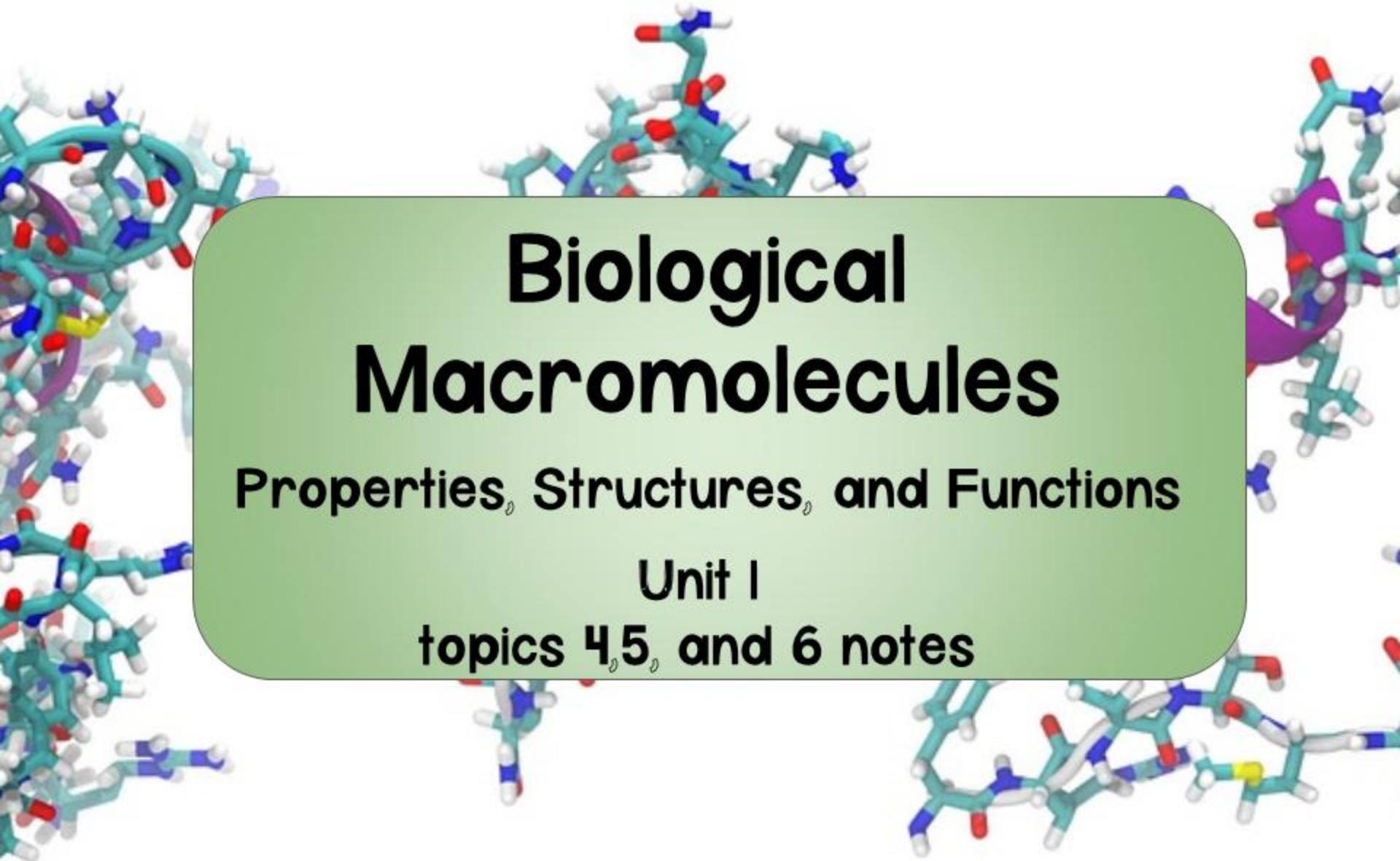


Biological Macromolecules

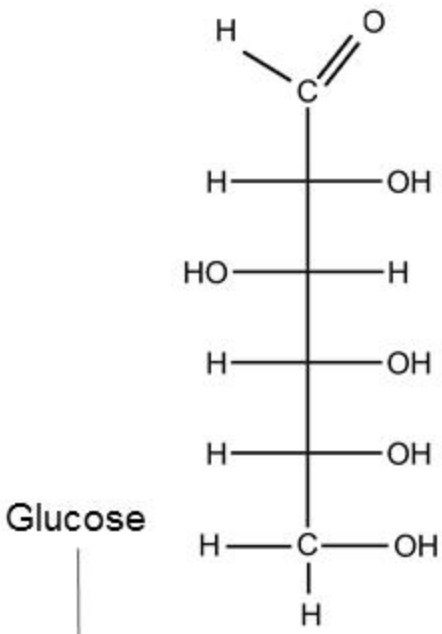
Properties, Structures, and Functions

Unit 1
topics 4,5, and 6 notes

Carbohydrates

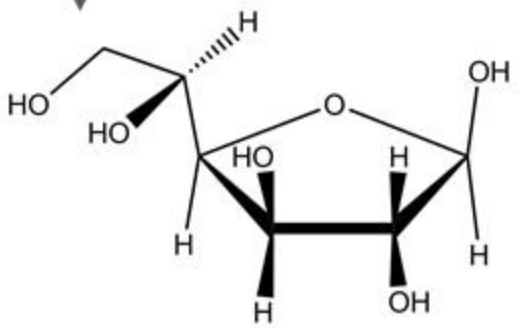
Carbohydrates

- Includes sugars and polymers of sugars
- Contain a carbonyl group and many hydroxyl groups
  - Comprised of C, H, and O
- Monosaccharides: simple sugars
  - Molecular formulas with multiples of the unit CH_2O
  - Most common is glucose
    - Nutrients and fuel for cells
    - Used in cellular respiration
  - Can serve as building blocks for amino acids, or as monomers for di- and polysaccharides



Glucose

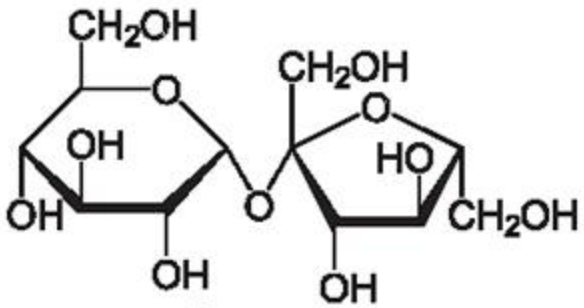
Forms a ring in aqueous solutions



Carbohydrates

Disaccharides: **two** monosaccharides joined together by covalent bonds

- Most common is sucrose
  - Monomers of sucrose: glucose and fructose
  - Plants transfer carbohydrates from roots to leaves in the form of sucrose



Sucrose

Carbohydrates

Polysaccharides: polymer with **many** sugars joined via dehydration reactions

Storage polysaccharides

- Plants store starch (polymer of glucose monomers)
  - Allows plants to store excess glucose
- Animals store glycogen (polymer of glucose)
  - Stored in liver and muscle cells

Structural polysaccharides

- Cellulose: tough substance that forms plant cell walls
- Chitin: forms exoskeleton of arthropods

Practice

1. You are given an unknown monosaccharide to identify in the lab. The only clue you are given is that it has 4 carbons. You (being an excellent AP bio student) figure out the formula. What is the unknown monosaccharide?

- Answer: $C_4H_8O_4$, Threose

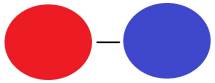
Proteins

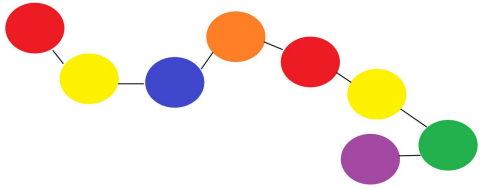
Formation of a Protein

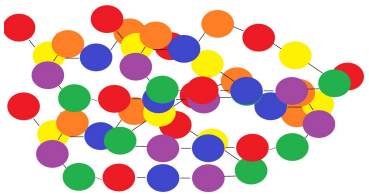
Amino acid → Peptide → Polypeptide → Protein

small

large







Proteins

Protein: molecule consisting of polypeptides (polymers of amino acids) folded into a 3D shape

- Comprised of C, H, O, N, and S
- Shape determines function

Amino Acids

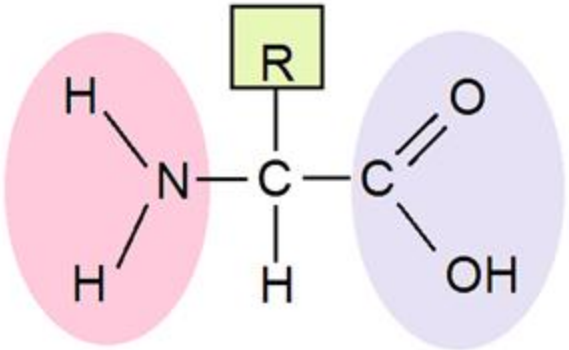
Molecules that have an amino group and a carboxyl group

- **20** different amino acids

General Structure

R = variable side chain

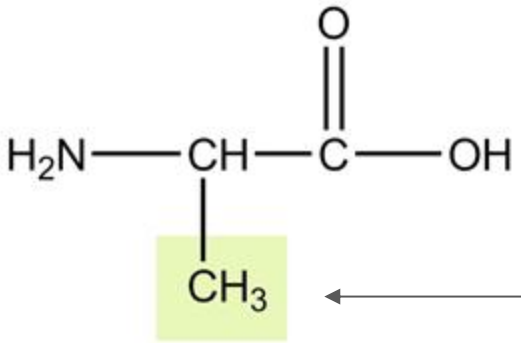
Amino group



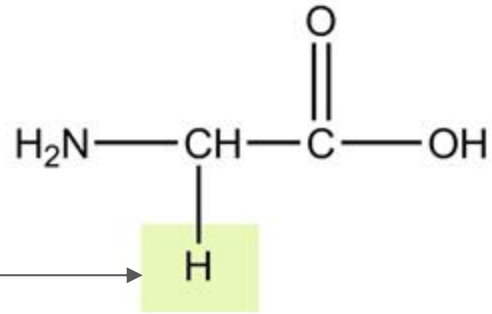
carboxyl group

Examples:

Alanine



Glycine



Unique side chain (R)

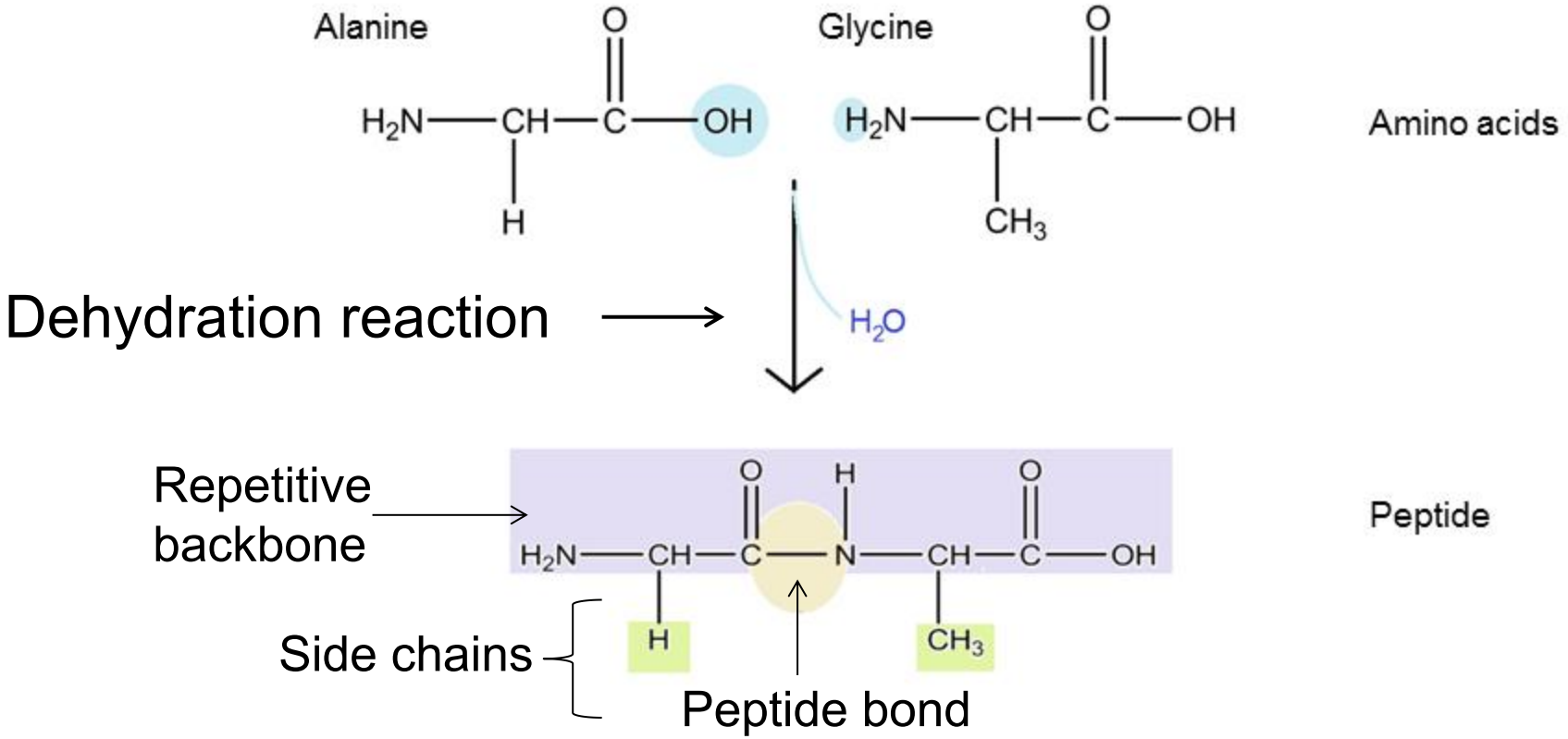
Amino Acids

Each amino acid (AA) has a unique side chain

- Unique aspects of the AA are based on the side chain's physical and chemical properties
- Side chains can be grouped as:
  - Nonpolar (hydrophobic)
  - Polar (hydrophilic)
  - Charged/ionic (hydrophilic)
- Side chains **interact**, which determine the **shape** and **function** of the protein

Formation of Peptide Bonds

To form a peptide bond the carboxyl group of one AA must be positioned next to the amino group of another AA



Polypeptides

Polypeptides: many AA linked by peptide bonds

- Each polypeptide has a unique sequence of AAs and directionality
  - Each end is chemically unique
  - One end is a free amino group (N-terminus)
  - One end is a free carboxyl group (C-terminus)

Polypeptides

- The sequence of AAs determines the 3D shape

Remember: SHAPE determines FUNCTION

  - When a polypeptide twists and folds (because of R group interaction) it forms a protein

Quick! Think, pair share
How is the unique sequence of AAs determined for a polypeptide?

→ Genes

Functions of Proteins

Function of proteins include:

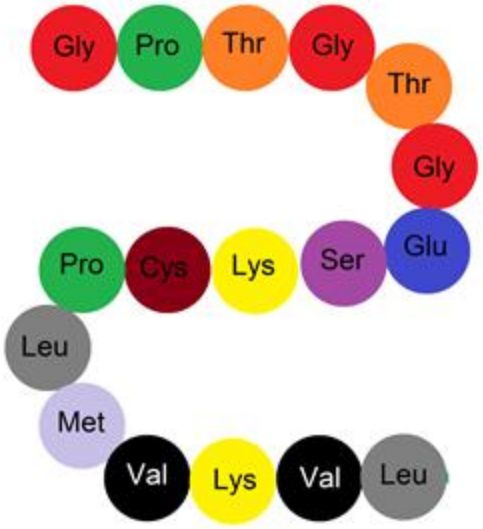
- Antibody-help protect the body from disease
- Enzyme- carry out chemical reactions or assist in creating new molecules
- Messenger- transmit signals (ie hormones)
- Structural- provide structure and support
- Transport/storage- bind to and carry small atoms and molecules through the body

Levels of Protein Structure

Primary

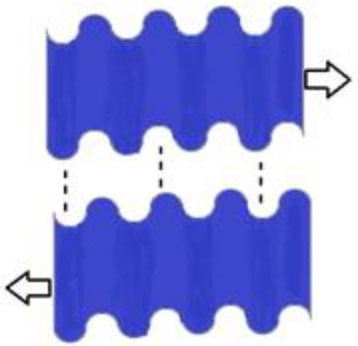
Linear chain of AA

- Determined via genes
- Dictates secondary and tertiary forms



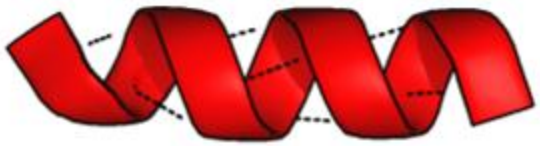
Secondary

Coils and folds due to **hydrogen bonding** within the polypeptide backbone



βpleated sheet- hydrogen bonds between polypeptide chains lying side by side

αhelix- hydrogen bonding between every 4th AA

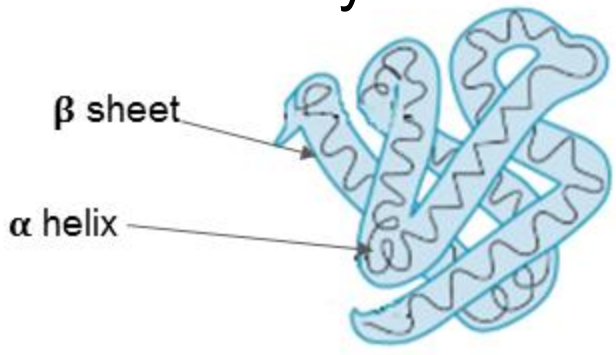


Levels of Protein Structure

Tertiary

3D folding due to interactions between the side chains of the AAs

- Reinforced by hydrophobic interactions and disulfide bridges of the side chains
  - The covalent bond formed between sulfur atoms of two cysteine monomers



Quaternary

Association of two or more polypeptides

- Found in only some proteins

All four levels of a protein's structure determine the protein's function

Practice

- Let’s work on the practice problems!

Practice

1. Cystic fibrosis is a serious, life-threatening disease that affects the lungs and digestive system of affected individuals. This disease results from the deletion of three nucleotides on the Cystic Fibrosis Transmembrane Conductance Regulator (CFTR) gene. This gene codes for a transmembrane protein that regulates ion channels in epithelial tissue. Provide an explanation for how this deletion could result in cystic fibrosis.

Nucleic Acids

Topic 6

Nucleic Acids

Nucleic acids: polymers made of nucleotide monomers

Function to:

- Store, transmit and express hereditary information

Two forms:

1. Deoxyribonucleic acid (DNA)
2. Ribonucleic acid (RNA)

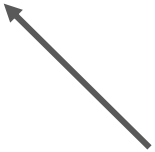
Components of Nucleic Acids

Nucleotides → Polynucleotides → Nucleic Acids

Nucleotides

Contain 3 parts:

1. Nitrogenous base
2. Five carbon sugar (pentose)
3. Phosphate group(s)



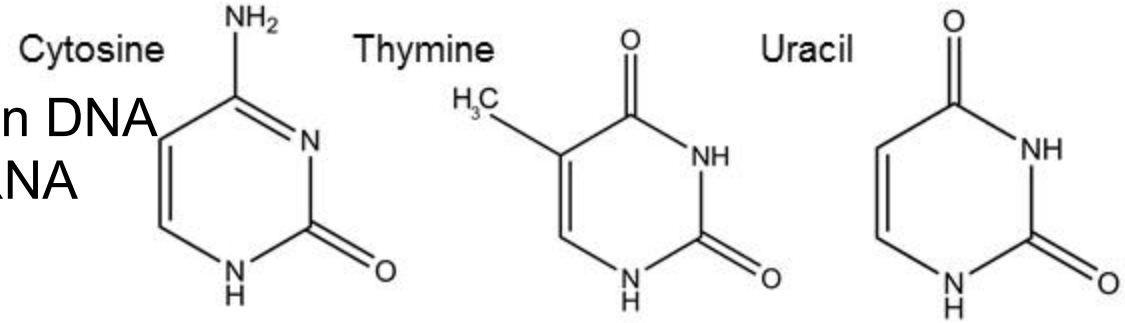
In polynucleotides each monomer only has one phosphate group

Nitrogenous Base

Two types: pyrimidines and purines

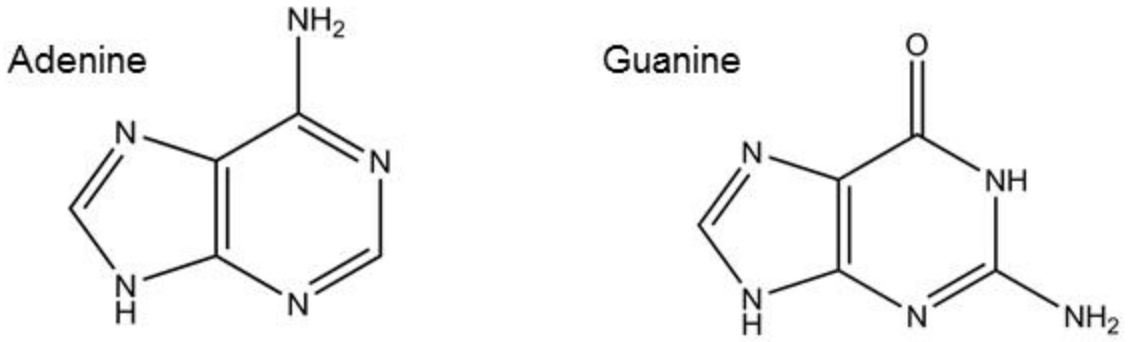
Pyrimidines: one ring with 6 atoms

- Cytosine
- Thymine } Only found in DNA
- Uracil } Only found in RNA



Purines: one ring with 6 atoms bonded to one ring with 5 atoms

- Adenine
- Guanine



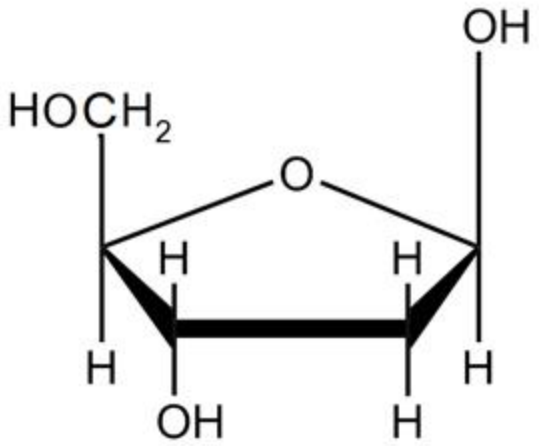
Five Carbon Sugar

A sugar is bonded to the base

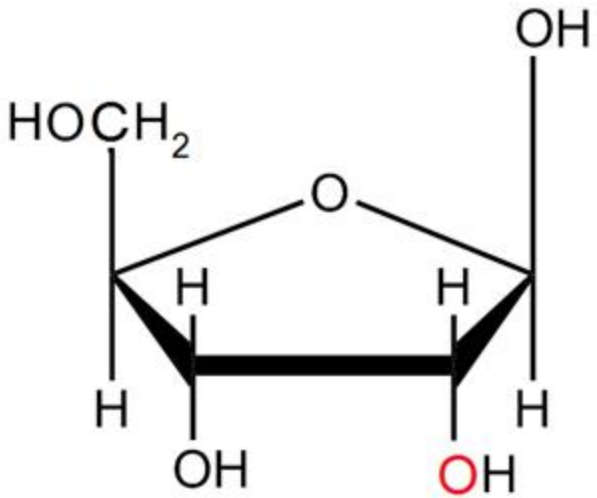
In DNA the sugar is deoxyribose

In RNA the sugar is ribose

Differ in structure and function



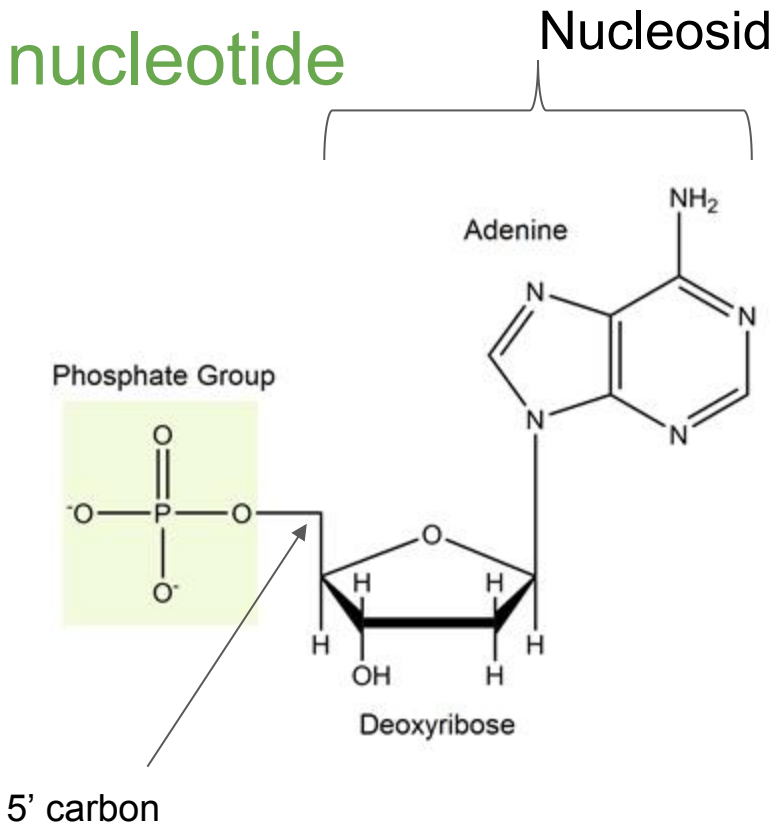
Deoxyribose

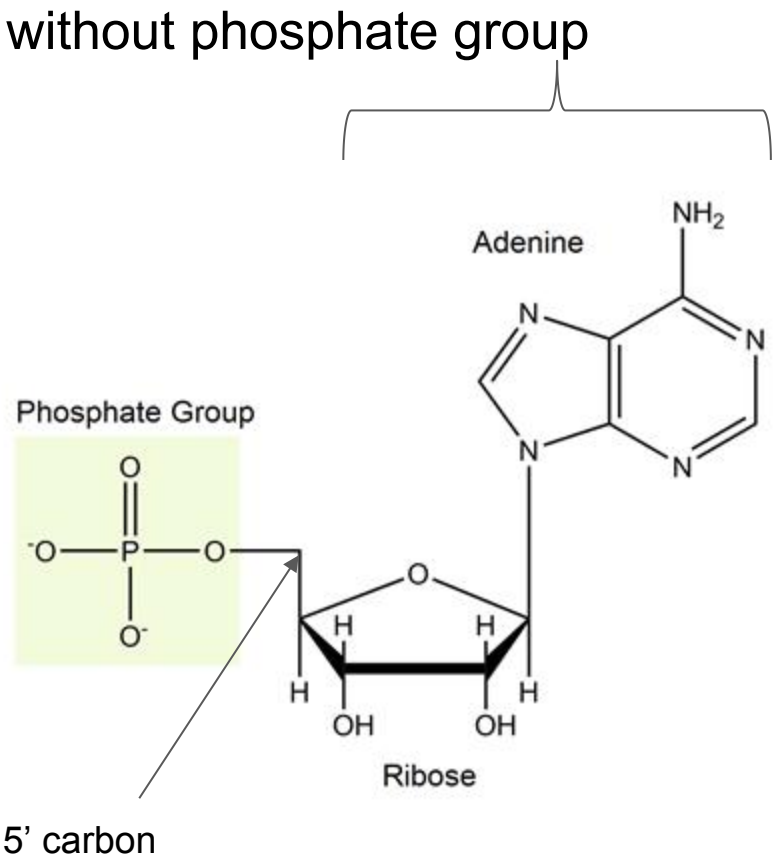


Ribose

Phosphate Group

A phosphate group is added to the 5’ carbon of the sugar (which is attached to the base) to form a nucleotide





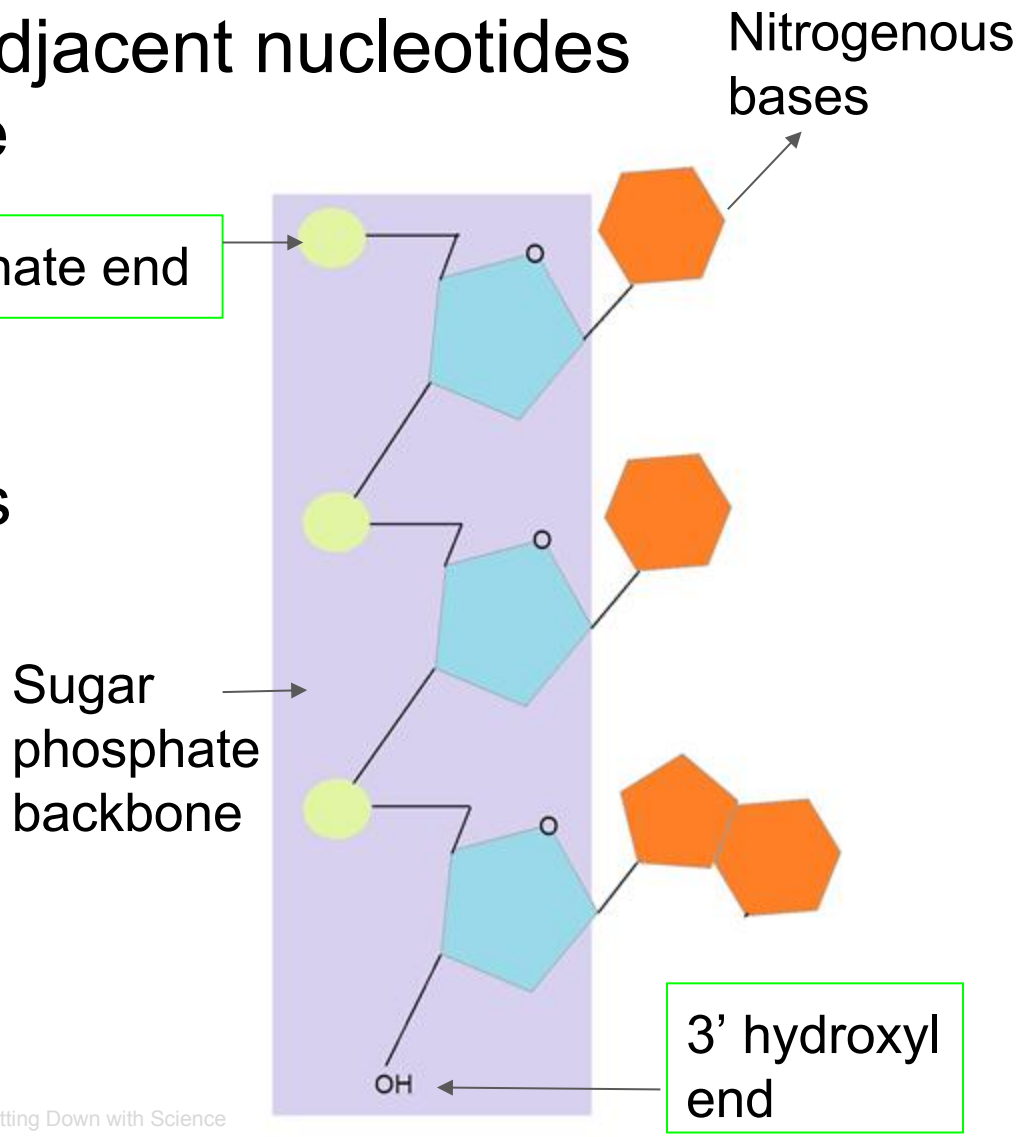
Polynucleotides

Phosphate groups link adjacent nucleotides

- Phosphodiester linkage
- Directionality
  - 5’ to 3’

The sequence of bases along the DNA or mRNA is unique for each gene

- Dictates AA sequence
  - Dictates primary structure of a protein
    - Dictates 3D structure of a protein

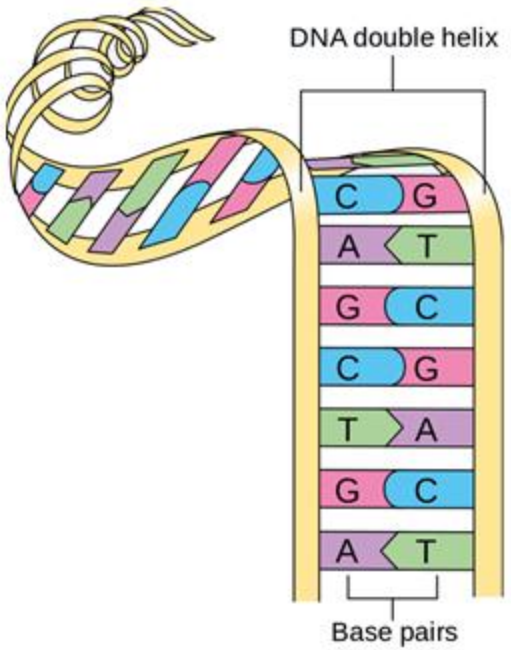


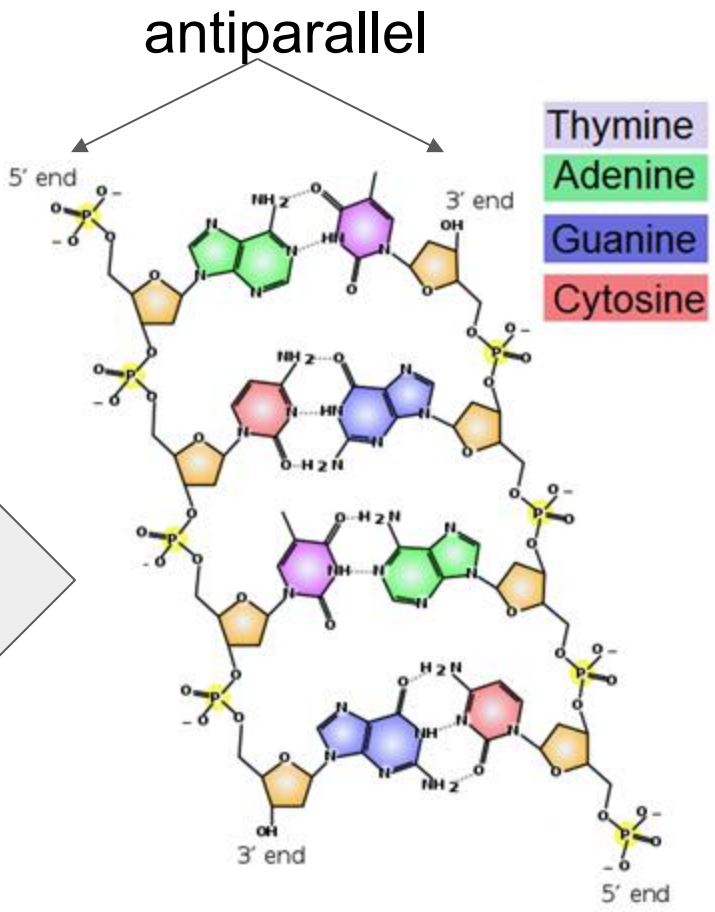
DNA

Consists of two polynucleotides

- Forms a double helix
  - Strands are antiparallel
  - Held together by hydrogen bonds between bases

Cytosine binds to guanine
Adenine binds to thymine

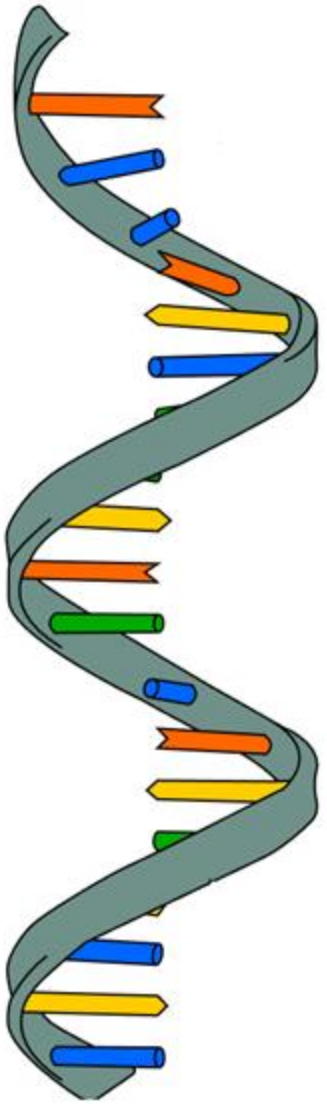




RNA

Single stranded polynucleotide

- Variable in shape
  - Due to base pairing within RNA
    - Adenine bonds to uracil
    - Cytosine bonds to guanine



Practice

1. You are given a segment of DNA:
    - 5’- CATGTCAAC-3’

What is the complimentary strand?

- Answer: 3’-GTACAGTTG-5’

Practice

- Let’s work on the practice problems!

Lipids

Lipids

Lipids: class of molecules that do not include true polymers

- Generally small in size
  - Often not considered to be a macromolecule
- Lipids are nonpolar-hydrophobic

Types of lipids:

1. Fats
2. Phospholipids
3. Steroids

Fats

Fats are composed of glycerol and fatty acids
Glycerol: classified as an alcohol (hydroxyl groups)
Fatty acids: long carbon chains (carboxyl group at one end)

- 3 fatty acids join to a glycerol via ester linkage
  - Bond between a hydroxyl and carboxyl group
- Classified as a saturated fatty acid or an unsaturated fatty acid
  - Saturated fatty acid: no double bonds between carbons in the carbon chain = more hydrogen (think: saturated with hydrogen)
  - Unsaturated fatty acid: contains one or more double bonds

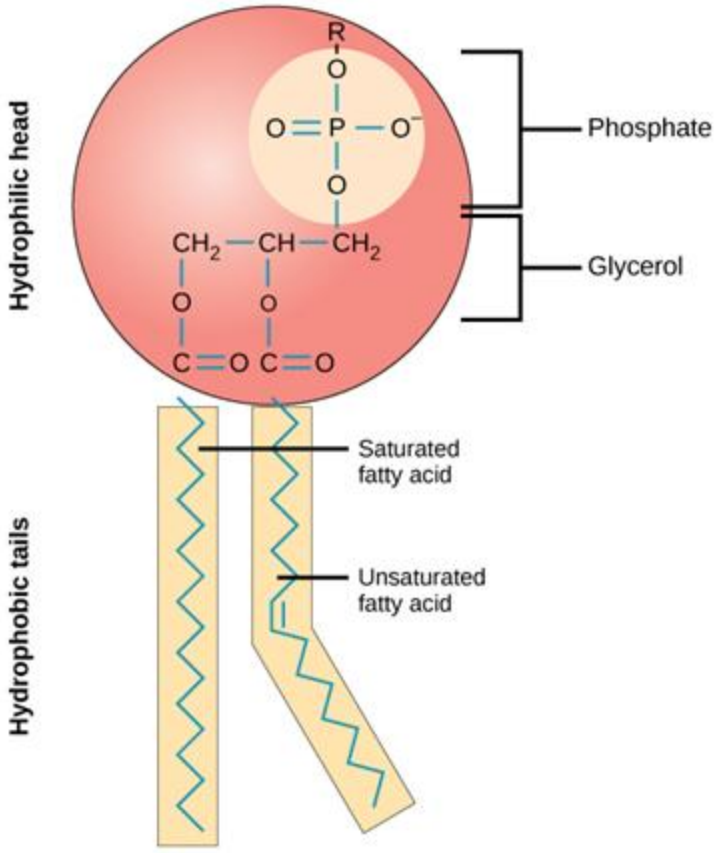
Phospholipids

Major component of cell membranes

- Two fatty acids attached to a glycerol and a phosphate

Assemble as a bilayer in H_2O

- Tails are hydrophobic
- Head is hydrophilic

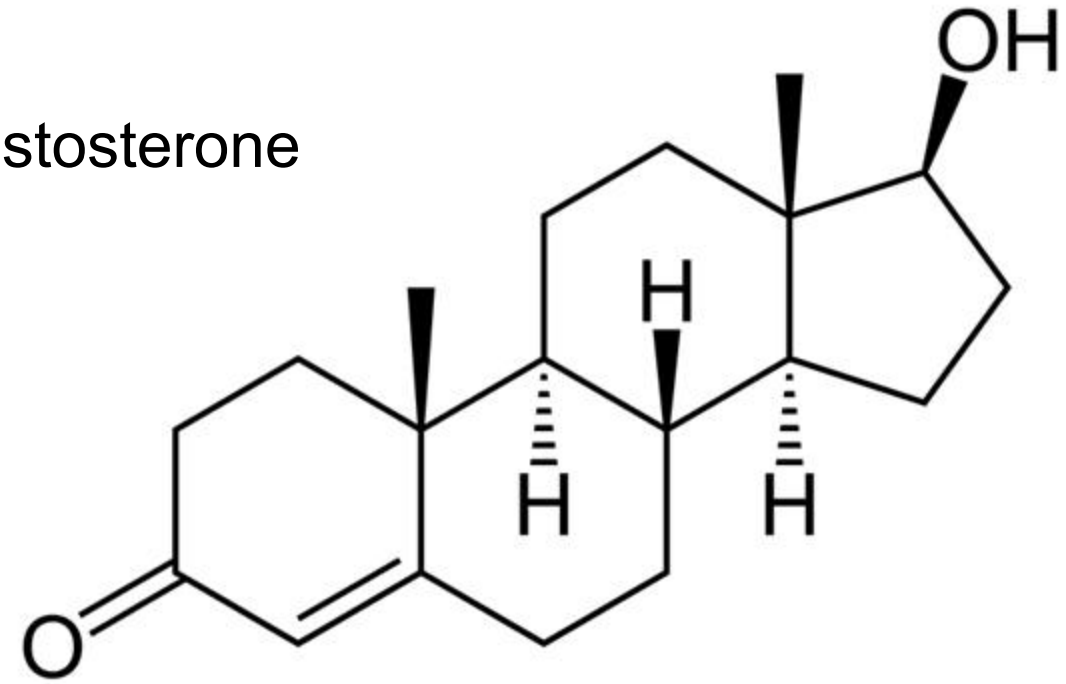


Steroids

Lipids that have four fused rings

- Unique groups attached to the ring determine the type of steroid

Example: testosterone



Putting it all together

Fill out this chart with the appropriate responses

Macromolecule	Elements involved	Monomer (sub-unit)	Polymer
Carbohydrates	Carbon, hydrogen, oxygen	monosaccharide	Polysaccharide
Proteins	Carbon, hydrogen, oxygen, nitrogen, sulfur	Amino acids	Polypeptides
Lipids	Carbon, hydrogen, oxygen (phosphorus for phospholipids)	Glycerol and fatty acids	Does not contain true polymers
Nucleic Acids	Carbon, hydrogen, oxygen, nitrogen, phosphorus	Nucleotides	DNA, RNA