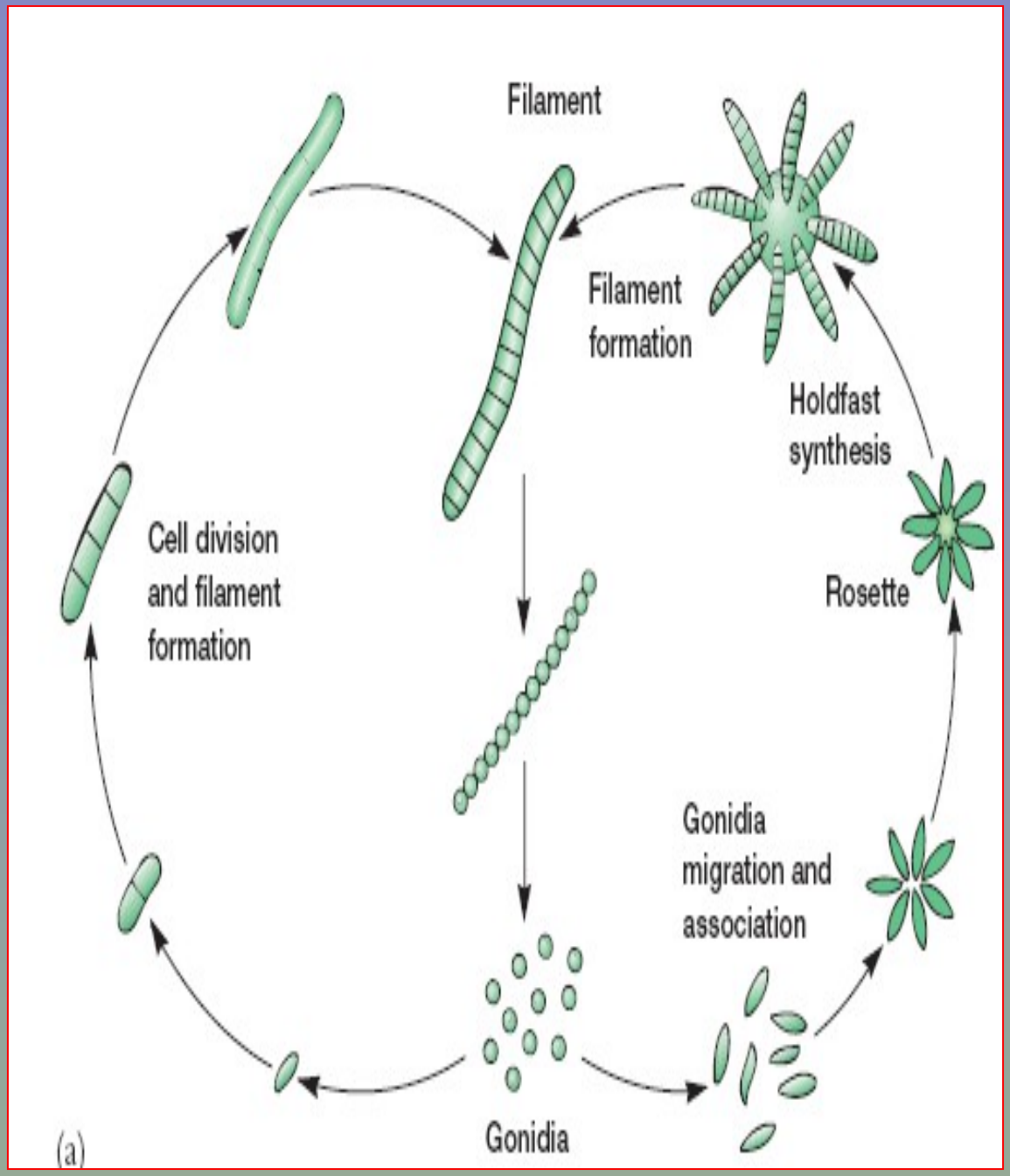


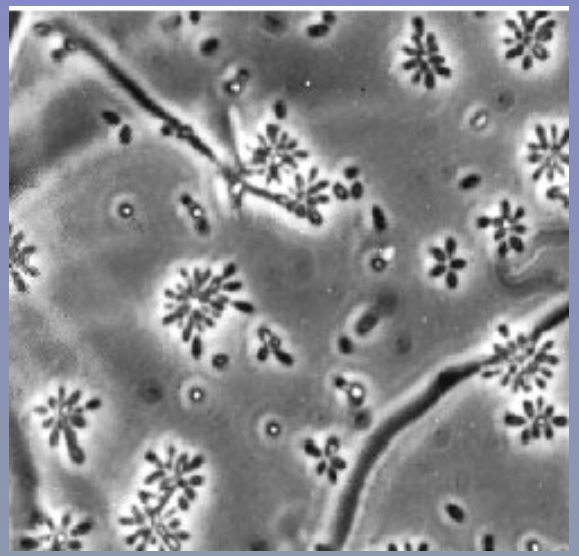
Figure 22.20 ***Beggiatoa.*** *Beggiatoa* sp. colony growing on agar.

Leucothrix

- ***Leucothrix*** is an aerobic chemoorganotroph that forms long filaments or trichomes up to 400 μ long. It is usually marine and is attached to solid substrates by a **holdfast**.
- ***Leucothrix*** *has a complex life cycle in which dispersal is by the* formation of **gonidia**. **Rosette** formation often is seen in culture.



.Leucothrix mucor



Thiothrix

- ***Thiothrix*** *is a related genus that forms* sheathed filaments and releases gonidia from the **open** end of the sheath.
- *Thiothrix* is a **chemolithotroph** that oxidizes hydrogen sulfide and deposits sulfur granules internally. It also requires an organic compound for growth (i.e., it is a **mixotroph**). *Thiothrix* grows in sulfide-rich flowing water and **activated sludge** sewage systems.

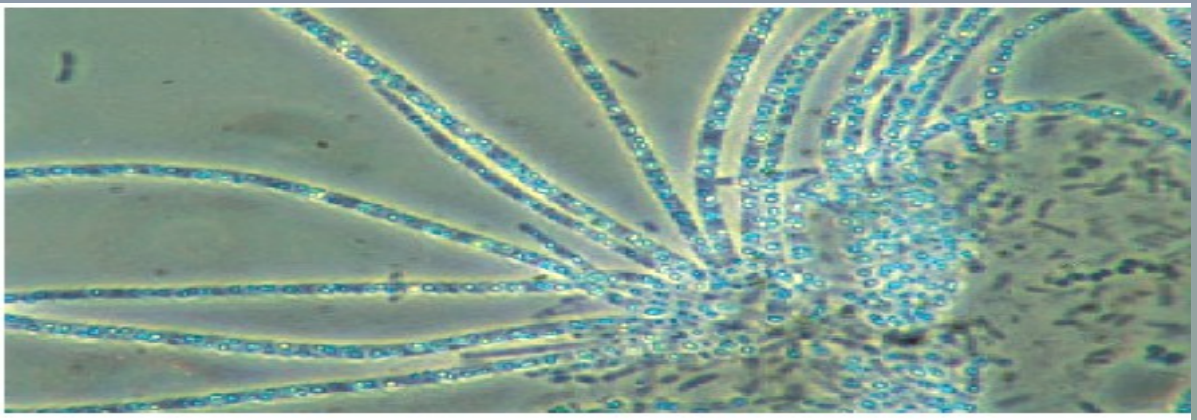


Figure 22.22 ***Thiothrix.*** A *Thiothrix* colony viewed with phase-contrast microscopy (×1,000).

Mixotrophy

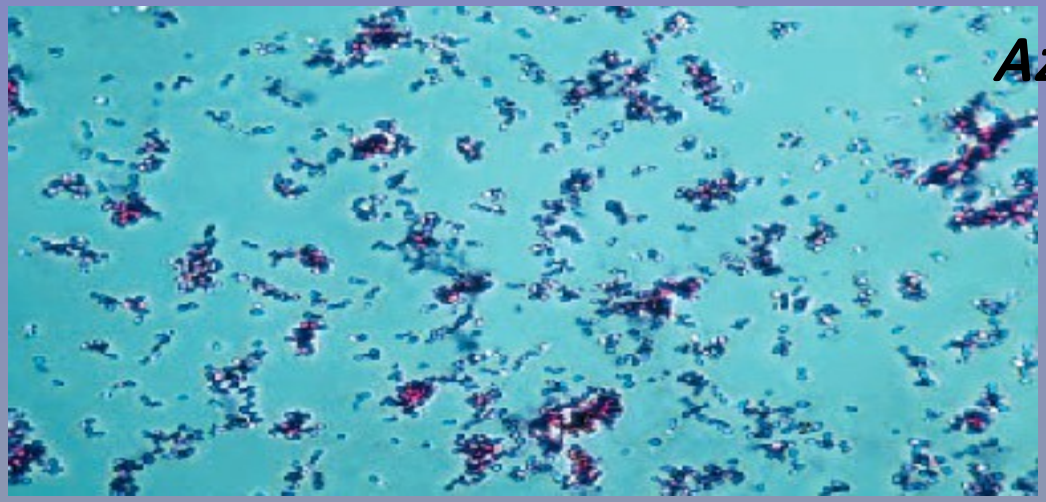
- **Mixotrophy:** A mode of metabolism in which energy is obtained by the oxidation of an inorganic substrate, and carbon is obtained from an organic substrate (and sometimes also from the fixation of CO2 via an autotrophic pathway).

Azotobacter

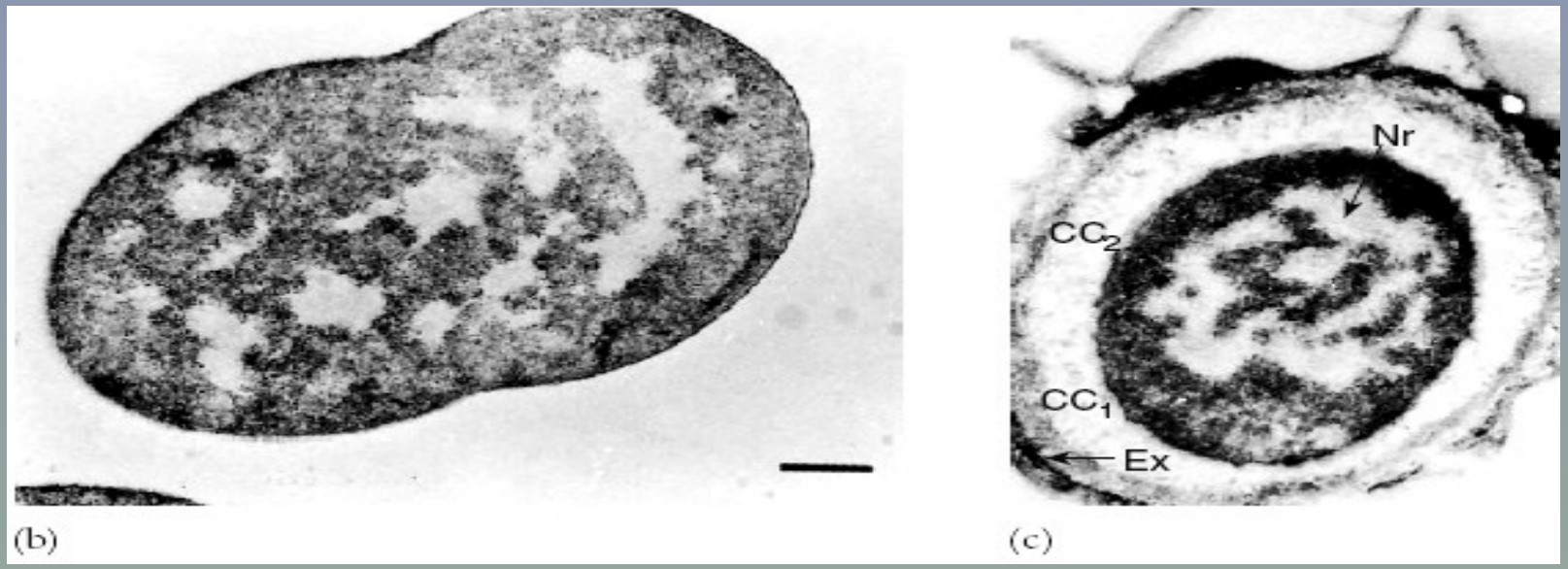
- The genus ***Azotobacter*** also is in the family Pseudomonadaceae. The genus contains large, ovoid bacteria, 1.5 to 2.0 μ in diameter, that may be motile by **peritrichous flagella**. The cells are often pleomorphic, ranging from rods to coccoid shapes, and form **cysts** as the culture ages.
- The genus is aerobic, catalase positive, and fixes nitrogen nonsymbiotically. *Azotobacter* is widespread in soil and water.

Cyst

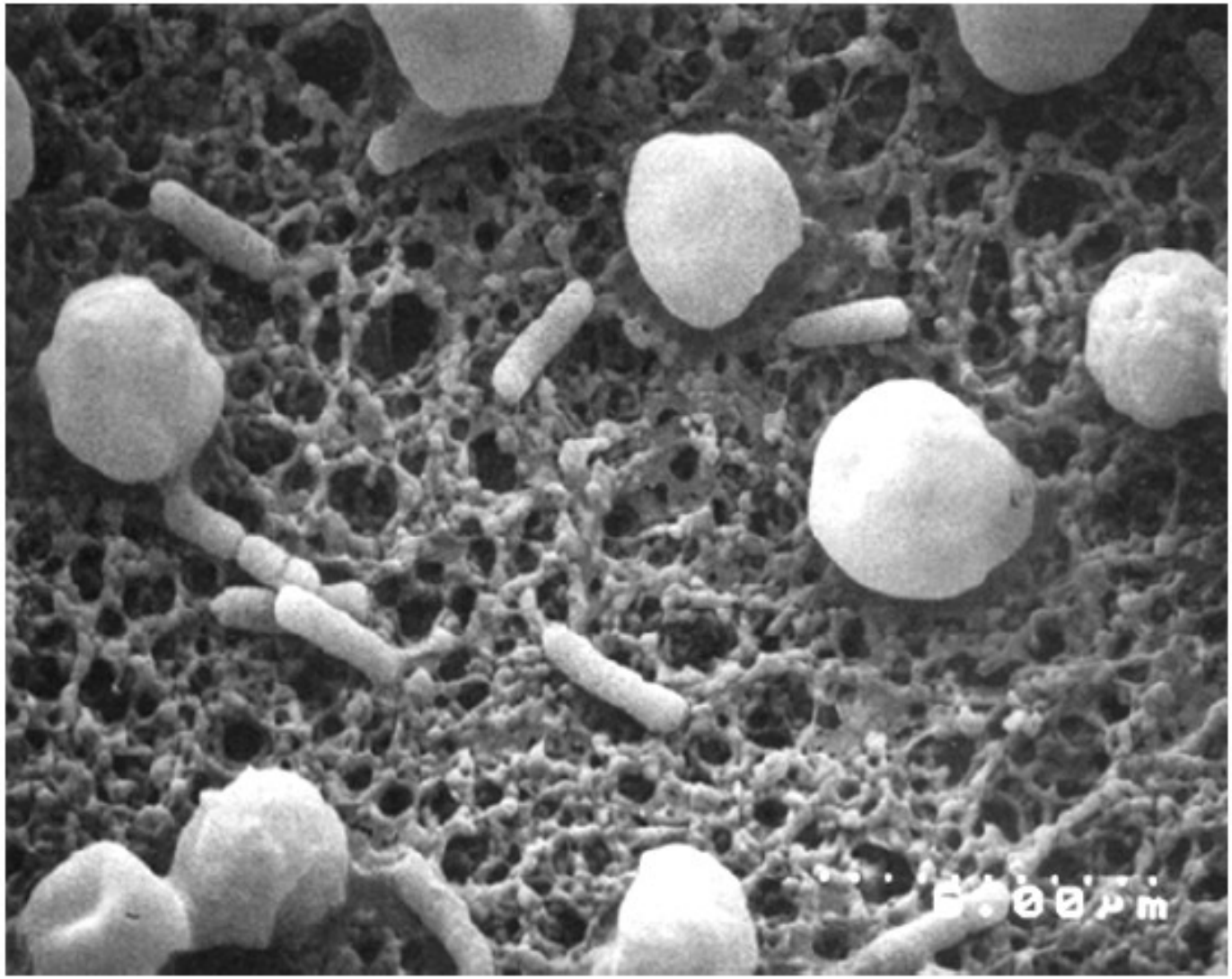
- **Cyst-formation occurs maximally in old cultures on nitrogen-free media containing 0.2% butanol.**
- During cyst formation (***encystment***), an organism produces a thick or thin wall within which it becomes totally enclosed. Cysts are usually resistant to desiccation, and may be resistant to e.g. ultraviolet radiation and/or heat.



Azotobacter chroococcum



In cyst: The nuclear region (Nr), exine layers (CC1 and CC2), and .exosporium (Ex) are visible



.132. Scanning electron micrograph of *E. coli* and *A. vinelandii* vegetative cells, × 1000 magnifi-
duced with permission from E.T. Efuet et al., Journal of Basic Microbiology *36:* 229–234, 1996,

Enterobacteriaceae

- The family ***Enterobacteriaceae*** contains gram-negative, peritrichously flagellated or nonmotile, facultatively anaerobic, straight rods with simple nutritional requirements.
- It has 41 genera and often called **enterobacteria** or **enteric bacteria.**
- The family can be divided into **two** groups based on their fermentation products. The majority (e.g., *Escherichia, Proteus, Salmonella, and Shigella)* carry out **mixed acid fermentation** and produce mainly lactate, acetate, succinate, formate (or H2 and CO2), and slightly ethanol (**Methyl Red** Test).
- *Enterobacter, Serratia, Erwinia, and Klebsiella* are butanediol fermenters. They produce mixed alcohols and slightly acids. (**Voges-Proskauer** test)
- Because the enteric bacteria are so similar in morphology, **biochemical tests** are normally used to identify them after examination of their morphology, motility, and growth responses.

A state-of-the-art medium developed for culturing and identifying the most common urinary pathogens. CHROMagar Orientation™ uses color-forming reactions to distinguish at least seven species and permits rapid identification and treatment.

Figure 22.28 Identification of Enterobacterial Genera. A dichotomous key to selected genera of enteric bacteria based on motility and biochemical characteristics. The following abbreviations are used: ONPG, *o*-nitrophenyl-β-D-galactopyranoside (a test for β-galactosidase); DNase, deoxyribonuclease; Gel. Liq., gelatin liquefaction; and VP, Voges-Proskauer (a test for acetoin).

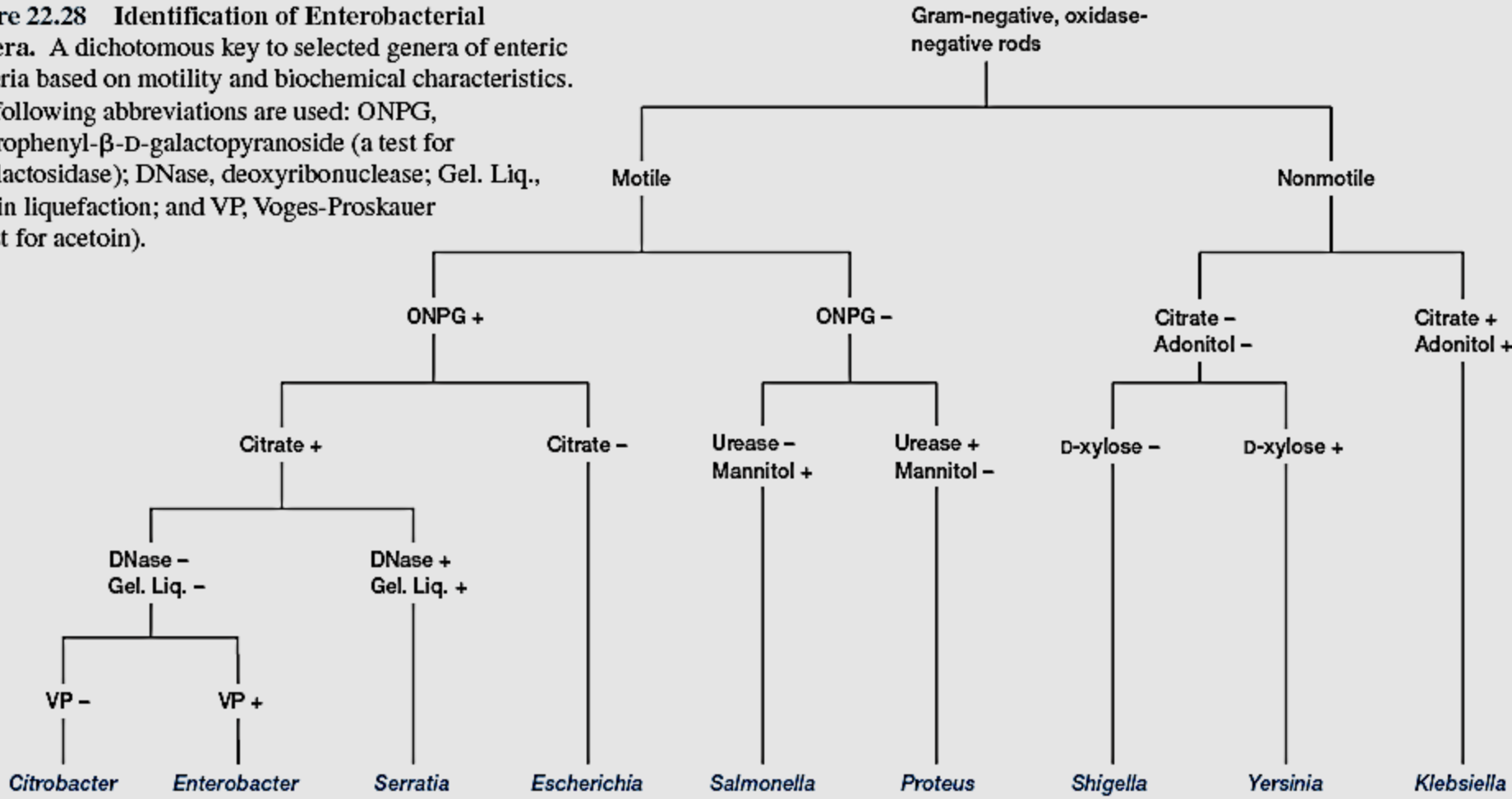


Table 22.7 Some Characteristics of Selected Genera in the *Enterobacteriaceae*

Characteristics	*Escherichia*	*Shigella*	*Salmonella*	*Citrobacter*	*Proteus*
Methyl red	+	+	+	+	+
Voges-Proskauer	–	–	–	–	d
Indole production	(+)	d	–	d	d
Citrate use	–	–	(+)	+	d
H_2S production	–	–	(+)	d	(+)
Urease	–	–	–	(+)	+
β-galactosidase	(+)	d	d	+	–
Gas from glucose	+	–	(+)	+	+
Acid from lactose	+	–	(–)	d	–
Phenylalanine deaminase	–	–	–	–	+
Lysine decarboxylase	(+)	–	(+)	–	–
Ornithine decarboxylase	(+)	d	(+)	(+)	d
Motility	d	–	(+)	+	+
Gelatin liquifaction (22°C)	–	–	–	–	+
% G + C	48–52	49–53	50–53	50–52	38–41
Other characteristics	1.1–1.5 × 2.0–6.0 μm; peritrichous when motile	No gas from sugars	0.7–1.5 × 2–5 μm; peritrichous flagella	1.0 × 2.0–6.0 μm; peritrichous	0.4–0.8 × 1.0–3.0 μm; peritrichous

E. coli

- ***Escherichia coli*** *is undoubtedly* the best-studied bacterium and the experimental organism of choice for many microbiologists. It is an inhabitant of the **colon** of humans and other warm-blooded animals, and it is quite useful in the analysis of water for **fecal contamination (Index):** **MPN** Test (Most Probability Number)
- Some strains cause **gastroenteritis** or **urinary tract** infections.

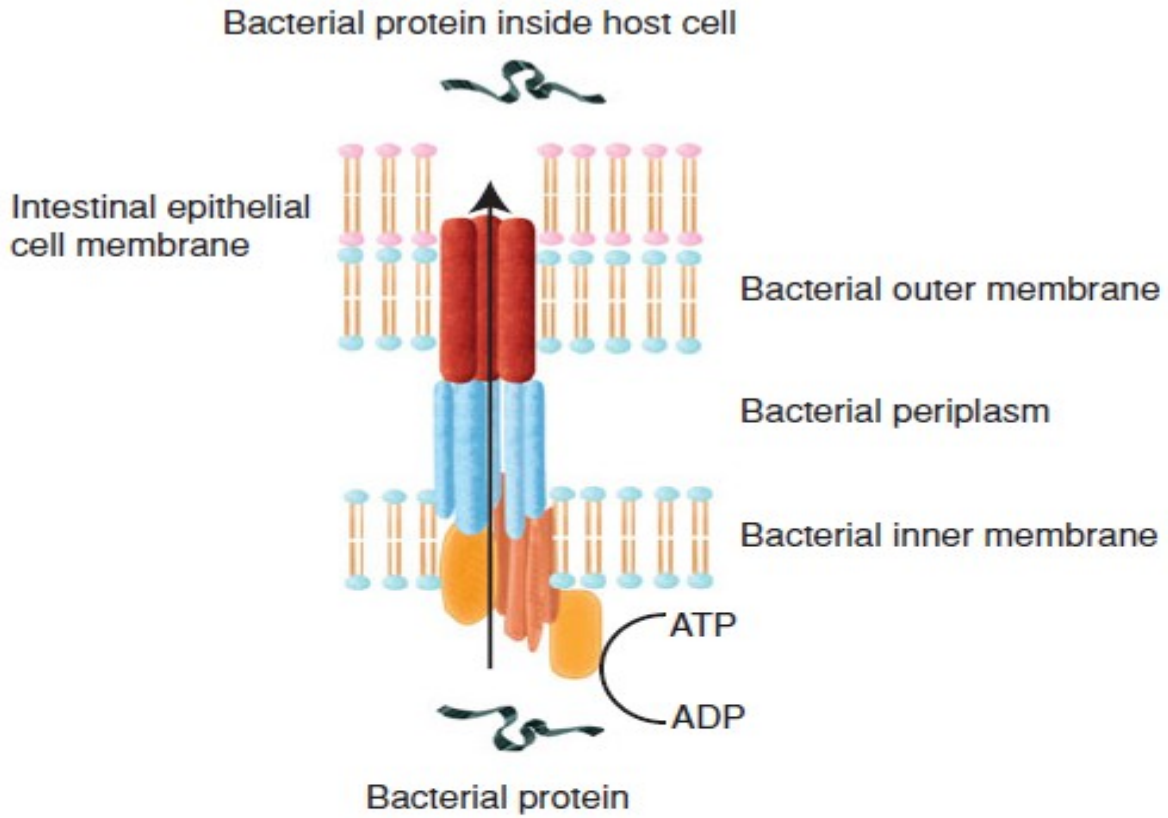


Figure 21-1. A schematic of the type III bacterial secretory system. Contact between the bacteria and host cell induces the bacterial cell to produce the proteins needed to construct the type III bacterial secretion system. EPEC produces the proteins that form a channel between the cytoplasm of the bacterium and the cytoplasm of the host cell so that bacterial proteins can be placed in the host cell. Some of these bacterial proteins cause alterations in the glycocalyx of the epithelial cells in the small bowel. ATP, adenosine triphosphate; ADP, adenosine diphosphate.

Enterobacteriaceae

- Several enteric genera contain very important human pathogens responsible for a variety of diseases: ***Salmonella,*** *typhoid fever and gastroenteritis;* ***Shigella****, bacillary dysentery (S. dysenteria);* ***Klebsiella****, pneumonia;* ***Yersinia****, plague (Y. pestis).*
- *Members of the genus* ***Erwinia*** *are major* pathogens of crop plants and cause blights, wilts, and several other plant diseases.
- ***E. carotovora*** **(Soft rot in fruits)**

Family *Pasteurellaceae*

- The family contains **six** genera: *Pasteurella, Haemophilus, Actinobacillus, Lonepinella, Mannheimia, and Phocoenobacter.*
- ***Pasteurella multilocida*** *and* ***P. haemolytica*** *are important animal* pathogens. *P. multilocida* is responsible for **birds cholera**, which destroys many chickens, turkeys, ducks, and geese each year. ***P. haemolytica*** *is at least partly responsible for pneumonia in cattle,* sheep, and goats.
- ***H. Influenzae*** type b is a major human pathogen that causes a variety of diseases, including meningitis in children.

Table 22.6 Characteristics of Families of Facultatively Anaerobic Gram-Negative Rods

Characteristics	*Enterobacteriaceae*	*Vibrionaceae*	*Pasteurellaceae*
Cell dimensions	0.3–1.0 × 1.0–6.0 μm	0.3–1.3 × 1.0–3.5 μm	0.2–0.3 × 0.3–2.0 μm
Morphology	Straight rods; peritrichous flagella or nonmotile	Straight or curved rods; polar flagella	Coccoid to rod-shaped cells, sometimes pleomorphic; nonmotile
Physiology	Oxidase negative	Oxidase positive; all can use D-glucose as sole or principal carbon source	Oxidase positive; heme and/or NAD often required for growth; organic nitrogen source required
G + C content	38–60%	38–63%	38–47%
Symbiotic relationships	Some parasitic on mammals and birds; some species plant pathogens	Most not pathogens (with a few exceptions)	Parasites of mammals and birds
Representative genera	*Escherichia, Shigella, Salmonella, Citrobacter, Klebsiella, Enterobacter, Erwinia, Serratia, Proteus, Yersinia*	*Vibrio, Photobacterium*	*Pasteurella, Haemophilus*

TABLE 4.6

Medically Important Families and Genera of Bacteria, with Notes on Some Diseases*

I. Bacteria with gram-positive cell wall structure

Cocci in clusters or packets that are aerobic or facultative
Family Micrococcaceae: *Staphylococcus* (members cause boils, skin infections)

Cocci in pairs and chains that are facultative
Family Streptococcaceae: *Streptococcus* (species cause strep throat, dental caries)

Anaerobic cocci in pairs, tetrads, irregular clusters
Family Peptococcaceae: *Peptococcus, Peptostreptococcus* (involved in wound infections)

Spore-forming rods
Family Bacillaceae: *Bacillus* (anthrax), *Clostridium* (tetanus, gas gangrene, botulism)

Non-spore-forming rods
Family Lactobacillaceae: *Lactobacillus, Listeria* (milk-borne disease), *Erysipelothrix* (erysipeloid)
Family Propionibacteriaceae: *Propionibacterium* (involved in acne)

Family Corynebacteriaceae: *Corynebacterium* (diphtheria)

Family Mycobacteriaceae: *Mycobacterium* (tuberculosis, leprosy)

Family Nocardiaceae: *Nocardia* (lung abscesses)

Family Actinomycetaceae: *Actinomyces* (lumpy jaw), *Bifidobacterium*

Family Streptomycetaceae: *Streptomyces* (important source of antibiotics)

II. Bacteria with gram-negative cell wall structure

Family Neisseriaceae
Aerobic cocci
Neisseria (gonorrhea, meningitis), *Branhamella*

Aerobic coccobacilli
Moraxella, Acinetobacter

Anaerobic cocci
Family Veillonellaceae
Veillonella (dental disease)

Miscellaneous rods
Brucella (undulant fever), *Bordetella* (whooping cough), *Francisella* (tularemia)

Aerobic rods
Family Pseudomonadaceae: *Pseudomonas* (pneumonia, burn infections)
Miscellaneous: *Legionella* (Legionnaires' disease)

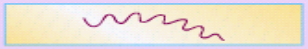
Facultative or anaerobic rods and vibrios
Family Enterobacteriaceae: *Escherichia, Edwardsiella, Citrobacter, Salmonella* (typhoid fever), *Shigella* (dysentery), *Klebsiella, Enterobacter, Serratia, Proteus, Yersinia* (one species causes plague)

Family Vibronaceae: *Vibrio* (cholera, food infection), *Campylobacter, Aeromonas*

Miscellaneous genera: *Chromobacterium, Flavobacterium, Haemophilus* (meningitis), *Pasteurella, Cardiobacterium, Streptobacillus*

Anaerobic rods
Family Bacteroidaceae: *Bacteroides, Fusobacterium* (anaerobic wound and dental infections)

Helical and curviform bacteria
Family Spirochaetaceae: *Treponema* (syphilis), *Borrelia* (Lyme disease), *Leptospira* (kidney infection)



Obligate intracellular bacteria
Family Rickettsiaceae: *Rickettsia* (Rocky Mountain spotted fever), *Coxiella* (Q fever)
Family Bartonellaceae: *Bartonella* (trench fever, cat scratch disease)
Family Chlamydiaceae: *Chlamydia* (sexually transmitted infection)

III. Bacteria with no cell walls

Family Mycoplasmataceae: *Mycoplasma* (pneumonia), *Ureaplasma* (urinary infection)