BIOL 230: Cell & Molecular Biology
Fall 2019 17-205 W, Sept. 4

http://accounts.smccd.edu/staplesn/biol230/

1. Pre-Lab writeups due each Mon. (for both M&W!!) at the start of lab. (*briefly*, **What**? **Why**? **How**? for each expt.). Question & **Hypothesis**?!
2. **LAB this week: Protein Concentration Assay, Spectrophotometry, and Micropipetting!!** ☺
3. ***QUIZ #1 DUE TODAY!*** *on SMCCD* ***CANVAS: https://smccd.instructure.com/.***
4. **Join the STEM/MESA program!!** Contact Cathy Lipe:. Scholarships, internships, interview workshops, application workshops, etc.
   a) To get the STEM Scoop via email each week, add your name to the list by filling out this 2 minute survey **https://bit.ly/2BC4gle**.
   b) **See CANVAS for STEM Canvas Page and STEM Scoop!!!! (Contact Marcella Grant at grantm@smccd.edu).**
5. **Meet in Lab, then walk to LIBRARY: MONDAY, 9/9, at 2:10 PM!!** ***Start thinking about possible research topics!!*** ☺
   – ******Due Oct. 2, with 1 or 2 Professional, Primary Reference!!***
6. **Extra Credit: STEM SPEAKER SERIES, Weds. @ 5pm-6pm, Sept. 11- Nov. 6. (NOT Oct. 9) in 6-102.** ***Write 1 page summary by the following week, and upload to CANVAS.***

1

REVIEW

1. List and define the general **structures and functions of the 4 major classes of macromolecules**. Provide specific examples. …..
2. Illustrate how the chemical **structures** of carbohydrates, lipids, nucleic acids and proteins generate their various **functions**. Describe & draw specific examples. …..
   • Note the relative elemental content and functional groups of each macromolecule. (eg: DNA vs. RNA, lipids, CHOs)

TODAY's Objectives: Students should be able to....

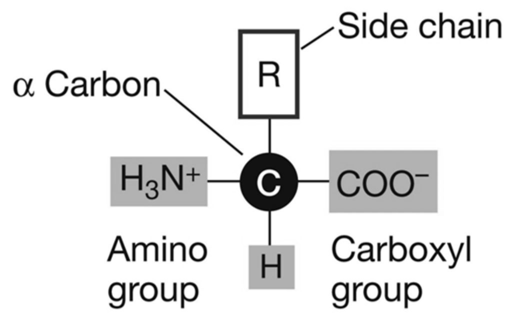
1. Describe the **levels of protein structure**, and illustrate each with a specific example.
2. Compare the structures and stabilities of **DNA and RNA**. How is each molecule suited to its biological function??
3. Describe the **Urey-Miller experiment**. What did it *prove*?
4. Diagram how **Louis Pasteur** conducted his experiments to determine how life truly arises. *What did he prove, and what did he disprove?*
5. State the **Cell Theory** and explain it's implications for our understanding of life on earth. (Convert between **metric size units** of m, cm, mm, μm, & nm.)

❖ ***Objectives and Study Guide Questions are your HOMEWORK between classes!!!*** ***DUE every WED. at the end of Lecture!!***

2

3.4) Proteins: Polymers of Amino Acids

- **Functions:**
  (most major cellular fxns! Except genetic info.)
  1. **support**
  2. **protection**
  3. **catalysis**
  4. **transport**
  5. **defense**
  6. **regulation**
  7. **movement**



- **They sometimes require an attached prosthetic group.**

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A. 20 amino acids (basic strx) =

amino, carboxy, H atom, & R group (on α-C)

R
|
H_2N—C^{α}— COOH ↔
|
H

R
+ |
H_3N— C^{α}— COO-
|
H

At physiological pH (in cell)

- **Side chains of amino acids may be <u>charged</u>, <u>polar</u>, or <u>hydrophobic</u>.**

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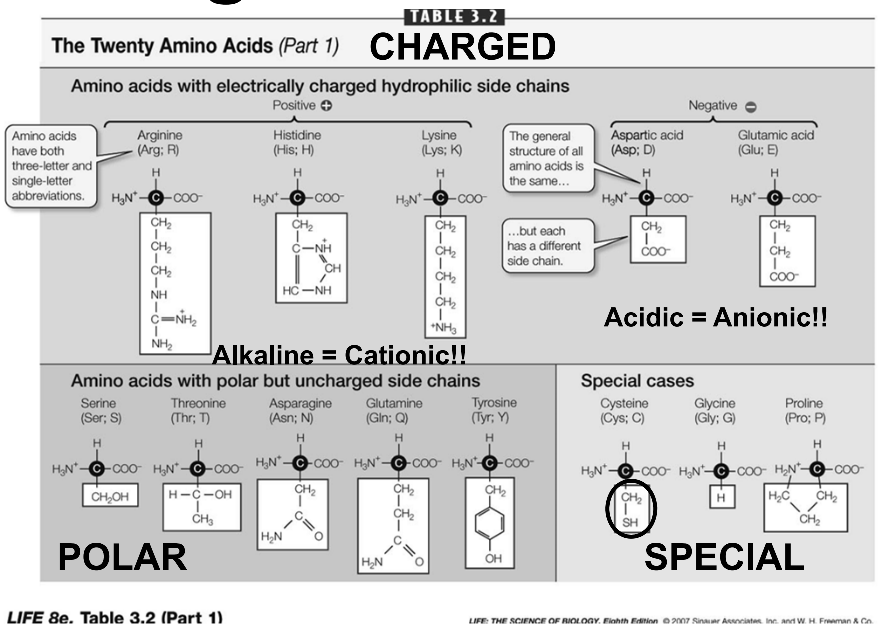
Charged & Polar AA's



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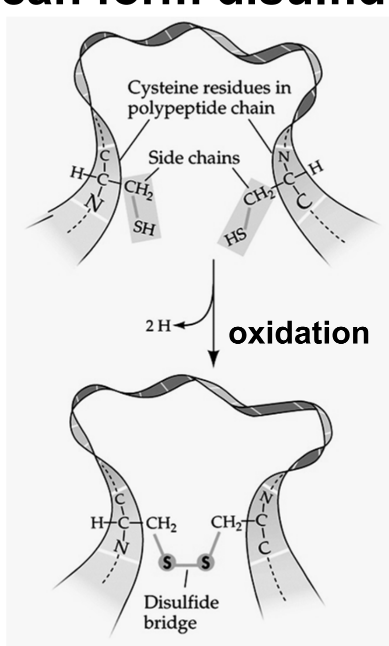
SH groups can form disulfide bridges

Cysteine residues **(cys)**



- ***Within a protein or***
- ***Between separate polypeptides***

figure 3.3 (2004, 7e)
[see fig. 3.5, 2007/2010]

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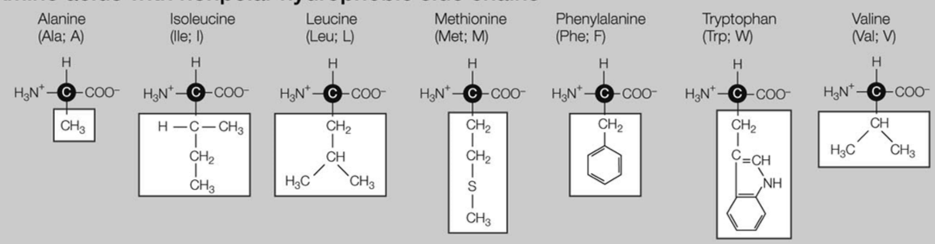
Hydrophobic AA's

TABLE 3.2

The Twenty Amino Acids *(Part 2)* **HYDROPHOBIC**

Amino acids with nonpolar hydrophobic side chains



***LIFE 8e*, Table 3.2 (Part 2)**

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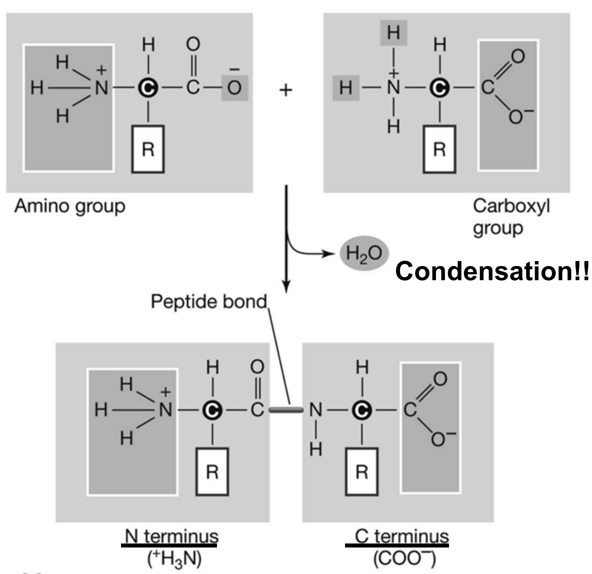
B. Amino acids are covalently bonded together by <u>Peptide Linkages</u>



***LIFE 8e*, Figure 3.6**

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C. Protein Structure: Polypeptide chains are folded into specific 3D shapes

- **Hierarchy: Primary → Secondary → Tertiary → Quaternary Structures**
  - ***AA sequence ultimately determines 3D structure and Prot. FUNCTION!!***
  - ***** [(Monomers →) <u>3D structure → Fxn</u>] *****
- ***All protein structure and function is ultimately specified by DNA!!!***

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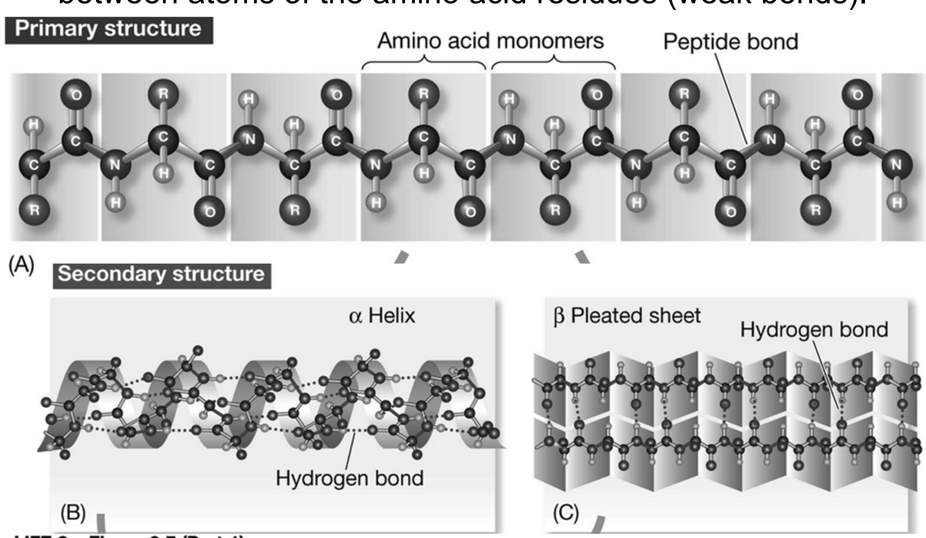
1. **<u>Primary structure</u>** = the sequence of amino acids
   - peptide linkages (covalent bonds); NCC-NCC-NCC-…. backbone.
2. **<u>Secondary structures</u>** = maintained by hydrogen bonds between atoms of the amino acid residues (weak bonds).



***LIFE 8e*, Figure 3.7 (Part 1)**

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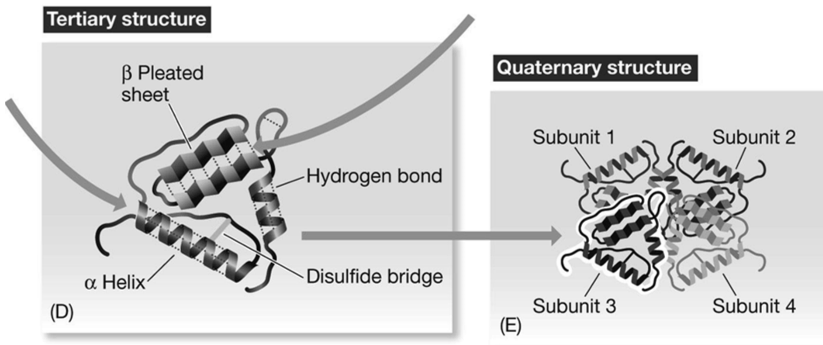
3. **Tertiary structure** = 3D bending and folding of the polypeptide chain (weak and S-S covalent bonding).
4. **Quaternary structure** = arrangement of polypeptides in a single functional unit consisting of more than one polypeptide subunit (weak bonding).



LIFE 8e, Figure 3.7 (Part 3)

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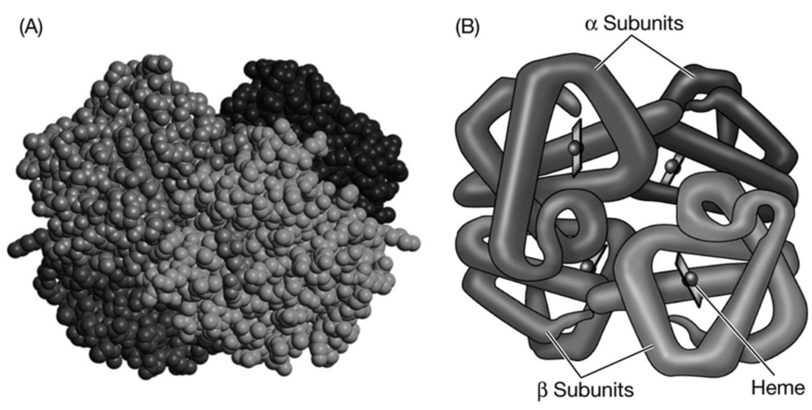
Hemoglobin and Quaternary Strx



LIFE 8e, Figure 3.9

- **Quaternary structure** = Multi-Subunit proteins!!
  - (> 1 polypeptide)

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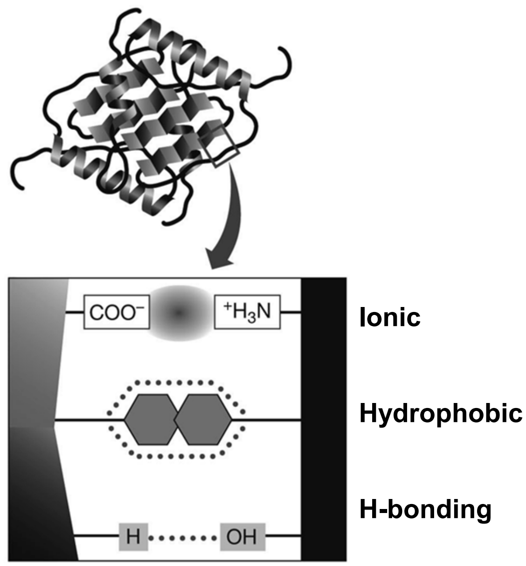
D. Binding of proteins to other molecules

❖ Weak chemical interactions are important!!



8e, Figure 3.10

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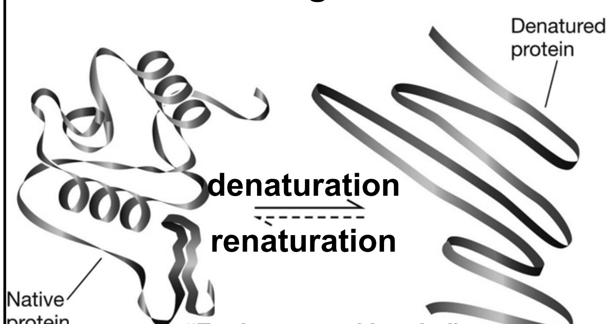
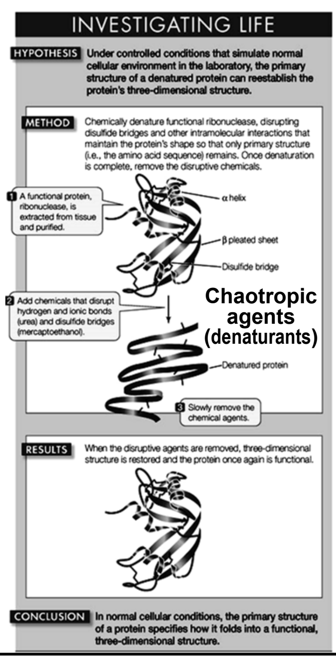
E. Proteins can be Denatured:

- by heat, acid, or chemicals (salts, solvents, etc.)
- lose tertiary and secondary structure and …
  - → ***Lose biological function***



"Environmental insults"
- **High temperature (and low)**
- **pH changes**
- **High concentrations of ions/salts**
- **Nonpolar substances (solvents)**



LIFE 8e, Figure 3.11

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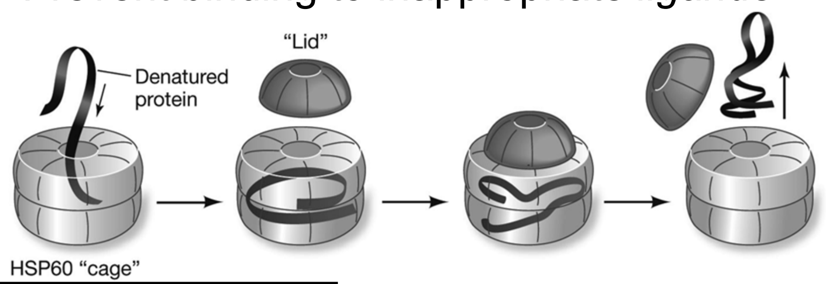
Chaperonins assist protein folding

- "***Molecular Chaperones***" – prevent inappropriate interactions
  - (like human Chaperones!)
- Prevent binding to inappropriate *ligands*



Newly synthesized, or denatured protein

***LIFE 9e*, Figure 3.12**

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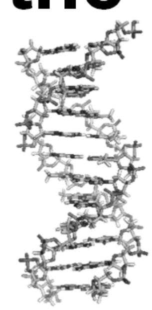
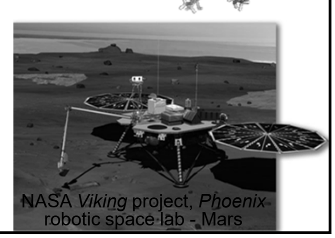
Chapter 4:

Nucleic Acids and the Origin of Life



1) **4.1 What Are the Chemical Structures and Functions of Nucleic Acids?**
2) **4.2 How and Where Did the Small Molecules of Life Originate?**
3) **4.3 How Did the Large Molecules of Life Originate?**
4) **4.4 How Did the First Cells Originate?**



NASA *Viking* project, *Phoenix* robotic space lab - Mars

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4.1) Nucleic Acids:
Informational Macromolecules

- In cells, **DNA** is the hereditary material.
- **DNA** and **RNA** play roles in **protein** formation.

❖ **Question:**

***** WHAT COMPOSITIONS, STRUCTURES, AND PROPERTIES OF NA's permit them to play these fundamental informational roles?? *****

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Nucleic Acids:
Informational Macromolecules

1. Nucleic acids = polymers of nucleotides.
2. **Nucleotide** =
   a) **Phosphate** group
   b) **Sugar (5C)**
      - Ribose in RNA, or Deoxyribose in DNA
   c) Nitrogen-containing **base** (purine or pyrimidine)
3. DNA: bases are Adenine, Guanine, Cytosine, and **Thymine** (AGC**T**)
4. RNA: **Uracil** substitutes for thymine (AGC**U**)

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Nucleo<u>t</u>ides vs. Nucleo<u>s</u>ides

- In the nucleic acids, bases extend from a <u>sugar–phosphate backbone</u>.
- **DNA and RNA <u>information</u>** resides in their **<u>base</u> sequences**

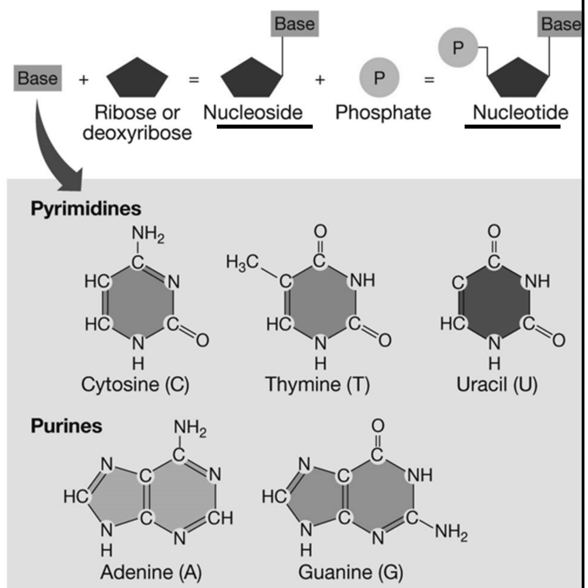

Figure 4.1 [4.1]

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4.2) <u>DNA</u> vs. <u>RNA</u>

DNA

1. **Deoxyribose sugar**
2. **Bases ACG<u>T</u>**
3. **Double stranded**
   - **(antiparallel)**
4. **Chemically stable**

RNA

1. **Ribose sugar**
2. **Bases ACG<u>U</u>**
3. **Single stranded**
4. **Chemically labile**

STRUCTURE → FUNCTION

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RNA

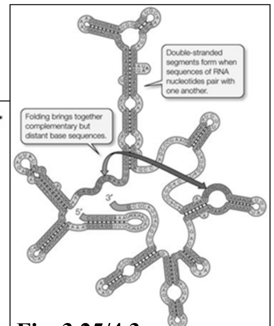
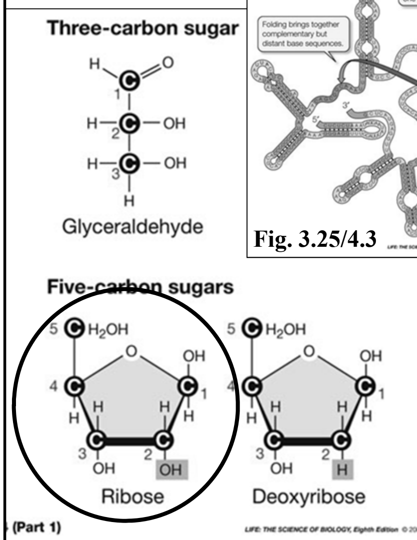


Fig. 3.25/4.3



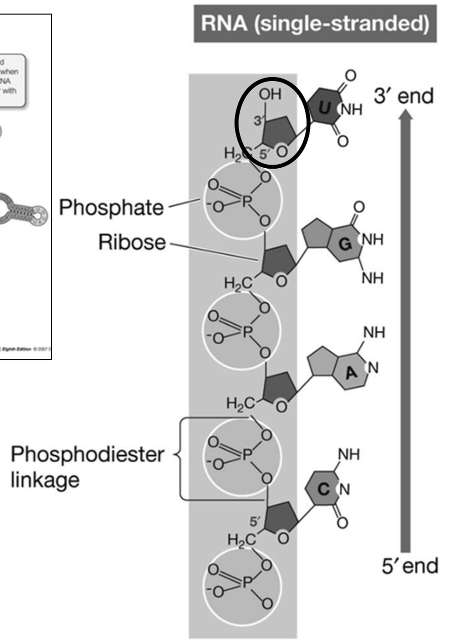


Fig. 3.14 Figure 4.2 (Part 1)

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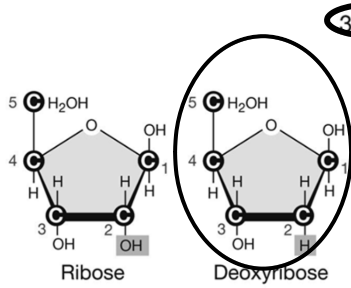
DNA



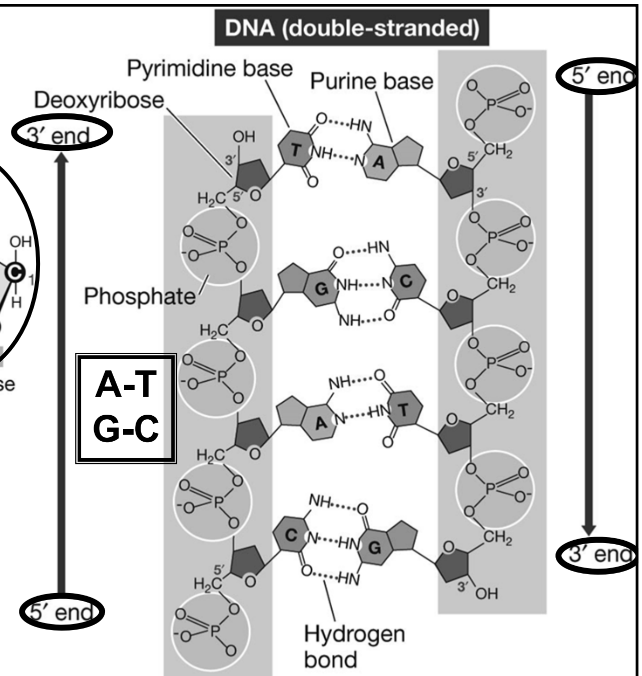


Figure 4.2 (Part 2)

Antiparallel

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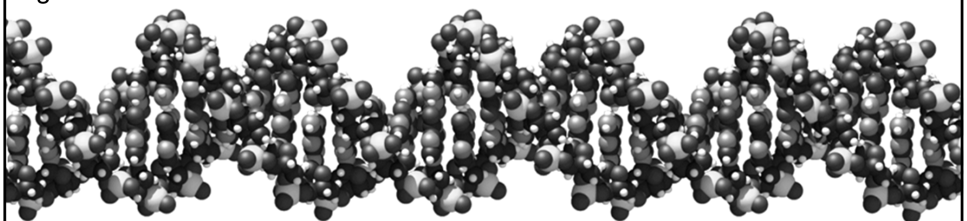
DNA Double Helix

Yell = **P**hosphorus
Red = **O**xygen
White = **H**ydrogen
Lt. Blue = **N**itrogen
Dk. Blue = **C**arbon

Figure 4.4



- **Stacks of bases, H-bonded at center (attached to sugar)**
  - **Hydrophobically stabilizing the double helix**
- **Hydrophilic sugar-phosphate backbone outside helix**

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Nucleic Acids: Uses of DNA Sequence Information

- **Comparing the DNA base sequences of different species:**
  - → information on evolutionary relatedness
  - Some unpredictable relationships based on observable forms, bodies, etc.

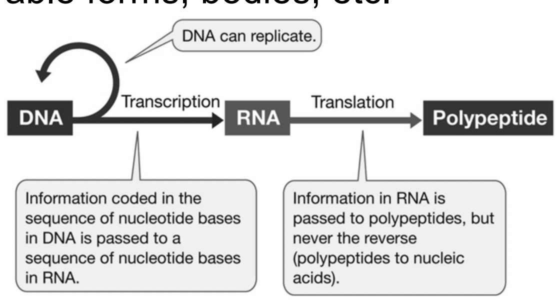

Figure 4.5 DNA Stores Information

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4.3) The Interactions of Macromolecules

- Both covalent and noncovalent linkages are found between the various classes
  - **Glycoproteins**
  - **Glycolipids**
  - **Lipoproteins**
  - **DNA-binding proteins, etc…**

    - .....energy, enzymes, and metabolism!!!.......

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4.4) Theories of the Origin of Life

A.) The theory of <u>CHEMICAL EVOLUTION</u>:

– conditions on the primitive Earth led to the formation of the large molecules unique to life.

❖ 1950s, **Stanley <u>Miller</u> and Harold <u>Urey</u>**

– Gases: experimental "primitive" atmosphere

– Energy: used a spark to simulate lightning

➢ Within days, the system contained numerous complex organic molecules.

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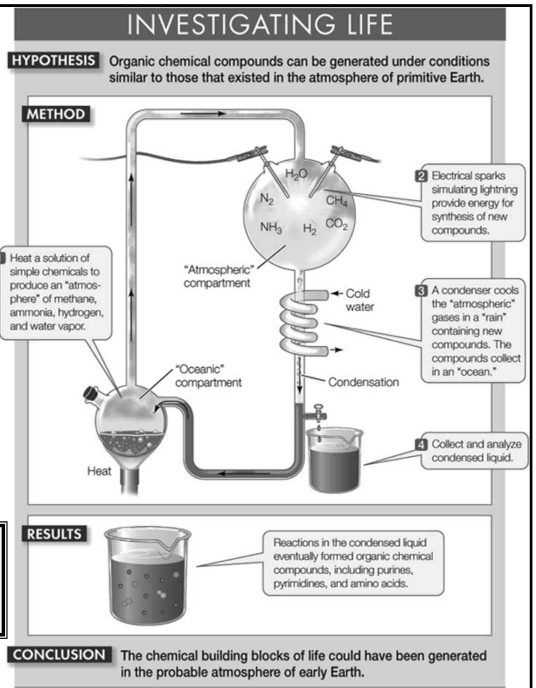
Figure 4.9: ***Synthesis of Prebiotic Molecules in an Experimental Atmosphere***

- **Water vapor**
- **Nitrogen gas**
- **Methane**
- **Hydrogen gas**
- **Carbon Dioxide**
- **Ammonia**
- ***NO oxygen!!***



Amino acids, purines, pyrimidines

Figure 4.9

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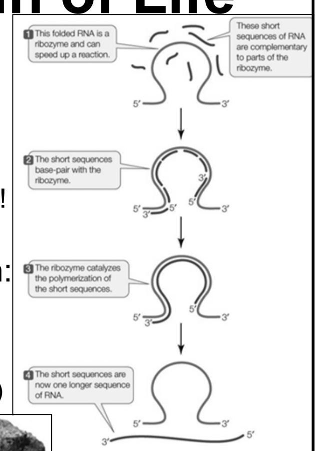
Theories of the Origin of Life

1. BIOCHEMICAL EVOLUTION:

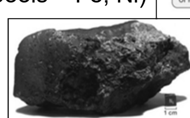
- The results of the Miller-Urey experiments have undergone several interpretative refinements.
  - Eg: catalytic clays, CO_2, N_2, H_2S, SO_2
  - More complex organic compounds resulted!!!!
    - Vitamins, caboxylic acids, fatty acids, sugars, ribose!

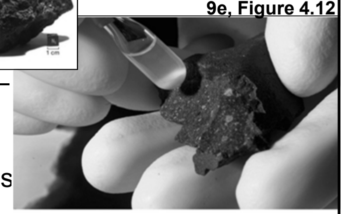
- The earliest stages of **chemical evolution**:
  - **<u>"RNA World"!?</u>** –
    - **<u>Informational</u>, & 3D structures = <u>catalytic</u>!!**
  - emergence of monomers and polymers
    - (catalytic clays - silicates, hot vents/pools – Fe, Ni)
  - probably have remained generally unchanged for 3.8 billion years.



9e, Figure 4.12

2. <u>Life from outer space?:</u>





- **<u>Antarctic meteorite, ALH84001, from Mars</u>** – Martian gases, water, polycyclic aromatic hydrocarbons

- In 1969, fragments of a meteorite were found to contain molecules unique to life, including purines pyrimidines, sugars, and ten amino acids.

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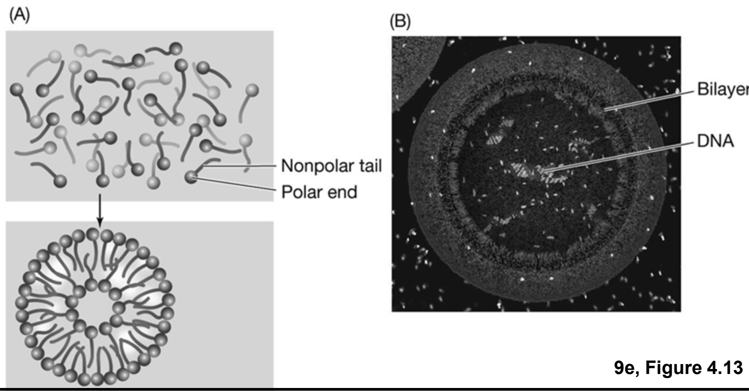
B. CELLULAR Evolution:

- In water, **fatty acids** will form a ***lipid bilayer*** around a compartment.
- These **protocells** allow small molecules such as sugars and nucleotides to pass through.
  - If short nucleic acid strands capable of self-replication are placed inside the protocells,
  - nucleotides can enter, and
  - become incorporated into new polynucleotide chains.



9e, Figure 4.13

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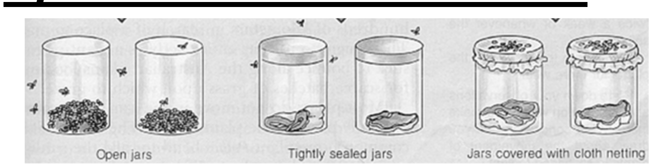
4.5) ** *All Life from Life!*

- ***Should we expect to see new life forms arise from the biochemical environment?***
- During the Renaissance,
  - most people thought that some forms of life arose directly from inanimate or decaying matter
  - by ***Spontaneous Generation.***



- In **1668, Francisco Redi** experimentally tested this hypothesis – filled six jars with decaying meat:

Conditions	**Results**
3 jars covered with fine net	No maggots
3 open jars	Maggots appeared
Conclude: No life from nonlife! (flies must lay eggs) but doubters remained.	

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All Life from Life

- The invention of the microscope……
  - **Antoni van Leeuwenhoek; R. Hook**
    - unveiled a vast new biological world which some scientists believed arose spontaneously from their rich chemical environment.
- In **1861**, **Louis Pasteur** completed experiments to disprove this idea……..
  - → ***Theory of Biogenesis***
  - ***Note:*** *Environmental and planetary conditions that exist on Earth today prevent life from arising from nonliving materials.*
    - ***Eg: conditions used in Urey-Miller Expt.***

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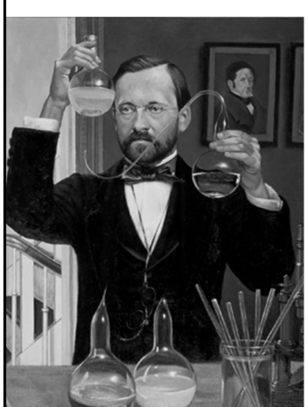
Figure 4.7: *Disproving the Spontaneous Generation of Life*



Boiling kills all microbes in beef broth

"swan neck" broken off

"swan neck" traps dust and microbes, but lets air in

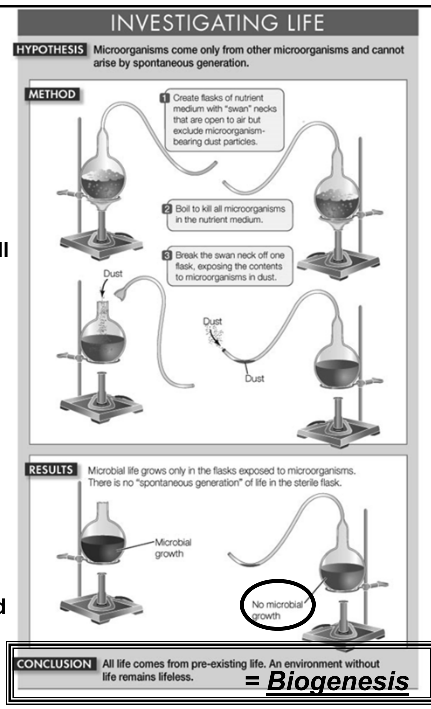


Figure 4.7

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