Carbohydrates, *briefly*

I. INTRODUCTION

A. The carbohydrate monomer ***glucose*** is the reactant for a central energy pathway (***glycolysis***) utilized by most of the living things on our planet.

B. Carbohydrate polymers (*glycogen and starch*) are an used by many living multicellular organisms as a way to store energy.

C. Carbohydrates are used by living things for recognition and transmitting information.

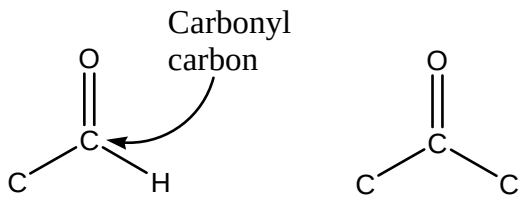
D. Carbohydrates are components of DNA & RNA.

E. Errors in carbohydrate biochemistry cause some human health problems.

Definition is structure based: ***Carbohydrates are polyhydroxy aldehydes and ketones***

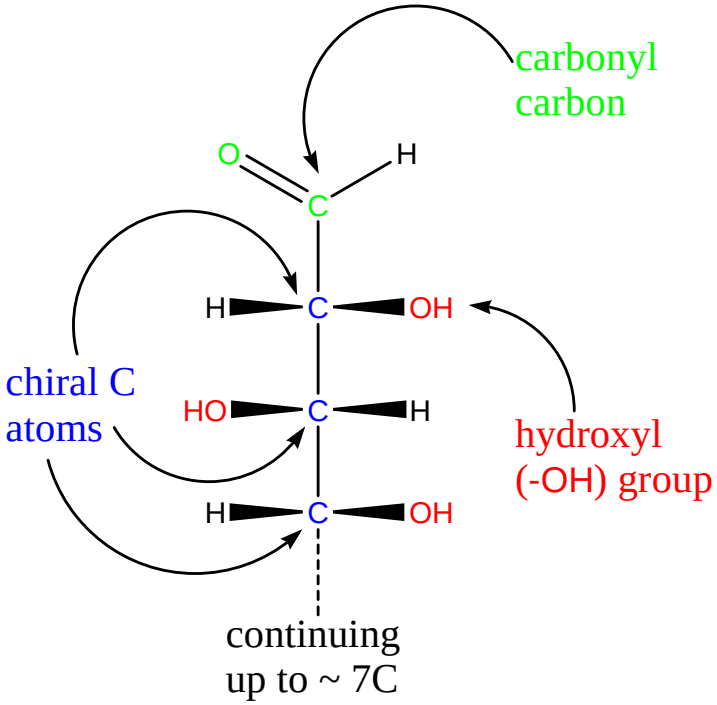
Carbohydrate = hydrated carbon??? $(CH_2O)_n$

Aldehyde vs. ketone



1. Is the carbohydrate shown at right an aldose or a ketose?
2. Do you remember what chiral means and why the blue C atoms indicated at right would be chiral?

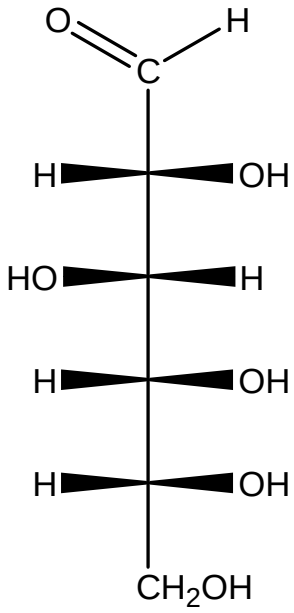
Structural features of a carbohydrate monomer



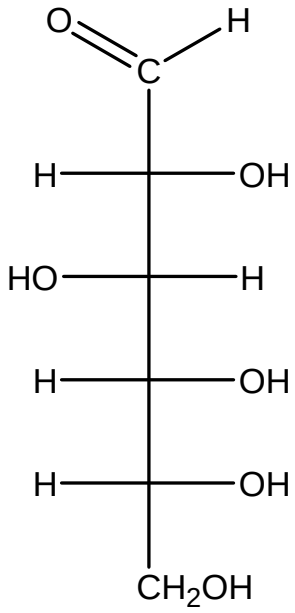
II. GLUCOSE AND GLYCOLYSIS

A. D-Glucose is an aldohexose. Because it is moderately *reduced*, we can obtain energy by *oxidizing* it. Examine/explain structures below. "D-" describes stereochemistry at C5.

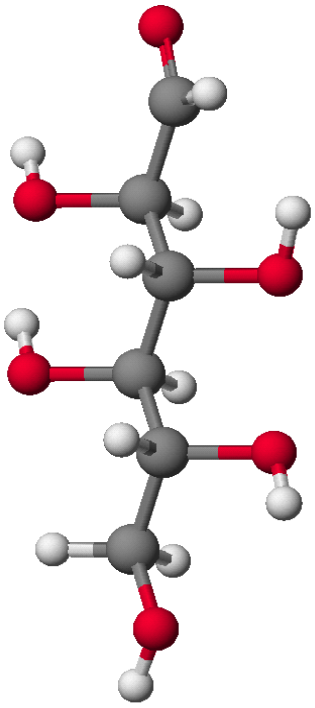
Perspective drawing



Fischer Projection

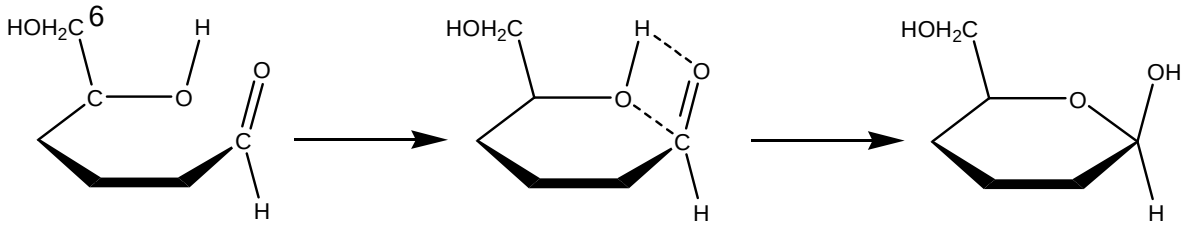


Ball & stick



Bothered by position of -OH's on ball & stick?

In aqueous solution the linear forms shown above are not the dominant form. An *intramolecular* reaction (-OH on C5 with carbonyl C) occurs that results in formation of a *cyclic hemiacetal*:



Box model

This is β-form:-OH at C1 is up.

B. Most living things on our planet can metabolize D-glucose

1. Green (red?) plants use energy from the sun to reduce CO_2.

$$6\ CO_2 + 6\ H_2O \xrightarrow{\text{sunlight}} C_6H_{12}O_6$$ (*i.e.*, glucose)

2. Plants usually store glucose as
   a) Disaccharides (sucrose = table sugar)
   b) Polysaccharides (starch)
3. Animals (and bacteria, fungi, *etc*. eat plants)

C. Most plants, animals, bacteria, etc. can obtain energy by performing glycolysis.

1. Overall reaction:

$$\text{glucose} + 2\ NAD^+ + 2\ ADP + 2\ P_i \rightarrow$$

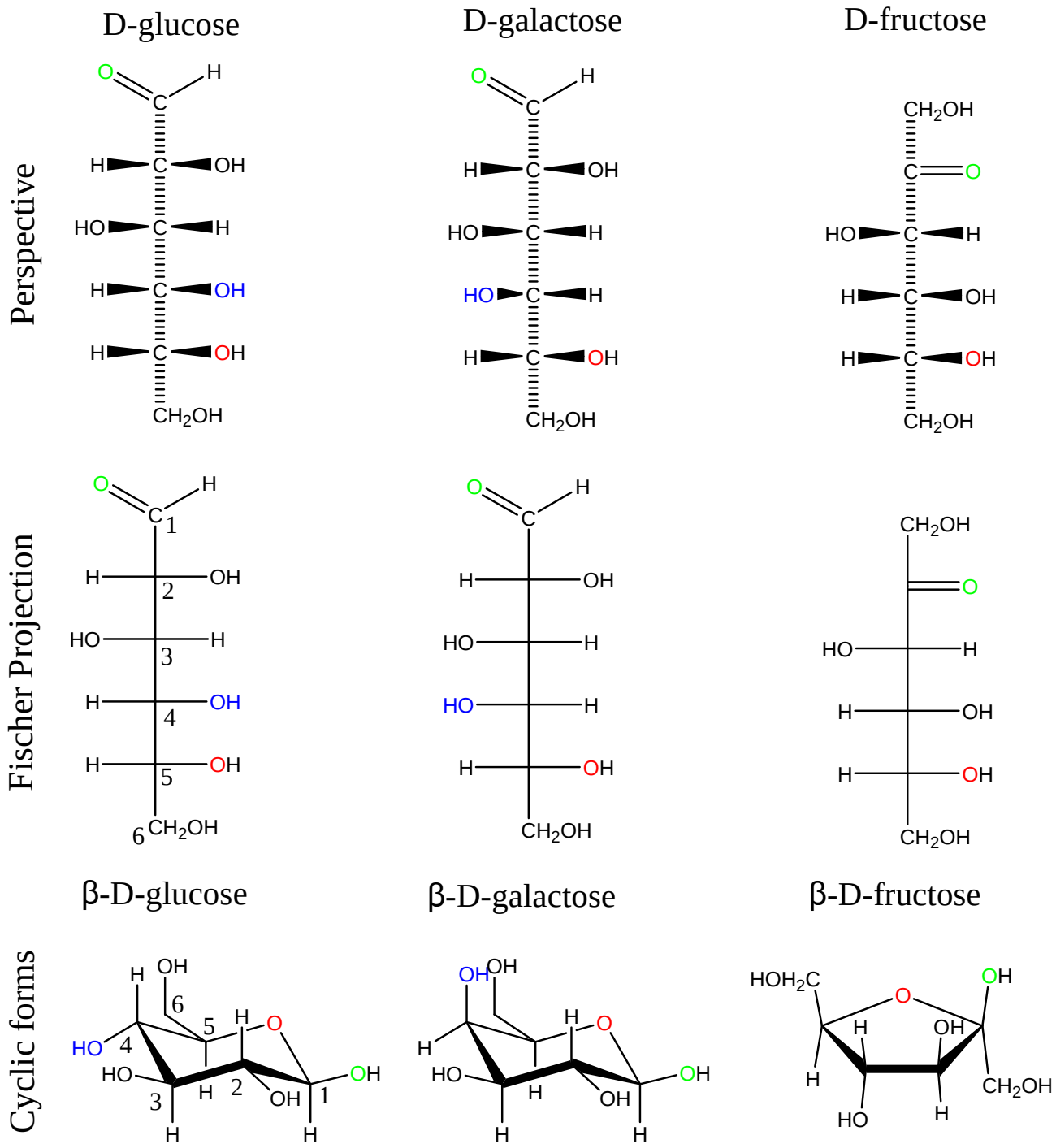
$$2\ \text{pyruvate} + 2\ NADH + 2\ ATP + 2\ H_2O + 4\ H^+$$

2. Energy rich compounds:
   a) ATP is used directly to drive unfavorable processes.
   b) NADH: energy (ATP) via oxidative phosphorylation.
   c) Pyruvate yields energy when run through Krebs'cycle.

3. Living things must have ATP and other high energy compounds to drive the formation of high energy polymers such as DNA, RNA, and proteins.

4. Would you expect to find many creatures with mutations in enzymes that run the glycolytic pathway? Why/why not?

D. Three hexoses that are important in your body:



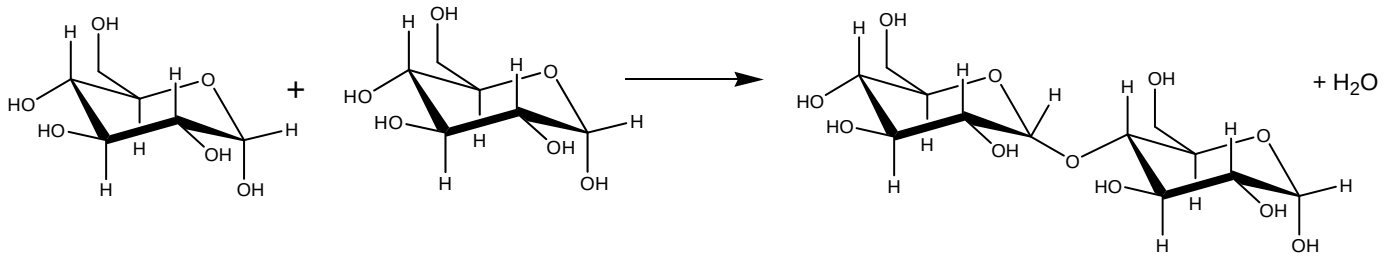
1. Which of the three representations is closest to what you would find in your body?
2. In what foods would you find these hexoses?
3. How do glucose and galactose differ?

III. CARBOHYDRATE POLYMERS (and smaller)

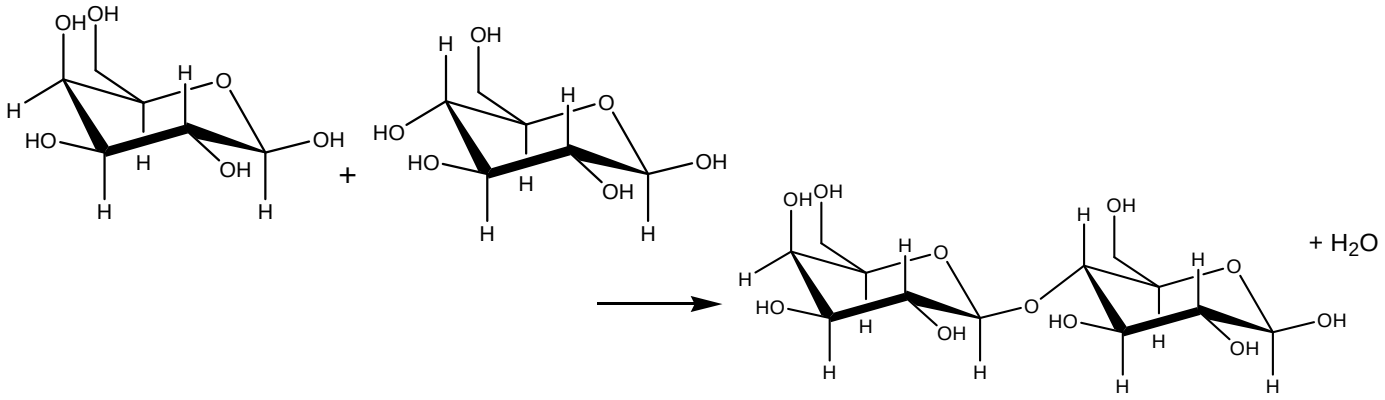
A. Many living things link simple carbohydrates like glucose together to form larger (complex) carbohydrates like disaccharides, oligosaccharides, and polysaccharides.

B. Disaccharides

1. glucose + glucose → maltose + H_2O (Note: α 1→4 linkage)



2. galactose + glucose → lactose + H_2O (Where is lactose found?)



C. Polysaccharides:

1. Starch

a) Plants link glucose as shown above (B 1) to yield a linear polymer called α-amylose.

b) They also form a branched (C1 to C6) polymer, amylopectin.

c) Together these two polymers comprise starch.

d) Plants also make a β 1→4 polymer called cellulose.

i) Is there much cellulose on our planet?

ii) (Chemically) Why can't we digest cellulose?

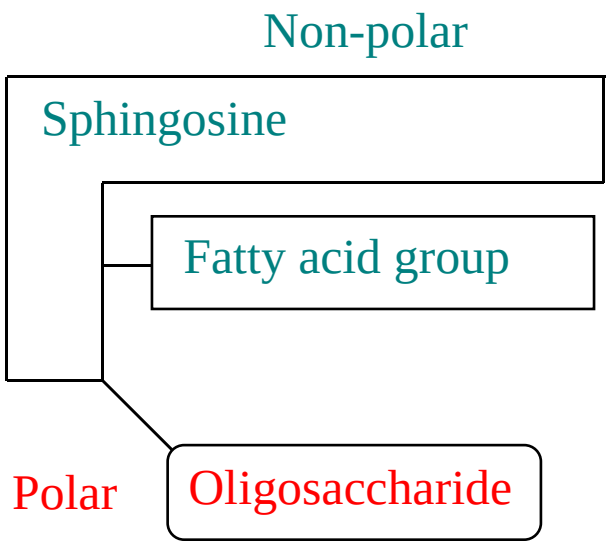
2. Animals (like us?) produce a glucose polymer (glycogen) as a way to store glucose.
   a) Glycogen is similar to amylopectin (greater branching)
   b) Glycogen is broken down when blood glucose drops.

IV. INFORMATION AND CARBOHYDRATES

A. We don't normally think of carbohydrates as doing many different jobs in the cell. However, both proteins and lipids may be covalently linked to carbohydrate, and their (protein and lipid) functions altered in the process. That said:

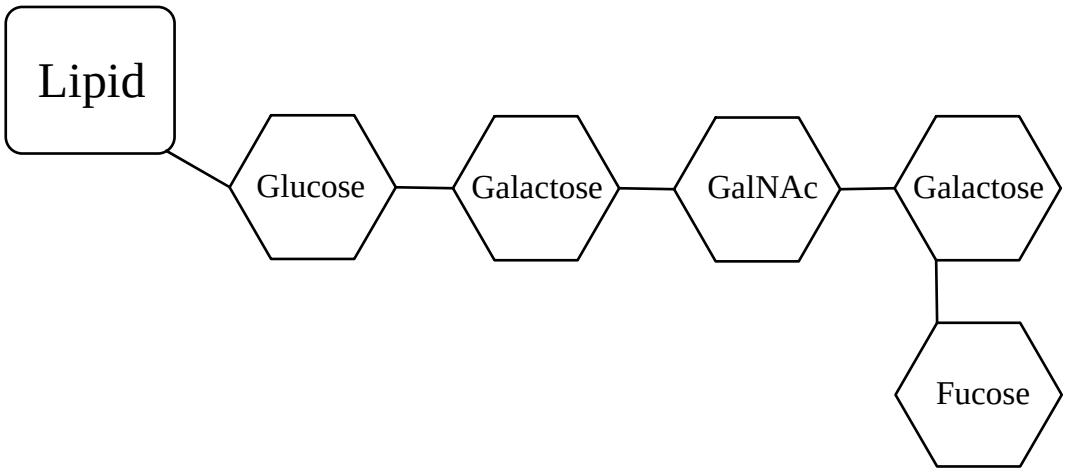
B. Carbohydrate derivatives such as inositol function as second messengers.

C. Carbohydrate oligomers linked to lipids (to form glycolipids) are the basis for the ABO blood group.



The structure of the oligosaccharide determines A, B, and O genotypes.

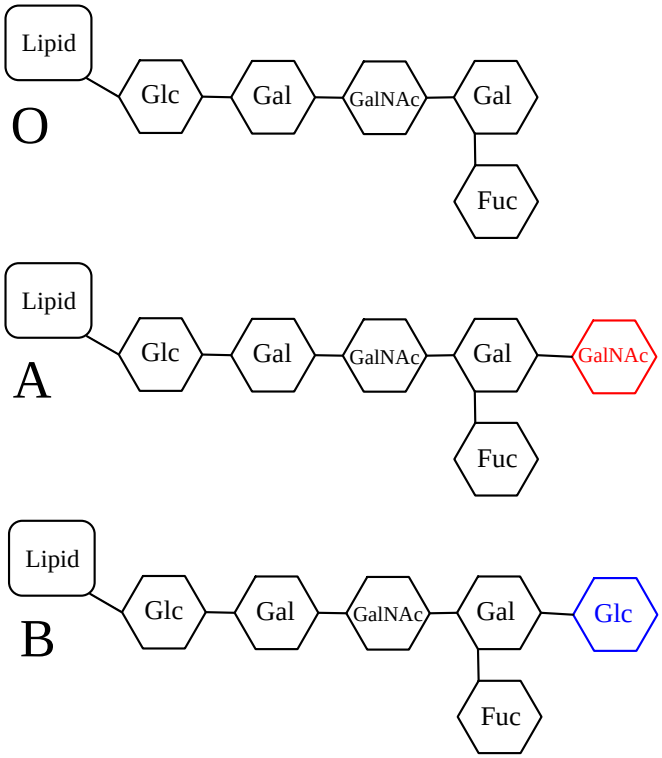
1. There is a basic oligo precursor for all 3 genotypes:



a) The O genotype lacks an enzyme to alter this structure.

b) The A genotype codes for an enzyme that alters this by adding N-acetylgalactosamine (GalNAc) to the outer galactose.

c) The B genotype codes for an enzyme that alters this by adding galactose to the outer galactose.

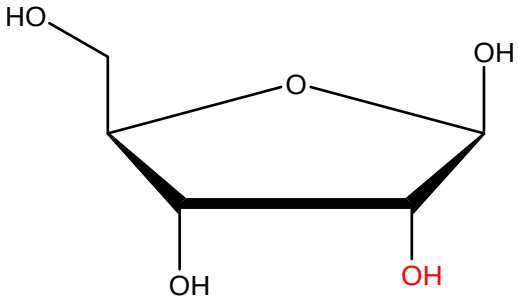


2. Genetics exp. anyone?

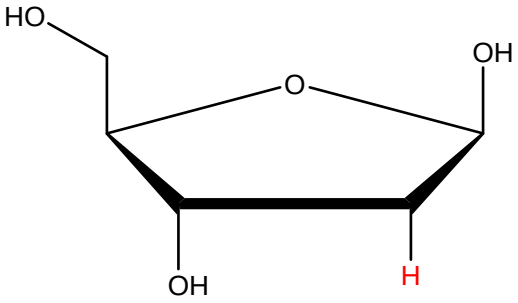
V. DNA & RNA CONTAIN AN ALDOPENTOSE

A. DNA is composed of nitrogenous bases (usually A, T, G, & C), the carbohydrate 2-deoxyribose, and phosphate.
B. RNA is composed of nitrogenous bases (often A, U, G, & C), the carbohydrate ribose, and phosphate.
C. Ribose and 2-deoxyribose differ only at C2:

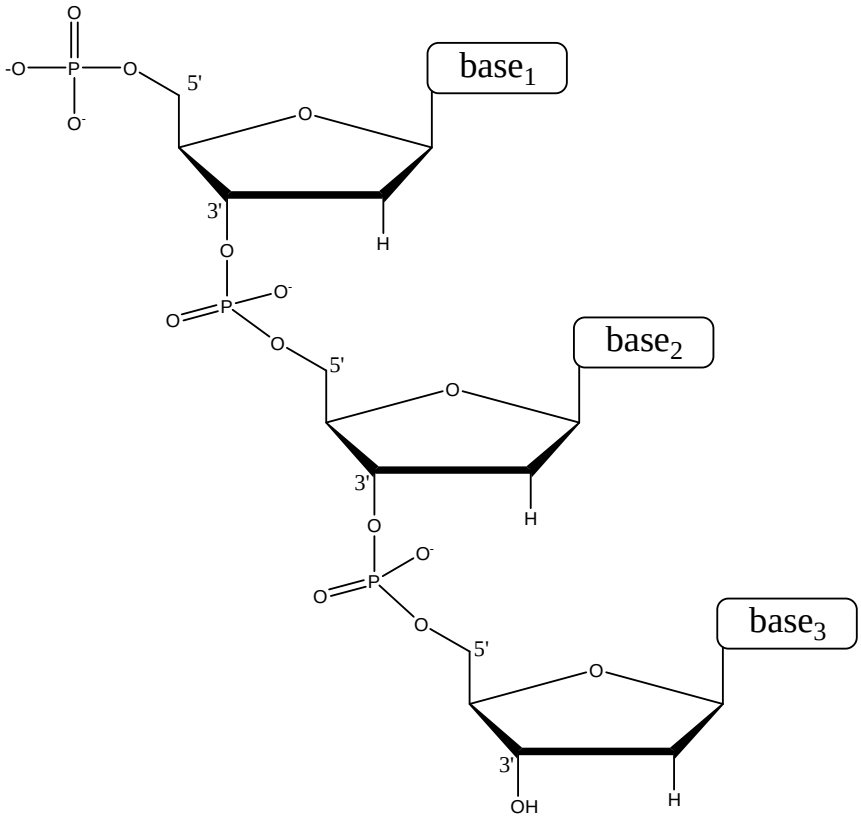
Ribose



2-Deoxyribose



D. General primary structure for DNA and RNA is similar:



1. Notice the chain has polarity: A 5' end and a 3' end.

What does the ' mean?

2. How would RNA differ from the structure shown at right?

VII. CARBOHYDRATES & HEALTH PROBLEMS

A. Diabetes mellitus

B. Lactose intolerance.