Bacteria I
General Nature

• 1) Prokaryotic
• 2) Single celled (some say multicellular)
• 3) Microscopic in size
• 4) Cell Wall usually present (varies, but contains carbohydrate called _______________
Typical Bacterial Cell (Prokaryotic)

Note that not all bacteria have all the structures shown. Structures labeled in red are found in all bacteria. Both the drawing and the micrograph show a bacterium sectioned lengthwise to reveal the internal composition.

Key Concept

Prokaryotic cells lack membrane-enclosed organelles. All bacteria contain cytoplasm, ribosomes, a plasma membrane, and a nucleoid. Almost all bacteria have cell walls.
Bacterial Colonies growing on Agar plates
Common Shapes of Bacteria

- Spherical: cocci (s. coccus)
  - single cells
  - pairs = *diplococci*
  - 4’ s = *tetrads*
  - 8’ s = *sarcinae*
  - chains = *streptococci*
  - grape-like clusters = *staphylococci*
More shapes

(a) Single bacillus

(b) Diplobacilli

(c) Streptobacilli

(d) Coccobacillus

Eukaryotic cells: Plant cells

- Plane of division
- Plasmodesmata

(d) Staphylococci

Eukaryotic cells: Animal cells

- Plane of division
- Gametes

(d) Coccobacillus
Rod Shaped

• Bacillus (Rod shaped)

*Bacillus anthracis*
More common shapes

• **Spiral = Spirilla**  (singular=spirillum)
  
  – **Spirochetes**: long spirilla with many tight coils
Typical spirillum
spirochetes
• some bacteria are genetically ________________ which means the cells can have many shapes.
Corynebacterium diphtheriae

- Pleomorphic species
Prokaryotic Cell Structure

• 1) Glycocalyx (sugar coat)

If firmly attached called a Capsule
If loosely attached called a slime layer
Bacterial Capsule/Slime Layer

- Function: protect cell from drying, chemicals, host body defenses; also helps for attachment to host cells.
- Increases virulence in pathogenic species
- Special capsule stain allows us to view.
Biofilms

- Slimy layers of bacteria formed by capsules
- Form on teeth, contact lenses, IUDs, in lungs, ear infections, other infections, shower door scum etc.
- Protect bacteria from drugs and body defense, 641 in text!
- Life cycle of a biofilm:
Life cycle of a biofilm:

1. Bacteria reproduce and begin to form structures.
2. Oxygen levels decrease toward the center.
3. Variety of environmental niches formed.
Life cycle of a biofilm, concluded

Biofilm affords protection from antibiotics and toxins

Cells dissolve slime and are released
• 99% of bacteria grow in biofilms (can be 100s of cells thick)!
  – Antibiotics, antibodies & phagocytes have difficulty penetrating
  – Can be 1500x more resistant!
• And……..Biofilms MOVE!
• Parts of the Bacterial Cell: 2) Flagella

• long, whip-like structures for motility (movement)
• location is important in identifying unknowns
  – Monotrichous: one flagellum (single polar flagellum)
  – Amphitrichous: flagella at each end of cell
  – Lophotrichous: 2 or more flagella at one end of cell
  – Peritrichous: flagella all over the cell
  – Atrichous (without flagella)

• too thin to see with light microscope
  – to view, thicken with flagella stain or use electron microscope
Types of Flagella arrangements

(a) Peritrichous

(b) Monotrichous and polar

(c) Lophotrichous and polar

(d) Amphitrichous and polar
How Flagella Work
• 3) __________ filaments
  • similar to flagella, but under outer membrane (sheath) of gram negative cell wall (endoflagella)
    – in spirochetes only
    – provide drilling motion (figure 4.10)
4) ______________

- Short, finger-like projections for attachment
- Important for virulence
5) Parts of the Bacterial Cell: Pili (pilus)

- Longer than fimbriae
- Usually 1 or 2 per cell
- Some pili used by bacteria in a mating process to exchange DNA
  - Sometimes called conjugation (sex) pili
- Motility now associated with pili
  - Twitching
  - Gliding
Bacteria II

6) Cell Wall

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Key Concept

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• **Parts of the Bacterial Cell**

• **Cell wall**: a thick, tough layer forming the shape of the cell
  – function: protection
  – Structurally different in gram + versus gram - bacteria
Parts of the Bacterial Cell

- The gram positive cell wall:
  - one thick layer of ________________ (sugars and amino acids bonded into one macromolecule; a very tough material)
Gram negative cell wall

The gram negative cell wall:
- two layers
  - thin inner layer of peptidoglycan
  - thicker outer membrane of protein and fat
Why should we know gram + & - ?

- Why is it important to know if a bacterial pathogen is gram positive or negative?
  - one of the important characteristics when identifying the bacterium
  - one of the important characteristics when choosing the best control method...:
• The gram stain

• primary stain: crystal violet
  – **all** bacteria stain violet

• __________ (agent that fixes the stain into the cells): aqueous iodine solution
  – cells become darker violet
• gram stain, continued

• decolorization: alcohol (95% ethanol) or an acetone/alcohol blend
  – only the gram negative cells decolorize
  – gram positive remain violet

• Counterstain:______________
  – gram negative cells stain red
  – gram positive remain violet
  – (Purple = Postive!)
• steps in gram stain

What would you see at this point!?
Figure 3.12

(a) 
1. Application of crystal violet (purple dye)
2. Application of iodine (mordant)
3. Alcohol wash (decolorization)
4. Application of safranin (counterstain)

(b) 
- Rod (gram-positive)
- Coccus (gram-positive)
- Vibrio (gram-negative)

KEY
- Purple: Crystal violet
- Orange: Iodine
- Clear: Alcohol
- Pink: Safranin

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items as seen in gram stain

- Yeast
- Spore
- Gram (-) rod
- Gram (+) coccus
- Gram (+) rod

Gram stain
7) Plasma Membrane

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Plasma membrane

• cytoplasmic (plasma) membrane
• also called cell membrane
• ultra-thin layer of fat and protein
phospholipids

Polar “Head” = Hydrophillic

NonPolar “Tails” = Hydrophobic

(c) Phospholipid molecules in lipid bilayer

Polar (hydrophilic) heads (phosphate group and glycerol)

Nonpolar (hydrophobic) tails (fatty acids)
detail of “________________________” of plasma membrane

- a living, functioning part of the cell
- _____________________________ (selective permeability)
Cell Membrane

Hydrophilic head

Hydrophobic tail

Outside cell

Cytoplasm (inside cell)

(a) Phospholipid bilayer of membrane
plasma membrane

• a vulnerable part of the cell
• easy to damage with heat or chemicals
Solution

Solute

Solvent (usually water)
Cell Membrane
10% Glucose

3% Glucose

Inside is Hyposmotic to the outside

10% Glucose

10% Glucose

Inside is Isosmotic to the outside

10% Glucose

50% Glucose

Inside is hyperosmotic to the outside
Things Can/Cannot go through:

*Can Go Through:

– Small, uncharged molecules (CO$_2$, O$_2$)
– Small, polar molecules (H$_2$O)
– Large non polar molecules (Steroids)
Transport

Passive – Does not require energy

- Dialysis
- Simple Diffusion
- Osmosis
- Facilitated

Active – Requires Energy (Na+/K+ Pump)
Other things attached a Cell Membrane
8) ________________

- The cytoplasm (cell fluid)
- semi-liquid contents of the cell
- complex mixture of chemicals
  - water
  - protein
  - many other chemicals
- forms a colloidal system
  - two states, sol and gel
Cytoplasm: a colloidal system

• ____: water continuous   ____: protein continuous

vulnerability: can permanently convert sol to gel with heat or chemicals
8A Stuff in the cytoplasm: Ribosomes

- ribosomes: bodies within the cytoplasm that function in protein synthesis
  - Composed of 2 subunits = 70 S (prokaryotic size)
    - S=Svedberg units of sedimentation with centrifugation
  - Consists of protein and ribosomal RNA (rRNA)
8B. ________________

- inclusion bodies: store nutrients (starch, glycogen, fats) for later use during periods of starvation
- Could store iron oxide or phosphate depending on cell.
8C. Genetic Material

• “Genes” are nucleic acids, discussed in unit 3 (used to make proteins!)

• Single chromosome
  – DNA only; no histone proteins
  – an endless loop not surrounded by nuclear membrane
  – never condenses to become visible with light microscope; can see with electron microscope
8D) ______________

• plasmids: small loops of extrachromosomal DNA
  – may be 0, 1 or more
  – often carry genes for virulence or drug resistance
  – Replicate independently of chromosomal DNA
8E) Endospore (Spore)

- A survival form of bacteria produced within the cell in response to adverse environmental conditions
- (Clostridium and Bacillus)
endospore

• Central, terminal, subterminal spores
spores:
Left *Bacillus*; right *Clostridium*

- Common spore-forming bacteria:
  - *Bacillus* spp. (aerobic, gram +, sporeforming bacilli)
  - *Clostridium* spp. (anaerobic, gram +, sporeforming bacilli)
• spore stained slide (green = spore)
endospore

• Spores can survive:
  – boiling
  – freezing
  – drying
  – vacuum
  – many disinfectants
  – time (250 million years?)
endospore

• to kill spores
  – steam autoclave
  – gas autoclave
  – some disinfectants
  – powerful radiation
spores: terms used

- **sporogenesis** = spore formation
- **germination** = reactivation
- **vegetative cells** = not spores