BIOL 240: General Microbiology

Spring 2020 Rm. 23-203 MW, Feb. 3-5

http://accounts.smccd.edu/staplesn/biol240/

1. **Pre-Lab Writeup #3 due today!: ALL of Expt. 4.**
   Be sure to prepare before each Monday's labs (for BOTH Mon. & Wed.)!!
   (What? Why? How? are we doing in the lab?? Hypothesis?)
2. **WATCH Online and answer Ch. 3 Objectives on Microscopy, ASAP. DUE this Wed., with Ch. 2!!**
3. **Study Guides & Lesson Objectives (see slides) due THIS WED. in Lab (Ch. 2a, 3?)!**
4. ***Extra Credit Opportunity: Starting This Wed: Wed. evenings, 5-6 pm, (2/4-3/25/2020) in Bldg. 6, Room 102 – STEM SPEAKER Series. 1 page summary & reflection due (on CANVAS) the following week.***
   - **https://www.canadacollege.edu/stemcenter/speaker-series.php**
1. **REVIEW SESSIONS for Midterm Exam #1 NEXT Mon./Wed. 2-3pm, and Wed. 8:15am-9:35am… *(Review Sheet will be updated this weekend)***

1

REVIEW:

1. Describe how the **Octet Rule** affects chemical bonding, and distinguish between the relative strengths of the **3 main chemical bonds** formed in biomolecules.
2. Distinguish between **4 types of chemical interactions and reactions** common in living systems…..
3. List 5 special **properties of water** that make it the "perfect" medium for life.

OBJECTIVES: Students should be able to: …..

1. List the **4 types of macromolecules** in living systems, and describe how the components of each particular ***molecular structure determines its biological function……***
   a) ***How is each Macromolecular polymer synthesized? How is each degraded?***
   b) ***What elements, functional groups and monomers does each have?***
   c) ***What general properties do these components confer?***
2. Describe, diagram and give examples of each level of **Protein Structure**.
3. **Ch. 4:** Describe **4 extracellular structures unique to prokaryotes**, & explain the function of each.
4. Compare and contrast **5 structural characteristics of the gram positive and gram negative cell walls**. Include illustrations.
5. Compare and contrast 8 differences between ***"prokaryotic" and eukaryotic cells***. What structures do they share in common? …..

❖ ***These questions are your HOMEWORK between classes!!!***
- ***DUE (and/or Study Guide questions) WED. at the start of Lab!!***

2

Acid-Base Balance

- The amount of $\mathbf{H^+}$ in a solution is expressed as pH. [$\mathbf{H_3O^+}$]
- pH = –log[H^+] (Molar = moles/L)
  - eg: **pH 7 = 1/10^7 (= 10^{-7}) moles H+/L**

❖ Increasing **[H^+],** increases **acidity**.

❖ Increasing **[OH^-]** or decreasing **[H^+]** increases **alkalinity**.

- Most organisms grow best b/tw **pH 6.5 & 8.5**.

3

Acid-Base Balance

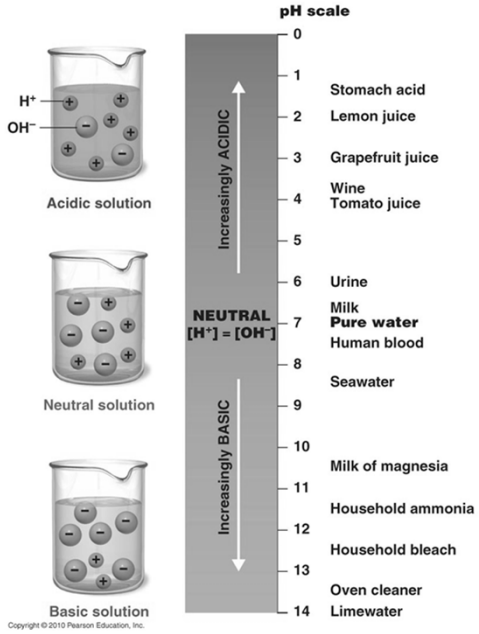
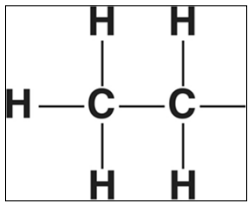


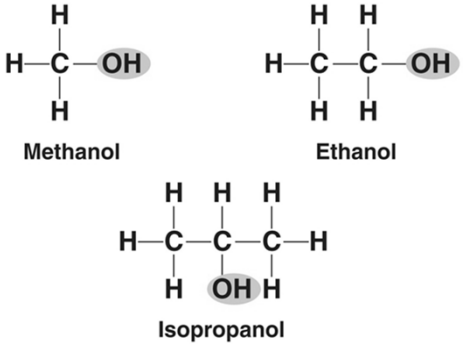
Figure 2.7

4

C. Organic Compounds

- ***Carbon skeleton***
  - The chain of carbon atoms in an organic molecule.
- ***Functional groups***
  - Responsible for most of the chemical properties of a particular organic compound.





Hydroxyl groups (-OH) → alcohols

5

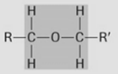
Functional Groups

Table 2.3

Table 2.3 Representative Functional Groups and the Compounds in Which They Are Found

Structure	Name of Group	Biological Importance
R—O—H	Alcohol	Lipids, carbohydates
	Aldehyde*	Reducing sugars such as glucose; polysaccharides
	Ketone*	Metabolic intermediates
	Methyl	DNA; energy metabolism
	Amino	Proteins

Table 2.3 Representative Functional Groups and the Compounds in Which They Are Found

Structure	Name of Group	Biological Importance
	Ester	Bacterial and eukaryotic plasma membranes
	Ether	Archaeal plasma membranes
	Sulfhydryl	Energy metabolism; protein structure
	Carboxyl	Organic acids, lipids, proteins
	Phosphate	ATP, DNA

*In an aldehyde, a C═O is at the end of a molecule, in contrast to the internal C═O in a ketone.

6

Organic Compounds

- Small organic molecules can combine into large ***macromolecules***.
- ***Macromolecules are polymers consisting of many small repeating molecules.***
  - The smaller molecules are called monomers.

7

Organic Compounds

- Monomers join by ***dehydration synthesis*** or ***condensation reactions***.

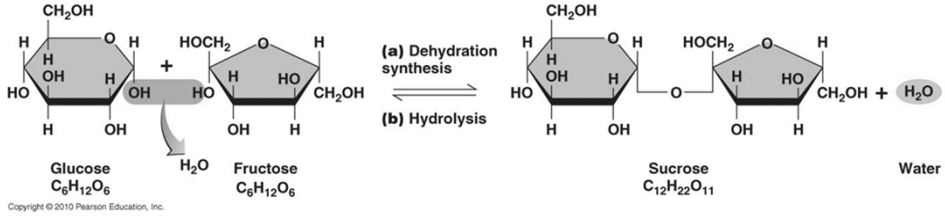


Figure 2.8

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1. Carbohydrates

- Are important for structure and as energy sources.
- Consist of C, H, and O with the formula $\underline{(CH_2O)_n}$
- ***Monosaccharides*** are simple sugars with 3 to 7 carbon atoms.

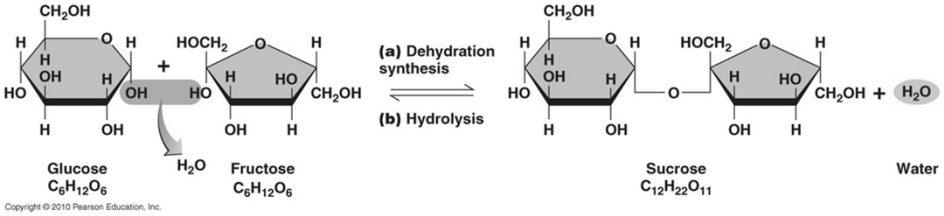

Figure 2.8

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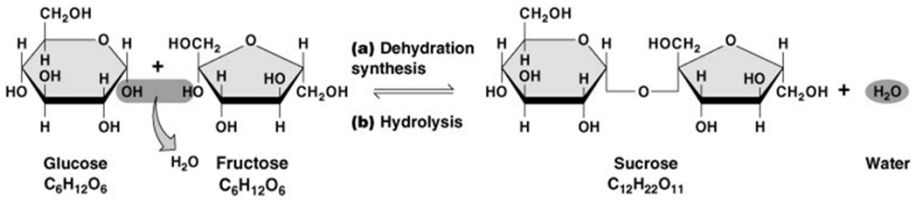
Carbohydrates

- Disaccharides are formed when two monosaccharides are joined in a ***dehydration synthesis (condensation)***.
  - Disaccharides can be broken down by ***hydrolysis***.



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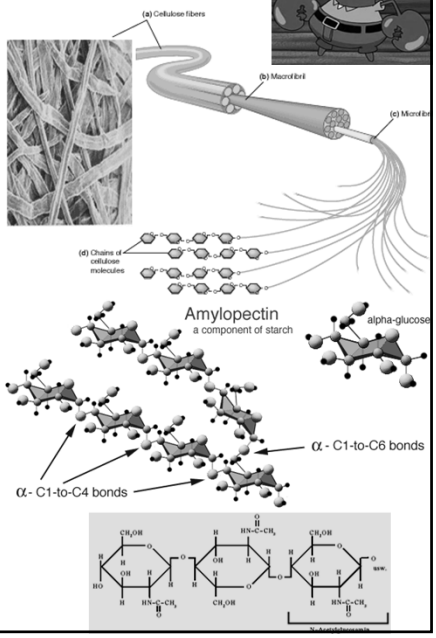
Carbohydrates

1. ***Oligosaccharides*** consist of 2 to 20 monosaccharides.
2. ***Polysaccharides*** = *tens or hundreds of monosaccharides joined by condensation rxns.*
3. **Starch, glycogen, dextran, & cellulose**
   - All polymers of glucose that are covalently bonded differently.
4. **Chitin** is a polymer of two sugars repeating many times.



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2. Lipids

- Are the primary components of cell membranes.
- Consist of **C**, **H**, and **O**.
- Are ***nonpolar*** and ***insoluble*** in water.
  - ***"Hydrophobic"***

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a.) Simple lipids

- = **fats** or ***triglycerides***
  - contain glycerol and fatty acids; formed by **dehydration synthesis**.
- ***Unsaturated fats***
  - have one or more double bonds in the fatty acids.
- **LENGTH** of fatty acid tails affects fluidity too.

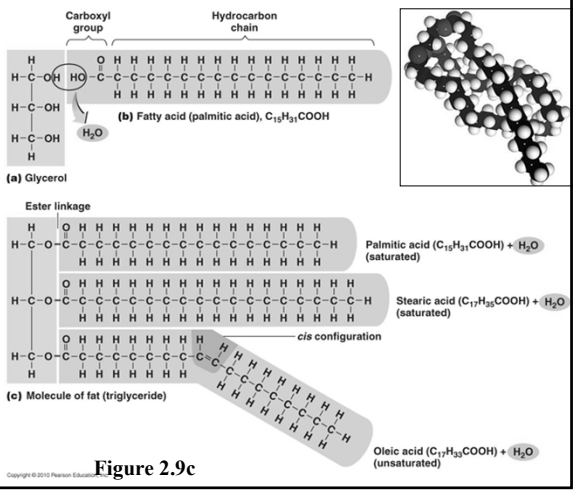

Figure 2.9c

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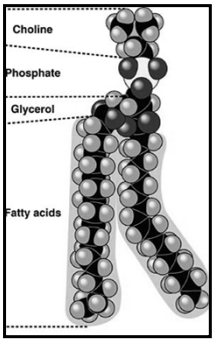
b.) Complex lipids

- Contain C, H, & O, + P, N, or S.
- Membranes are made of ***phospholipids***
  - **Hydrophilic head;**
  - **Hydrophobic tail**



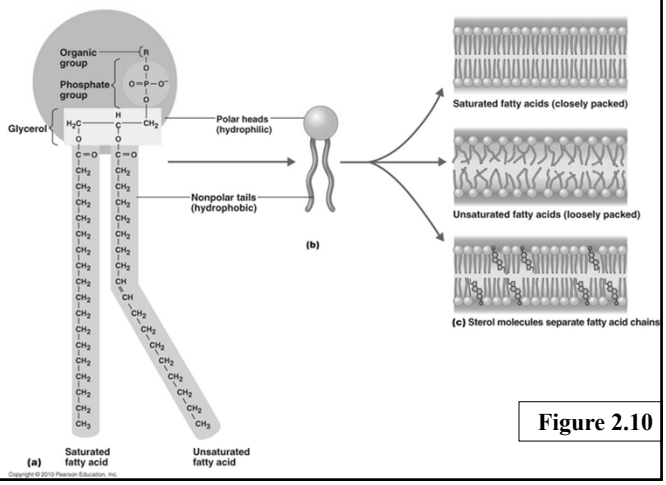


Figure 2.10

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c.) Steroids

- Consist of **four carbon rings**, with an **–OH group** attached to one ring.
  - Are part of membranes.
  - Precursors to hormones.

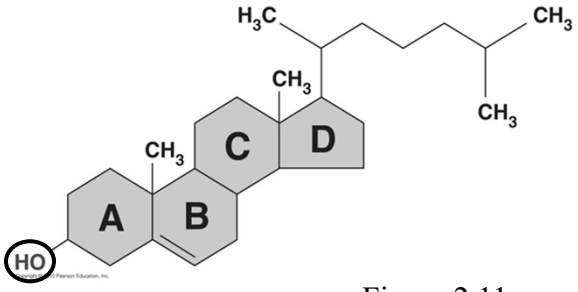

Figure 2.11

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3. Proteins

- Are essential in cell structure and function.

1. ***Enzymes*** are proteins that speed chemical reactions.
2. ***Transporter proteins*** move chemicals across membranes.
3. Flagella are made of proteins.
4. Some bacterial toxins are proteins.

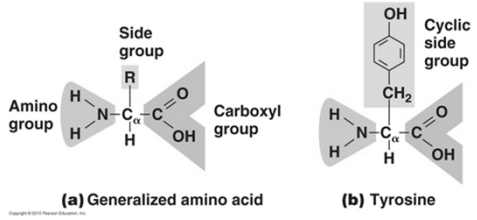

Figure 2.12

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a.) Proteins – Amino Acids

- Consist of subunits called ***amino acids***.

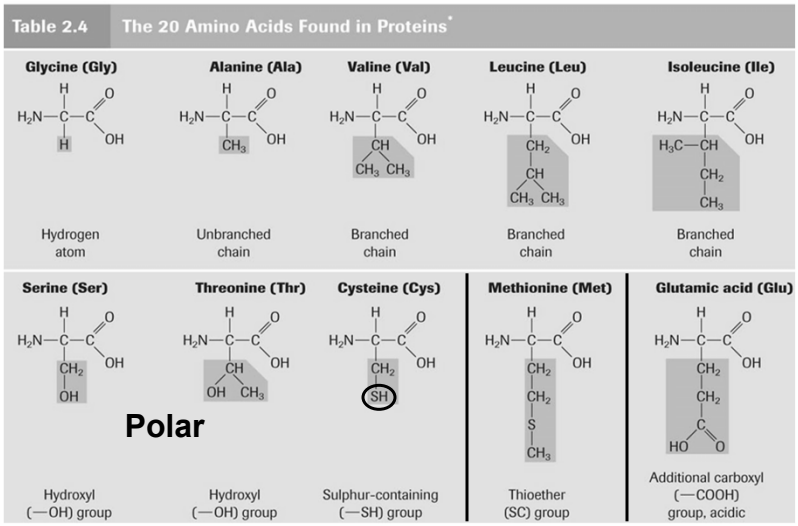

Table 2.4.1

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Amino Acids

Acidic, anionic

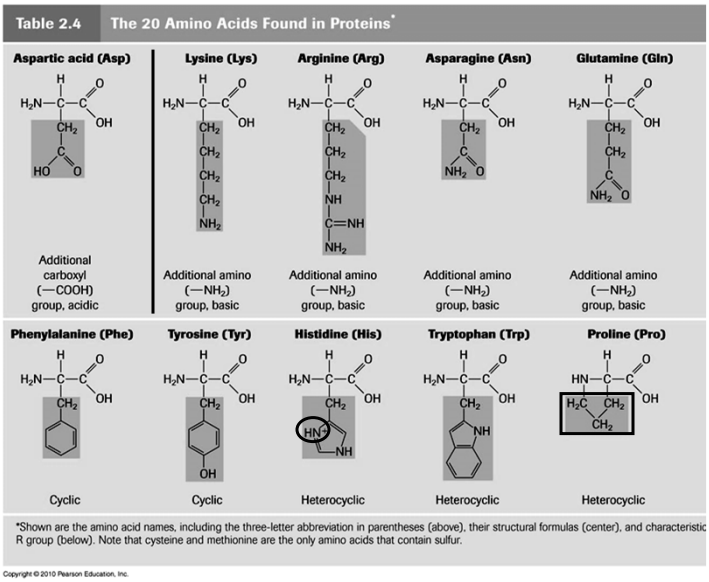

Table 2.4.2

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b.) Peptide Bonds

- ***Peptide bonds*** between amino acids are formed by Dehydration Synthesis/ Condensation Reactions

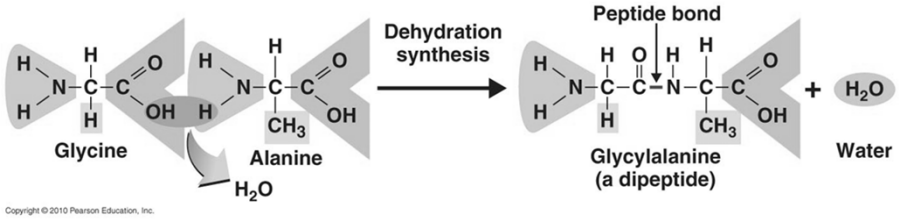

Figure 2.14

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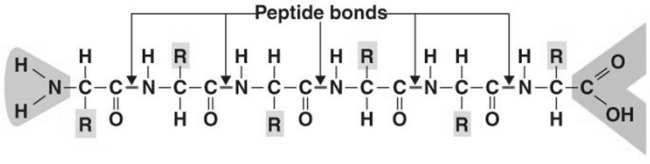
c.) Levels of Protein Structure

1. The ***primary structure*** is a polypeptide chain
   - LINEAR SEQUENCE and number of AA's.
   - ***Covalent peptide bonds*** (-C—N-)
     - ***…. -NCC-NCC-NCC-NCC- ….***

1°



(a) Primary structure: polypeptide strand

Figure 2.15a

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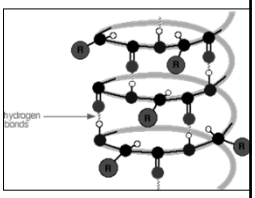
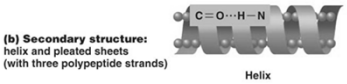
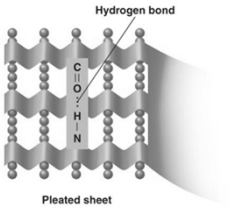
Levels of Protein Structure

2. The ***secondary structure*** – amino acid chain folds and coils in a regular (α) **helix** or (β) **pleats**.
   - Simple folded/coiled structures
   - Hydrogen-bonding.



2°





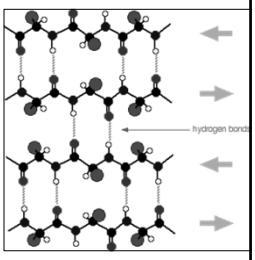


Figure 2.15b

http://www.chemguide.co.uk/organicprops/aminoacids/proteinstruct.html

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Levels of Protein Structure

3°

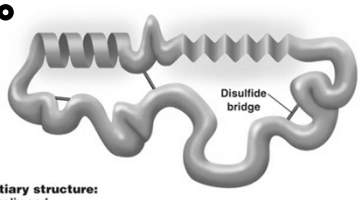
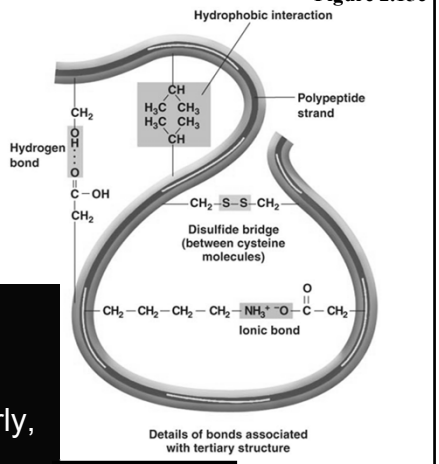
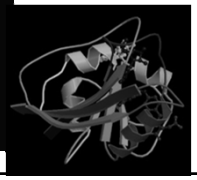
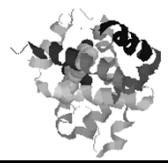


Figure 2.15c



3. The ***tertiary structure*** (3D structure!!):
   - the polypeptide folds irregularly,
   - forming disulfide bonds, H-bonds, hydrophobic interactions, & ionic bonds between amino acids in the chain.





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Levels of Protein Structure

4. The ***quaternary structure*** consists of two or more polypeptides.
   - ❖ **Two or more (≥ 2), 3D-folded polypeptides** associated into a multi-peptide complex.
     - Same types of bonds as found in tertiary structure connect the separate polypeptides.

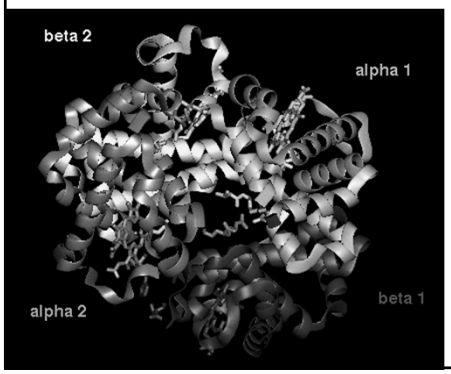
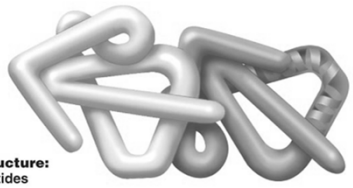


Figure 2.15d

4°



(d) Quaternary structure: two or more polypeptides in their folded states

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d.) Complex Macromolecules

❖ **Conjugated proteins** consist of amino acids and other organic molecules:

1) **Glycoproteins**
2) **Nucleoproteins**
3) **Lipoproteins**
4) **Phosphoproteins …..**

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4. Nucleic Acids

- Consist of ***nucleotides***.
- Contain information. Some are catalytic!...
- Nucleotides consist of a:
  - ***(Phosphate-Sugar-Base)***
  1. Pentose – 5C sugar (ribose or deoxyribose)
  2. Phosphate group = $\mathbf{PO_4^{2-}}$
  3. Nitrogen-containing base (purine or pyrimidine).

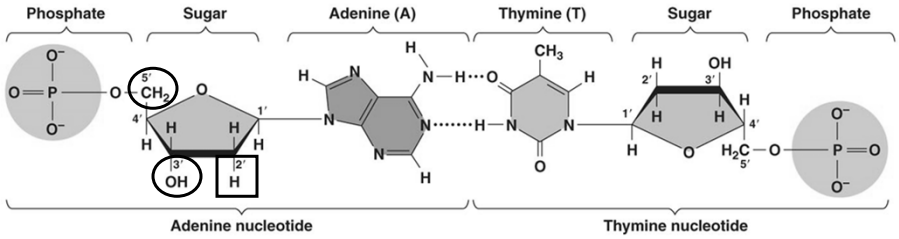

Figure 2.16

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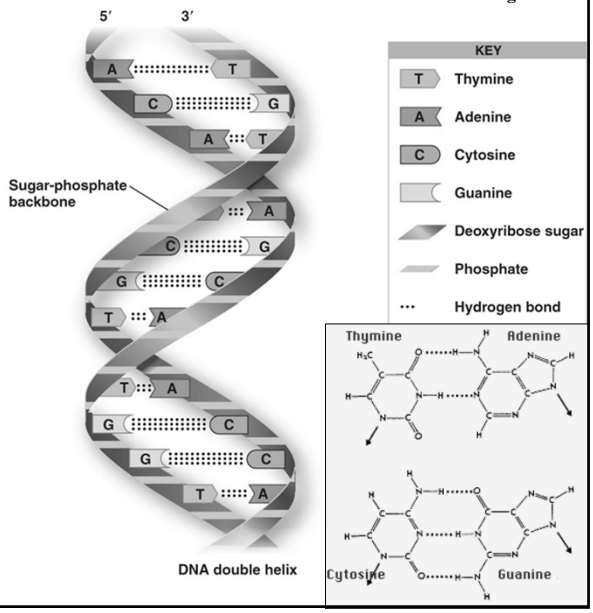
a.) DNA

Figure 2.16

1. Has deoxyribose
2. Exists as a double helix
3. Strands assemble **5'Phos. → 3'OH**
4. **A** hydrogen bonds only with **T**
5. **C** hydrogen bonds only with **G**
6. Strands are **ANTIPARALLEL.**



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b.) RNA

1. Has **ribose**.
2. Is single-stranded
3. Strands assemble **5'Phos. → 3'OH**
4. **A** hydrogen bonds only with **U**
5. **C** hydrogen bonds only with **G**
6. Complex 3D folding.

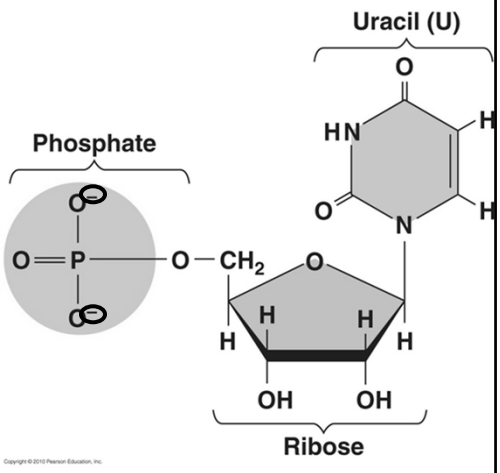

Figure 2.17

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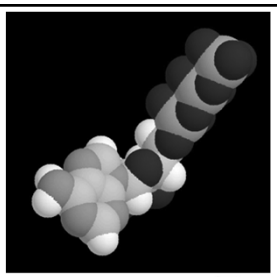
c.) ATP

- Has ribose, adenine, and 3 phosphate groups



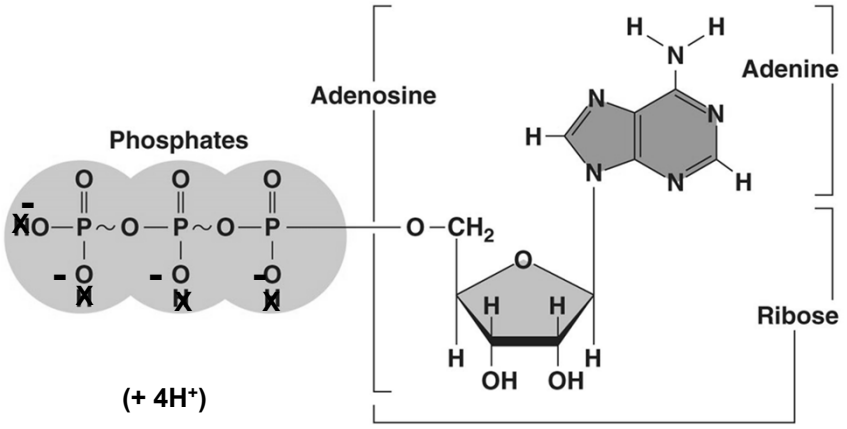


Figure 2.18

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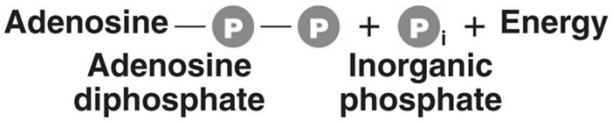
ATP

- Is made by <u>dehydration synthesis</u>.
  - Absorbs/requires energy = ***Endergonic***
- Is broken by <u>hydrolysis</u> to liberate useful energy for the cell.
  - Releases energy = ***Exergonic***



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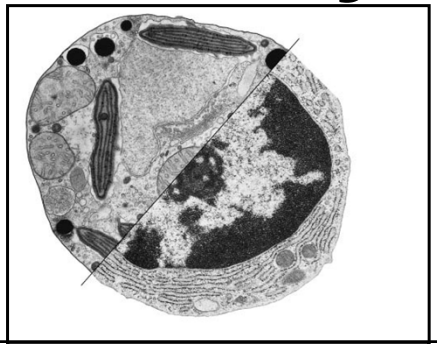
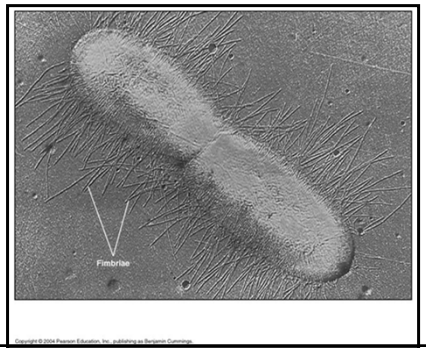
Chapter 4 Functional Anatomy of Prokaryotic & Eukaryotic Cells





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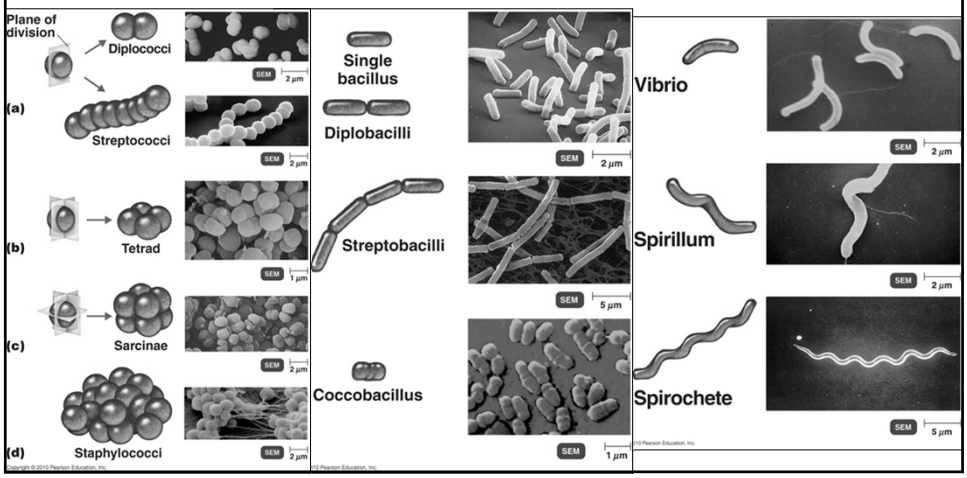
4.1) Prokaryotic Cells

- **Average size: 0.2 -1.0 µm × 2 - 8 µm**
- **Basic shapes:**



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- Unusual shapes
  - Star-shaped *Stella*
  - Square *Haloarcula*
- Most bacteria are monomorphic (one shape)
- A few are ***pleiomorphic*** (many forms/shapes)

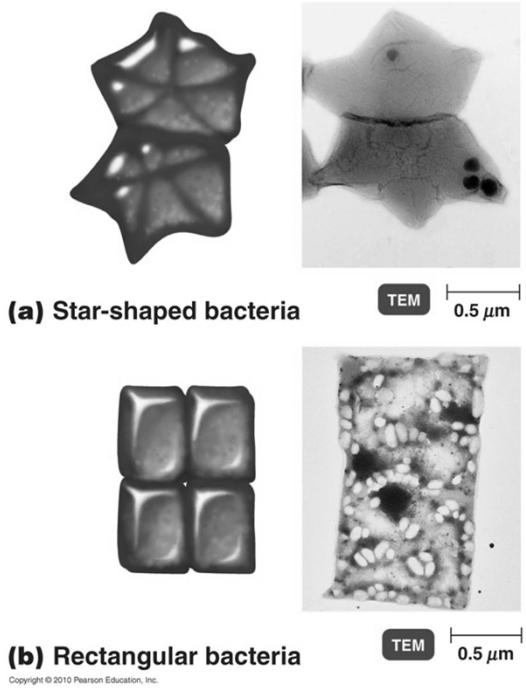

Figure 4.5

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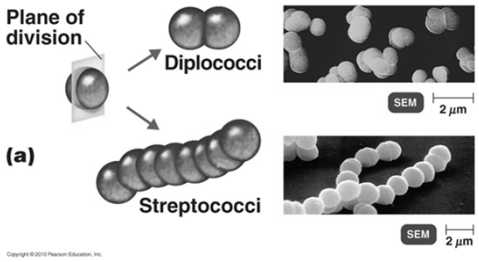
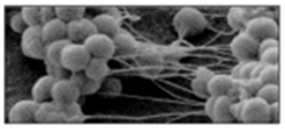
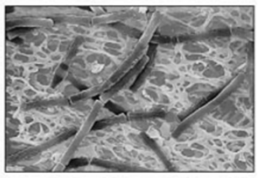
Arrangements



- **Pairs**: diplococci, diplobacilli
- **Clusters**: staphylococci



- **Chains**: streptococci, streptobacilli



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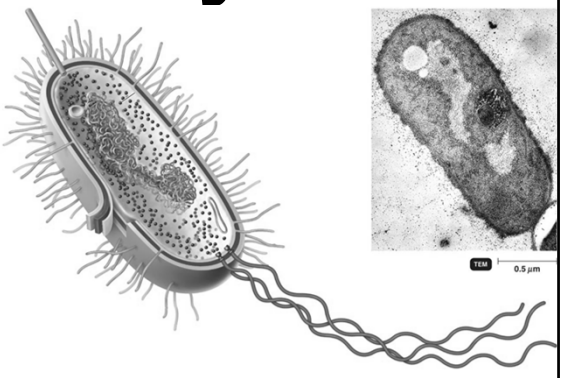
A. Glycocalyx

Figure 4.6



- Outside cell wall
- Usually sticky
- A ***capsule*** is neatly organized
- A ***slime layer*** is unorganized & loose
  - Extracellular polysaccharide (EPS) allows cell to attach
  - Capsules prevent phagocytosis

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B. Flagella

- Outside cell wall
- Made of chains of ***flagellin***
- Attached to a protein ***hook***
- Anchored to the wall and membrane by the ***basal body***

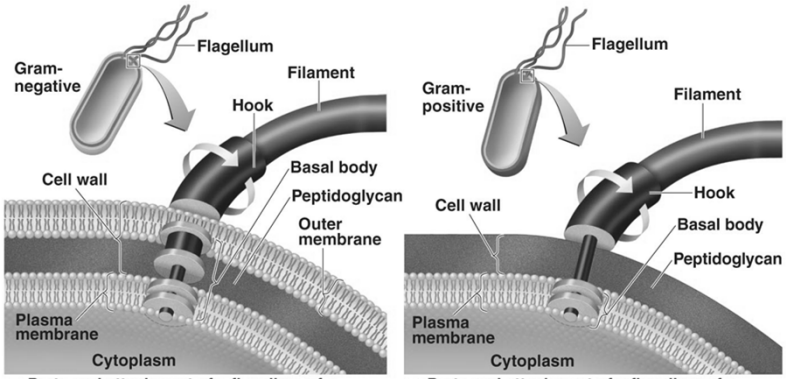

Figure 4.8

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Flagella Arrangement

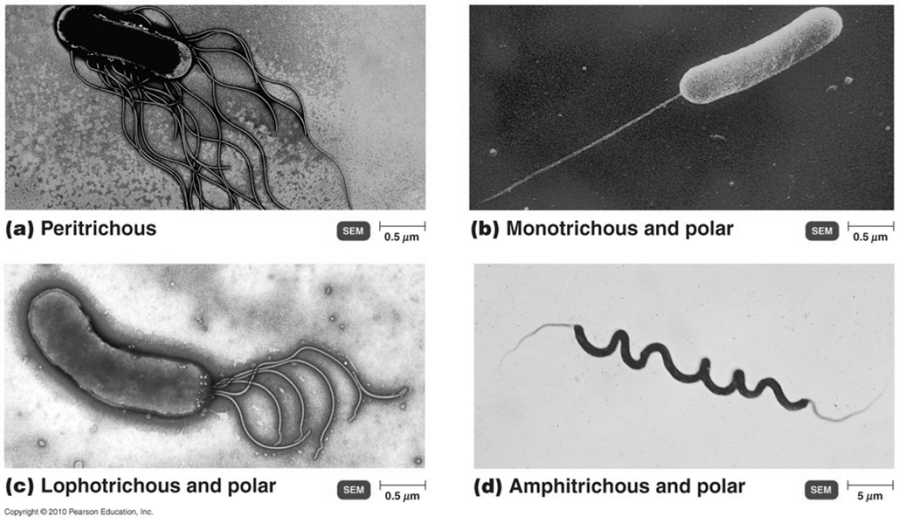

Figure 4.7

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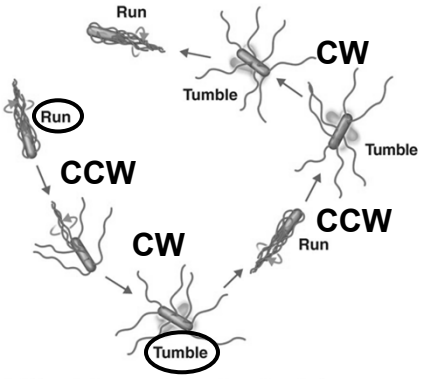
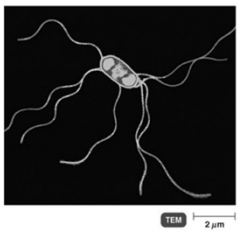
Motile Cells

- Rotate flagella to ***run*** or ***tumble.***
- Move toward or away from stimuli (***taxis***)
- Flagella proteins are H antigens
  - e.g., *E. coli* O157:H7



(a) A bacterium running and tumbling. Notice that the direction of flagellar rotation (blue arrows) determines which of these movements occurs. Gray arrows indicate direction of movement of the microbe.



(b) A *Proteus* cell in the swarming stage may have more than 1000 peritrichous flagella.

http://youtu.be/xEVq7jCT4kw

http://web.biosci.utexas.edu/psaxena/MicrobiologyAnimations/Animations/BacterialMotility/PLAY_motility.html

Figure 4.9

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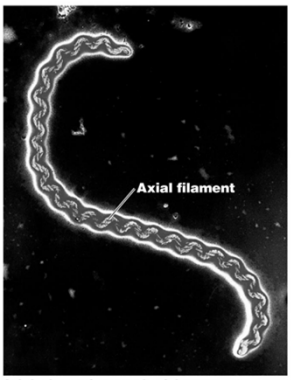
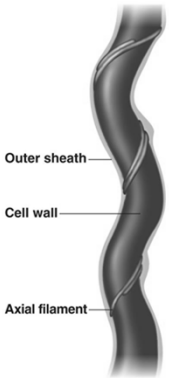
B_2. Flagella: ***Axial Filaments***

- ***Endoflagella***
- In **spirochetes**
- Anchored at one end of a cell
- Rotation causes cell to move



(a) A photomicrograph of the spirochete *Leptospira*, showing an axial filament



(b) A diagram of axial filaments wrapping around part of a spirochete. (See Figure 11.24a for a cross section of axial filaments)

http://youtu.be/pUomEHMLHwU

Figure 4.10

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C. Fimbriae & Pili

1. ***Fimbriae*** allow attachment.

2. ***Pili*** are used to transfer DNA from one cell to another.

Figure 4.11

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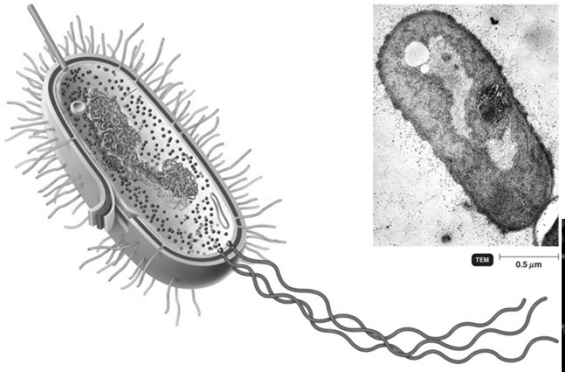
D. Cell Wall

- Prevents osmotic lysis
- Made of peptidoglycan (in bacteria)



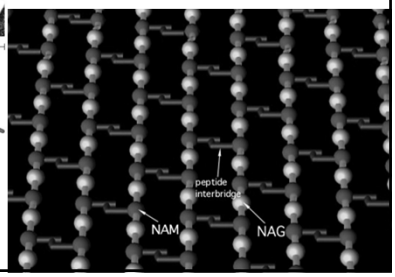


Figure 4.6

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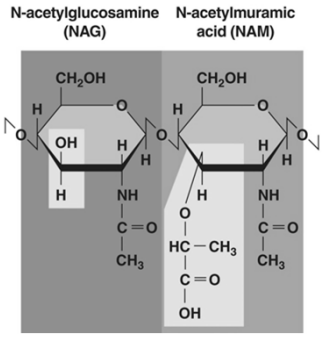
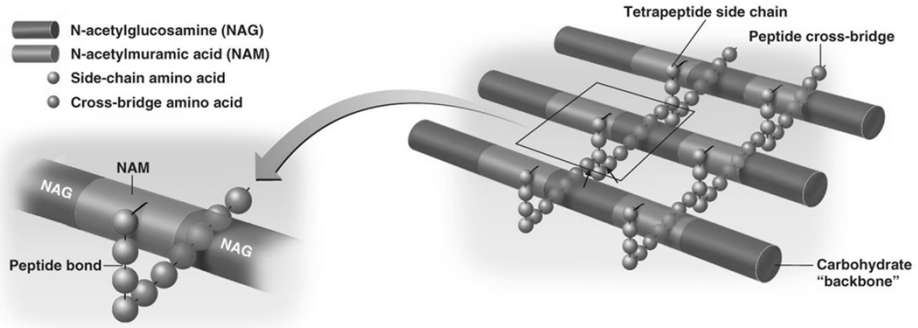
Peptidoglycan

- Polymer of disaccharide.
  - N-acetylglucosamine (**NAG**) &
  - N-acetylmuramic acid (**NAM**)
- Linked by polypeptides.





(a) Structure of peptidoglycan in gram-positive bacteria

Figure 4.13a

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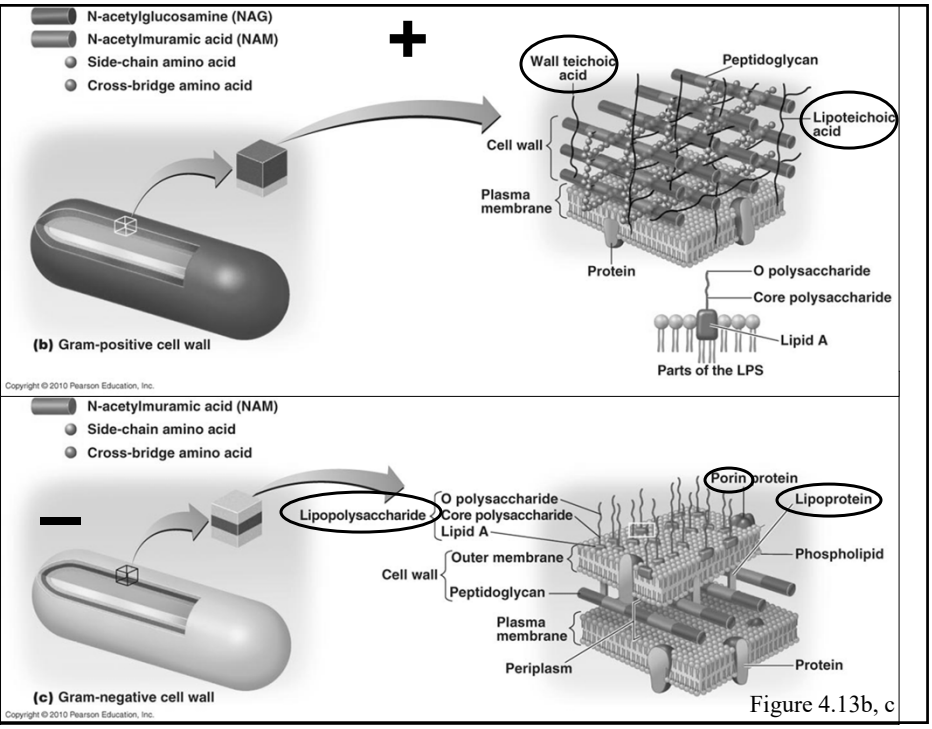

Figure 4.13b, c

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1. Gram-Positive cell walls

- **Teichoic acids:**
  - ***Lipoteichoic acid*** links to plasma membrane
  - ***Wall teichoic acid*** links to peptidoglycan
- May regulate movement of cations
- Polysaccharides provide antigenic variation

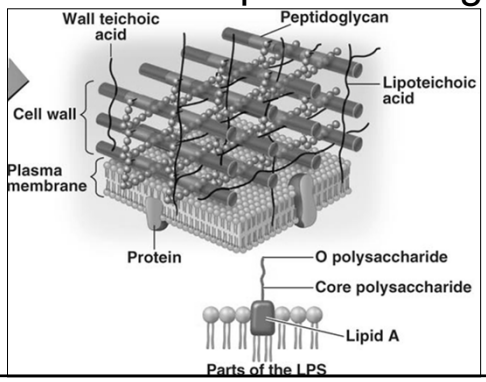

Figure 4.13b

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2. Gram-Negative Outer Membrane

1. Lipopolysaccharides, lipoproteins, phospholipids.
2. Forms the ***periplasm*** between the outer membrane and the plasma membrane.
3. Protection from phagocytes, complement, antibiotics.
   a. **O polysaccharide antigen**,
      - e.g., *E. coli* **O157:H7**. (H = flagellum protein antigen)
   b. **Lipid A** is an endotoxin.
   c. **Porins** (proteins) form **channels** through membrane

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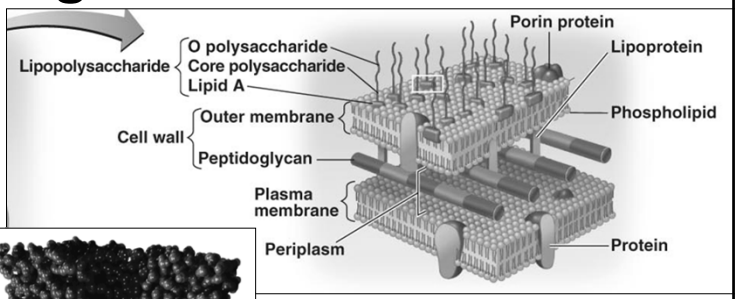
Gram-Negative Outer Membrane



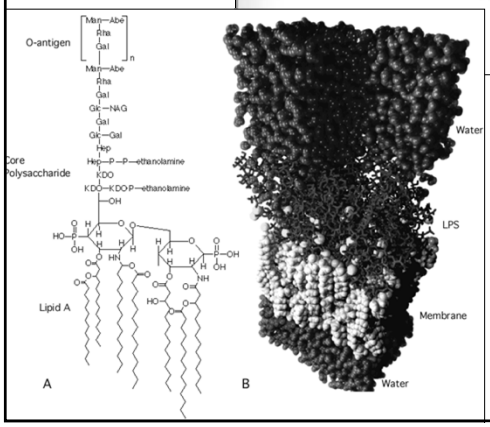


Figure 4.13c

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Gram-positive Cell Walls

1. Thick peptidoglycan
2. ***Teichoic acids, Lipoteichoic acids***
3. In acid-fast cells, contains mycolic acid

Gram-negative Cell Walls

1. Thin peptidoglycan
2. No teichoic acids
3. Outer membrane
   - ***Lipopolysaccharide***
     - ***Lipid A = endotoxin***
     - ***O-antigen = polysacc.***

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Gram Stain Mechanism

- Crystal violet-iodine crystals form in cell.
- **Gram-positive**
  - Alcohol dehydrates peptidoglycan.
  - CV-I crystals do not leave.
- **Gram-negative**
  - Alcohol dissolves outer membrane and leaves holes (large spaces) in peptidoglycan.
  - CV-I washes out.

http://faculty.ccbcmd.edu/courses/bio141/labmanua/lab6/images/gram_stain_11.swf

http://highered.mheducation.com/olcweb/cgi/pluginpop.cgi?it=swf::530::530::/sites/dl/free/0073525502/930300/Gram_Stain.swf::Gram%20Stain

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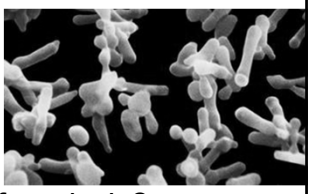
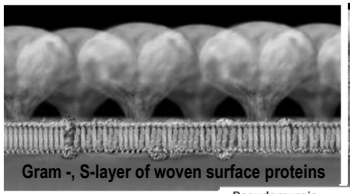
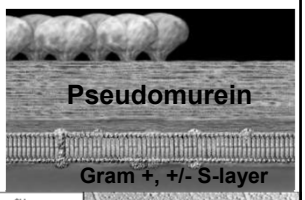
3. Atypical Cell Walls

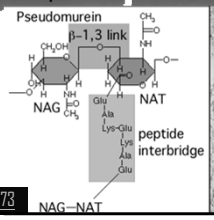
- **Mycoplasmas:**
  - Lack cell walls; smallest bacteria!
  - ***Sterols*** in plasma membrane
    - waxy; fatty; hydrophobic; stabilizes from lysis?



- **Archaea:**
  - Wall-less, or
  - Walls of ***pseudomurein***
    - (lack NAM and D amino acids)
    - ***NAT*** =
      - N-acetylalosaminuronic acid







http://www.microbiologytext.com/index.php?module=Book&func=displayarticle&art_id=73

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