GROUPS WITHIN THE FOUR MAJOR CATEGORIES OF BACTERIA

Each of the four major categories of bacteria described in Chapter IV is divided into various groups. The tables in this chapter provide brief descriptions of these groups.

Table V.1 The groups within Major Category I (Gram-negative eubacteria that have cell walls)

GROUP	NAME	IMPORTANT FEATURES
1 p. 27	THE SPIROCHETES	Gram-negative helically shaped cells that are highly flexible. Motile by periplasmic flagella rather than by flagella that project from the cell into the external medium. Chemoorganotrophic. Anaerobic, microaerophilic, facultatively anaerobic, or aerobic. Occur either free-living or in association with animal, mollusk, arthropod, or human hosts. Some are pathogenic.
2 p. 39	AEROBIC/MICROAEROPHILIC, MOTILE, HELICAL/VIBRIOID GRAM-NEGATIVE BACTERIA	Gram-negative cells that are helical (having one or more complete helical turns) or vibrioid (having less than one complete helical turn). Motile by polar flagella and swim in straight lines with a characteristic corkscrew-like motion. Aerobic or microaerophilic, having a respiratory type of metabolism with oxygen as the normal electron acceptor. Some also may exhibit anaerobic respiration with electron acceptors other than O_2, such as nitrate or fumarate. Chemoorganotrophic, but some can grow autotrophically with H_2 as the electron donor. Occur in soil, freshwater or marine environments, within plant roots, or in the reproductive organs, intestinal tract, and oral cavity of humans and animals. Some are pathogenic for animals or humans. Some are predatory on other microorganisms.
3 p. 65	NONMOTILE (OR RARELY MOTILE), GRAM-NEGATIVE CURVED BACTERIA	Chemoorganotrophic heterotrophs. Saprophytic. Four types of organisms are included in this group, as follows: I. Curved or C-shaped bacteria that may form rings by overlapping of the ends of a cell. Coils and helices may occur. Gas vacuoles may occur. Aerobic. Occur in soil, freshwater, or marine environments. II. Vibrioid or straight rods. Gas vacuoles are formed. Aerotolerant anaerobes, having a strictly fermentative type of metabolism. III. Bow-shaped cells with gas vacuoles. Cells arranged in coenobia of two rings or four rings (cloverleaf appearance). Pretzel-shaped cells may occur. Occur in ponds and lakes where sulfide is present and oxygen is absent. IV. Slender S-shaped cells arranged side-by-side in flat, sigmoid aggregates of four or multiples of four. Aggregates are occasionally motile. Occur in fresh and brackish waters where sulfide is present and oxygen is absent. Note: II above contains straight rods as well as curved rods.
4 p. 71	GRAM-NEGATIVE AEROBIC/ MICROAEROPHILIC RODS AND COCCI	Chemoorganotrophic heterotrophs, but some may grow autotrophically by using H_2 as an electron donor. Do not form prosthecae, stalks, sheaths, or gas vacuoles. Do not possess gliding motility. Do not reproduce by budding. Can grow under an air atmosphere and have a strictly respiratory type of metabolism with O_2 as the terminal electron acceptor. Some are also capable of anaerobic respiration with terminal electron acceptors other than O_2. Occur in soil, freshwater, or marine environments, within plant roots, or in the reproductive organs, intestinal tract, and oral cavity of humans and animals. Some are pathogenic for animals or humans.

Table V.1 *(continued)*

GROUP	NAME	IMPORTANT FEATURES
5 p. 175	**FACULTATIVELY ANAEROBIC GRAM-NEGATIVE RODS**	Chemoorganotrophic heterotrophs, but some may grow autotrophically by using H_2 as an electron donor. Do not form prosthecae, stalks, sheaths, or gas vacuoles. Do not possess gliding motility. Do not reproduce by budding. Capable of growing under an air atmosphere by a respiratory type of metabolism; also capable of growing anaerobically by fermentation. Occur either free-living or in association with animal, human, or plant hosts. Some are pathogenic.
6 p. 291	**GRAM-NEGATIVE, ANAEROBIC, STRAIGHT, CURVED, AND HELICAL RODS**	Chemoorganotrophic heterotrophs. Obtain energy by anaerobic respiration or by fermentation. Do not respire anaerobically with sulfate or other oxidized sulfur compounds or with elemental sulfur as electron acceptors.
7 p. 335	**DISSIMILATORY SULFATE- OR SULFUR-REDUCING BACTERIA**	Anaerobic. Chemoorganotrophic heterotrophs. Respire anaerobically either with sulfate and other oxidized sulfur compounds or with elemental sulfur as terminal electron acceptors. Endospores not formed.
8 p. 347	**ANAEROBIC GRAM-NEGATIVE COCCI**	Chemoorganotrophic heterotrophs. Have a strictly fermentative type of metabolism.
9 p. 351	**THE RICKETTSIAS AND CHLAMYDIAS**	Obligate intracellular parasites of eucaryotic hosts (vertebrates or arthropods). May be rod-shaped, coccoid, or pleomorphic. Many species are pathogenic.
10 p. 353	**ANOXYGENIC PHOTOTROPHIC BACTERIA**	Bacteria that contain bacteriochlorophyll and can use light as an energy source. When growing under illumination the organisms are anaerobic and do not evolve O_2 during photosynthesis. Some are also capable of growing in the dark by respiring with oxygen. Do not contain phycobiliproteins.
11 p. 377	**OXYGENIC PHOTOTROPHIC BACTERIA**	Bacteria that contain chlorophyll *a*, can use light as an energy source, and evolve O_2 in a manner similar to that of green plants. Two subdivisions are included, as follows: I. Contain chlorophyll *a* and have phycobiliproteins (allophyco-cyanin, phycocyanin and sometimes phycoerythrin). These organisms are called *cyanobacteria*. II. Contain chlorophyll *a* and chlorophyll *b* but lack phycobiliproteins.
12 p. 427	**AEROBIC CHEMOLITHOTROPHIC BACTERIA AND ASSOCIATED ORGANISMS**	Nonphototrophic. The following subdivisions can be recognized: I. Nitrifiers. Reduced inorganic nitrogen compounds (ammonia and nitrite) can be used as energy sources for growth. II. Sulfur oxidizers. Reduced inorganic sulfur compounds can be oxidized, and most organisms can utilize this as sole source of energy. III. Obligate hydrogen oxidizers. Hydrogen gas (H_2) is used as the energy source for growth, and organic sources of carbon are not used. IV. Nonprosthecate and nonstalked bacteria that produce or deposit iron and/or manganese oxides on or within the cells. V. Magnetotactic bacteria. Bacteria that exhibit tactic responses to magnetic fields. The cells contain iron-rich, electron-dense intracellular inclusions (magnetosomes).

Table 5.1 Differential characteristics of genera and families in Group 5[a]

Characteristic	Zymomonas	Chromobacterium	Cardiobacterium	Calymmatobacterium	Gardnerella	Eikenella	Streptobacillus	Family Enterobacteriaceae	Family Vibrionaceae	Family Pasteurellaceae
Cell diameter, μm	1.0–1.4	0.6–0.9	0.5–0.75	0.5–0.15	ca. 0.5	0.3–0.4	0.1–0.7	0.3–1.5	0.3–1.3	0.2–0.4
Main shape of cells:										
Straight rods	+	+	+	+	+	+	+	+	D	+
Curved or vibrioid	–	–	–	–	–	–	–	–	D	–
May stain Gram variable	–	–	+	–	+	–	–	–	–	–
Acid from D-glucose	+	+[b]	+		+	–	+	+	+	+
Major product of sugar fermentation:										
Ethanol	+		–		–			–	–	–
Lactic acid	–		+		–			–	–	–
Acetic acid	–		–		+			–	–	–
Colonies are violet	–	+[c]	–	–	–	–	–	–	–	–
Motility (swimming)	–[d]	+	–	–	–	–	–	D	+	–
Flagellar arrangement:										
Polar	–	–						–	+	
Lateral	+[d]	–						+[f]	–	
Mixed[g]	–	+						–	D	
Oxidase	–	+	+		–	+	–	–	D	D
Catalase	+	+	–		–	–	–	+[e]	D	D
NO_3^- reduced to NO_2^-	–	+[h]	–		–	+	–	+[e]	+[e]	+[e]
Indole produced	–	–[i]	+[j]		–	–	–	D	D	D
Hemin required for aerobic growth	–	–	+	–	–	–	–	–	–	D
Many strains appear to corrode surface of agar media	–	–	–	–	–	+	–	–	–	–
Na^+ required or stimulatory for growth								–	D	–
Organic nitrogen sources required								–[g]	–[g]	+
Plant pathogenicity	–	–	–	–	–	–	–	D	–	–
Causes donovanosis (granuloma inguinale) in humans	–	–	–	+	–	–	–	–	–	–
Causes one form of rat-bite fever in humans	–	–	–	–	–	–	+	–	–	–
Causes vaginitis in humans	–	–	–	–	+	–	–	–	–	–

[a] Symbols: see standard definitions.

[b] Most strains show a fermentative attack on glucose, but approximately 20% show an oxidative attack.

[c] White variants occur that are difficult to identify and may be mistaken for *Aeromonas* or *Vibrio* species.

[d] Most strains are nonmotile but a few are motile by means of 1–4 subpolar or lateral flagella.

[e] A few exceptions occur.

[f] Except *Tatumella*, which may have polar, subpolar, or lateral flagella.

223–225, 1985) ... to be a junior subjective synonym ... (F.W. Hickman-Brenner, J.J. Farmer III, D.J. Brenner, G.R. Fanning, unpublished observations).

SUBGROUP 3: Family Pasteurellaceae

Coccoid to straight rod-shaped cells, usually 0.2–0.4 × 0.4–2.0 µm. Pleomorphism with cell swelling and formation of filaments may occur. Gram negative. **Contain demethylmenaquinones;** ubiquinones may or may not be produced. **Nonmotile. Aerobic with varying degrees of microaerophilia, facultatively anaerobic.** Chemoorganotrophic, having **both a respiratory and a fermentative type of metabolism.** Optimal growth temperature is 37°C. D-Glucose and other carbohydrates are catabolized with production of acid; however, conventional fermentation test media may fail to detect the accumulation of acid fermentation products with some of the most fastidious species. Usually anaerogenic, but gas producing species do occur. **Oxidase, catalase, and alkaline phosphatase reactions are characteristically positive,** but negative reactions occur in some species. **Nitrates are reduced to nitrites.** Complex media supplemented with yeast extract and serum or whole blood lysate are used for primary isolation. Require organic nitrogen sources. **Varying patterns of nutritional requirements may include several amino acids, B vitamins, β-nicotinamide, adenine nucleotides, and haematin or protoporphyrin. Parasitic in vertebrates,** particularly mammals and/or birds.

Type genus: *Pasteurella.*

Differentiation of **Pasteurellaceae** ...

Pasteurellaceae from the other families and genera are presented in Table 5.1.

Differentiation of the genera in **Pasteurellaceae:**

Editorial note: In *Bergey's Manual of Systematic Bacteriology* it is indicated that each of the genera in *Pasteurellaceae* is heterogenous and that each must be redefined on the basis of genetic and biochemical criteria. Since the publication of *Bergey's Manual of Systematic Bacteriology* new studies have confirmed this heterogeneity, transferred species between existing genera, and added new species to each of the existing genera (Mutters et al., Int. J. Syst. Bacteriol. *35:* 309–322, 1985; Schlater et al., J. Clin. Microbiol. *27:* 2169–2174, 1989; De Ley et al., Int. J. Syst. Bacteriol. *40:* 126–137, 1990; Sneath and Stevens, Int. J. Syst. Bacteriol. *40:*148–153, 1990). The data from these studies indicate that there may be a need for at least 4 additional genera, but that phenotypic definitions for the new genera as well as the established genera are difficult to establish.

Pending further studies to establish and define genera in the family *Pasteurellaceae,* differentiation among the genera will not be attempted. A biochemical profile of each species in the family is given in Table 5.53. Where proposals to transfer species to another genus have been made, the new genus name is used, without prejudice, with the old genus name given in parentheses. It must be noted that both names are valid.

Genus **Actinobacillus**

Spherical