1 **Chapter 11**

The Prokaryotes:
Domains Bacteria and Archaea

2 **The Prokaryotes**

3 **Domain Bacteria**

- Proteobacteria
  - From the mythical Greek god Proteus, who could assume many shapes
  - Gram-negative
  - Chemoheterotrophic

4 **The Alphaproteobacteria**

- *Pelagibacter ubique*
  - Discovered by FISH technique
  - 20% of prokaryotes in oceans
  - 0.5% of all prokaryotes
  - 1354 genes

5 **The Alphaproteobacteria**

- Human pathogens
  - *Bartonella*
    - *B. henselae*: Cat-scratch disease (sever skin rash/sores)
  - *Brucella*: Brucellosis (profuse sweating/ joint and muscle pain- comes from contaminated food)
  - *Ehrlichia*: Tickborne (fever, headaches, pain etc…)

6 **The Alphaproteobacteria**

- Obligate intracellular parasites
  - *Ehrlichia*: Tickborne, ehrlichiosis
  - *Rickettsia*: Arthropod-borne, spotted fevers
    - *R. prowazekii*: Epidemic typhus
    - *R. typhi*: Endemic murine typhus
    - *R. rickettsii*: Rocky Mountain spotted fever

7 **Rickettsias**

8 **The Alphaproteobacteria**

- *Wolbachia*: Live in insects and other animals (primarily affects reproductive abilities of insects by killing males, feminogenesis, or parthenogenesis)

9 **Wolbachia**

10 **The Alphaproteobacteria**

- Have prosthecae-cytoplasmic extrusions
  - *Caulobacter*: Stalked bacteria found in lakes
  -

11 **The Alphaproteobacteria**

- Plant pathogen
  - *Agrobacterium*: Insert a plasmid into plant cells, inducing a tumor

12 **The Alphaproteobacteria**

- Chemoautotrophic
  - Oxidize nitrogen for energy
  - Fix CO_2

- *Nitrobacter*: $NH_3 \rightarrow NO_2^-$
- *Nitrosomonas*: $NO_2^- \rightarrow NO_3^-$

13 **The Alphaproteobacteria**

- Nitrogen-fixing bacteria
  - *Azospirillum*
    - Grow in soil, using nutrients excreted by plants
    - Fix nitrogen
  - *Rhizobium*
    - Fix nitrogen in the roots of plants

14 **The Alphaproteobacteria**

- Produce acetic acid from ethanol
  - *Acetobacter*
  - *Gluconobacter*

15

16

- ✓ Make a dichotomous key to distinguish the orders of alphaproteobacteria described in this chapter. 11-1
- ✓
- ✓
- ✓
- ✓
- ✓
- ✓
- ✓

17 **The Betaproteobacteria**

- *Thiobacillus*
  - Chemoautotrophic; oxidize sulfur: $H_2S \rightarrow SO_4^{2-}$
- *Sphaerotilus*
  - Chemoheterotophic; form sheaths

18 **The Betaproteobacteria**

- *Neisseria*
  - Chemoheterotrophic; cocci
  - *N. meningitidis*
  - *N. gonorrhoeae*

19 **The Betaproteobacteria**

- *Spirillum*
  - Chemoheterotrophic; helical

20 **The Betaproteobacteria**

- *Bordetella*
  - Chemoheterotrophic; rods
  - *B. pertussis*
- *Burkholderia*
  - Nosocomial infections- (stemming from treatment in hospitals)

-

21 **The Betaproteobacteria**

- *Zoogloea*
  - Slimy masses in aerobic sewage-treatment processes

22

- ✓ Make a dichotomous key to distinguish the orders of betaproteobacteria described in this chapter. 11-2
- ✓
- ✓
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- ✓
- ✓
- ✓

23 **The Gammaproteobacteria**

- Pseudomonadales
  - *Pseudomonas*
    - Opportunistic pathogens
    - Metabolically diverse
    - Polar flagella
  -

24 **The Gammaproteobacteria**

- Pseudomonadales
  - *Moraxella*
    - Conjunctivitis
  - *Azotobacter* and *Azomonas*
    - Nitrogen fixing

25 **The Gammaproteobacteria**

- Legionellales
  - *Legionella*
    - Found in streams, warm-water pipes, cooling towers
    - "Pneumonia-like"
    - *L. pneumophilia*
  - *Coxiella*
    - Q fever transmitted via aerosols or milk
    - (high fever, nausea, head aches..etc..)

26 **The Gammaproteobacteria**

- Vibrionales
  - Found in coastal water
    - *Vibrio cholerae* causes cholera
    - *V. parahaemolyticus* causes gastroenteritis

27 **The Gammaproteobacteria**

1 - Enterobacteriales (enterics)
  - Peritrichous flagella; facultatively anaerobic
2 - *Enterobacter*
- *Erwinia*

- *Escherichia*
- *Klebsiella*
- *Proteus*
- *Salmonella*
- *Serratia*
- *Shigella*
- *Yersinia*

28 **The Gammaproteobacteria**

29 **The Gammaproteobacteria**

30 **The Gammaproteobacteria**

- Pasteurellales
  - *Pasteurella*
    - –Cause pneumonia and septicemia
  - *Haemophilus*
    - –Require X (heme) and V (NAD^+, $NADP^+$) factors
    - –Sp. cause numerous mild and serious infections, including bacteremia, meningitis, pneumonia, otitis media, cellulitis

31 **The Gammaproteobacteria**

- *Beggiatoa*
  - Chemoautotrophic; oxidize H_2S to S^0 for energy
- *Francisella*
  - Chemoheterotrophic; tularemia

32

- ✓ Make a dichotomous key to distinguish the orders of gammaproteobacteria described in this chapter. 11-3
- ✓
- ✓
- ✓
- ✓
- ✓
- ✓
- ✓

33 **The Deltaproteobacteria**

- *Bdellovibrio*
  - Prey on other bacteria

34 **The Deltaproteobacteria**

-
- *Desulfovibrionales*
  - Use S instead of O_2 as final electron acceptor

35 **The Deltaproteobacteria**

- *Myxococcales*
  - Gliding
  - Cells aggregate to form myxospores

36

- ✓ Make a dichotomous key to distinguish the deltaproteobacteria described in this chapter. 11-4
- ✓

✓

37 **The Epsilonproteobacteria**
- *Campylobacter*
  - One polar flagellum
  - Gastroenteritis

38 **The Epsilonproteobacteria**
- *Helicobacter*
  - Multiple flagella
  - Peptic ulcers
  - Stomach cancer

39
- ✓ Make a dichotomous key to distinguish the epsilonproteobacteria described in this chapter. 11-5
- ✓

40 **Nonproteobacteria Gram-Negative Bacteria**

41 **Phototrophic**
- Oxygenic photosynthesis
- Anoxygenic photosynthesis

42 **Oxygenic Photosynthetic Bacteria**
- Cyanobacteria
  - Gliding motility
  - Fix nitrogen

43 **Cyanobacteria**

44 **Anoxygenic Photosynthetic Bacteria**
- Purple sulfur
- Purple nonsulfur
- Green sulfur
- Green nonsulfur

45 **Purple Sulfur Bacteria**

46
- ✓ Make a dichotomous key to distinguish the gram-negative nonproteobacteria described in this chapter. 11-6
- ✓
- ✓ Both the purple and green photosynthetic bacteria and the photosynthetic cyanobacteria use plantlike photosynthesis to make carbohydrates. In what way does the photosynthesis carried out by these two groups differ from plant photosynthesis? 11-7
- ✓

47 **The Gram-Positive Bacteria**

48 **Firmicutes**
- Low G + C
- Gram-positive

49 **Clostridiales**
- *Clostridium*

- Endospore-producing
- Obligate anaerobes
-

50 **Bacillales**
- *Bacillus*
  - Endospore–producing rods

51 **Bacillales**
- *Staphylococcus*
  - Cocci

52 **Lactobacillales**
- Generally aerotolerant anaerobes; lack an electron-transport chain
  - *Lactobacillus*
  - *Streptococcus*
  - *Enterococcus*
  - *Listeria*

53 **Mycoplasmatales**
- Wall-less; pleomorphic
- 0.1 - 0.24 µm
- *M. pneumoniae*

54
- ✓ Make a dichotomous key to distinguish the low G + C gram-positive bacteria described in this chapter. 11-8
- ✓
- ✓
- ✓
- ✓
- ✓
- ✓

55 **Actinobacteria**
- High G + C
- Gram-positive

56 **Actinobacteria**
- *Actinomyces*
- *Corynebacterium*
- *Frankia*
- *Gardnerella*
- *Mycobacterium*
- *Nocardia*
- *Propionibacterium*
- *Streptomyces*

57
- ✓ Make a dichotomous key to distinguish the high G + C gram-positive bacteria described in this chapter. 11-9
- ✓
- ✓
- ✓
- ✓

✓

58 **Nonproteobacteria Gram-Negatives**

59 **Planctomycetes**

- *Gemmata obscuriglobus*
  - Double internal membrane around DNA

60 **Chlamydias**

- *Chlamydia trachomatis*
  - Trachoma
  - STI, urethritis
- *Chlamydophila pneumoniae*
- *Chlamydophila psittaci*
  - Psittacosis- parrot fever (dry cough, shortness of breath)

61 **Life Cycle of the Chlamydias**

62 **Spirochetes**

- *Borrelia*
- *Leptospira*
- *Treponema*

63 **Bacteroidetes**

- Anaerobic
  - *Bacteroides* are found in the mouth and large intestine
  - *Cytophaga*: Cellulose-degrading in soil

64 **Fusobacteria**

- *Fusobacterium*
  - Are found in the mouth
  - May be involved in dental diseases

65

✓ Make a dichotomous key to distinguish Planctomycetes, chlamydias, spirochetes, Bacteroidetes, *Cytophaga*, and *Fusobacteria*. 11-10

✓

✓

✓

✓

66 **Domain Archaea**

67 **Domain Archaea**

Extremophiles

- Hyperthermophiles
  - *Pyrodictium*
  - *Sulfolobus*
- Methanogens
  - *Methanobacterium*
- Extreme halophiles
  - *Halobacterium*

68

✓ What kind of archaea would populate solar evaporating ponds? 11-11

✓

✓

✓

69 **Microbial Diversity**

70 **Microbial Diversity**

- Bacteria size range
  - *Thiomargarita* (750 µm)
  - Nanobacteria (0.02 µm) in rocks

71 **Microbial Diversity**

- PCR indicates up to 10,000 bacteria per gram of soil.
- Many bacteria have not been identified because they
  - Haven't been cultured
  - Need special nutrients
  - Are a part of complex food chains requiring the products of other bacteria
  - Need to be cultured to understand their metabolism and ecological role

72

✓ How can you detect the presence of a bacterium that cannot be cultured? 11-12

✓

✓

✓