

## 7.016 Recitation 4 – Fall 2018

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### Summary of Lectures 5 (9/14) & 6 (9/17):

**Carbohydrates:** Carbohydrates include monosaccharides, disaccharides, trisaccharide or polysaccharides. A monosaccharide is composed of carbons flanked by H atoms or -OH groups, is hydrophilic and can exist in a linear or cyclic structure. Monosaccharides are linked together by glycosidic bonds to form polysaccharides including starch, chitin and cellulose. Carbohydrates are used as an energy source, as a source for carbon, and can be attached to other macromolecules, including lipids and proteins, to serve as recognition markers for the cell. Proteins covalently attached to carbohydrates (glycans) are called **glycoproteins**: We have different **blood groups** due to the variation in the glycans that are attached to cell surface protein on mature red blood cells.

**Nucleic acids:** Nucleic acids [Deoxyribonucleic acids (DNA)/Ribonucleic acids (RNA)] are biological macromolecules specialized for the storage, transfer and use of genetic information. They are built from basic building blocks called nucleotide triphosphates (deoxy-ribonucleotide or dNTP in DNA and ribonucleotides or rNTPs in RNA): **A**denosine triphosphate (ATP), **T**hymidine triphosphate (TTP), **G**uanosine triphosphate (GTP), **C**ytosine triphosphate (CTP) and **U**ridine triphosphate (UTP). The A and G are purine bases whereas the T, C and U are pyrimidine bases.

Polymers of nucleic acid are formed by condensation or dehydration reaction that leads to the formation of a 3'→5' covalent phosphodiester bond. DNA in the cell is the hereditary material and is usually double-stranded. The two strands of DNA are complementary and anti-parallel.

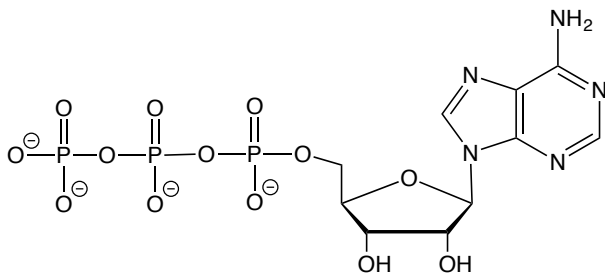
The RNA is usually single-stranded and is of three major types: ribosomal (rRNA), transfer (tRNA) and messenger (mRNA). The mRNA gets translated to proteins. In comparison, the tRNA and rRNA are involved in the synthesis of proteins. Recent research has also revealed new classes of RNAs known as siRNA (small interfering) and miRNA (micro), which play important regulatory roles.

Nucleotides also serve as energy sources (ATP and GTP) and second messengers (cAMP) during intracellular or cell-cell signaling.

### Questions:

1. The following schematic represents an ATP molecule that is used to build RNA and also serves as the energy currency of the cell.

a) **Circle** the group(s) that you will alter so that this molecule could serve as a monomer for DNA.



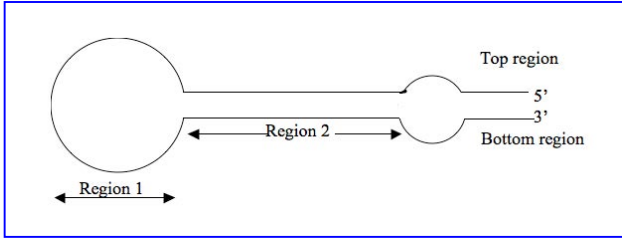
b) Draw an arrow to the atom that forms a covalent bond with the terminal nucleotide of a growing nucleic acid polymer.

c) Name the molecule(s) that are produced from ATP if it is used as an energy source

d) Draw an asterisk by the atom(s) that form hydrogen bond(s) with a nitrogenous base on the complementary strand of DNA or RNA. Identify the base in DNA and in RNA.

e) If a double stranded DNA has 30% A, give the percentages of G, C, T in this molecule.

2. The following diagram represents a complex three-dimensional conformation of a RNA molecule.



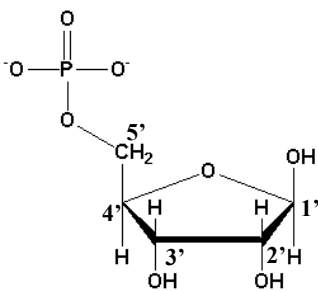
a) Within Region 2, what bonds/interactions are **primarily involved** in stabilizing the RNA structure?

b) In Region 1, if the sequence of the top region is AUUUGUAA, can you predict the % of bases i.e. %A, %U %C and %G of the bottom region? **Explain.**

c) In the Region 2, where you see complementary base pairing, if the sequence of the top region is AUUUGUAA, can you predict the % of bases i.e. %A, %U %C and %G of the bottom region? **Explain.**

d) Why is RNA more reactive compared to DNA?

3. Consider the structure of the following monomer.



a) Classify this monomer as a **carbohydrate/ lipid/ protein.**

b) Circle **ALL** the options that classify this molecule. **Explain** why you selected these options.

- hydrophobic  
charged
- polar  
uncharged
- hydrophilic
- nonpolar

4. Many patients often need blood transfusions. We have four major blood groups based on the type of antigen located on the surface of circulating RBCs: Type A, Type B, Type O (universal donor) and Type AB (universal acceptor). The structure of A, B and O antigens are shown below. Matching blood groups is critical for successful blood transfusions.

The diagram illustrates the structures of O, A, and B antigens. Each antigen is shown as a glycolipid with a red blood cell membrane. The O antigen has a base structure. The A antigen has an additional N-acetylglucosamine (GlcNAc) sugar. The B antigen has an additional galactose sugar. Red circles and green arrows highlight the differences between the antigens.

**ABO Blood group antigens are cell surface glycoconjugates (glycolipids)**

	O blood group	A blood group	B blood group	A/B blood group
Galactose	None	None	One	One
N-Acetyl glucosamine	One	Two	One	Two
N-Acetyl galactosamine	None	None	None	One
Fucose	One	One	One	One

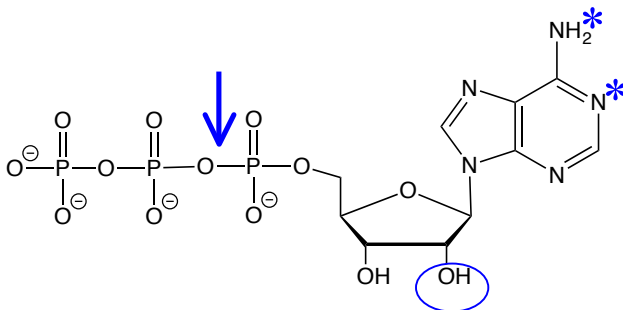
Slide 11 from Prof. Imperial's Lecture 5 (9/14) 11

a) You want to use glycosidases to hydrolyze the bonds indicated by the arrows in the A and B antigen. Would you use the same enzyme for both antigens? Why or why not?

b) Assuming you are successful, can the modified RBCs be given to any patient irrespective of the patient's blood group type? **Why or why not?**

### Solutions to Questions:

1. The following schematic represents an ATP molecule that is used to build RNA and also serves as the energy currency of the cell.



a) **Circle** the group(s) that you will alter so that this molecule could serve as a monomer for DNA.

b) Draw an arrow to the atom that forms a covalent bond with the terminal nucleotide of a growing nucleic acid polymer.

c) Name the molecule(s) that are produced from ATP if it is used as an energy source  
*ADP, AMP and pyrophosphate*

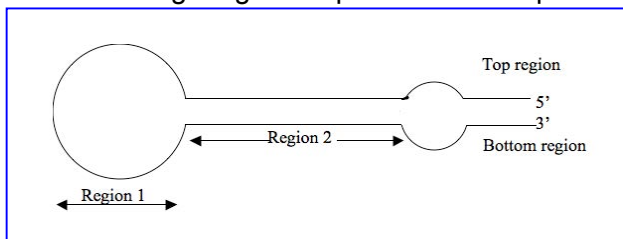
d) Draw an asterisk by the atom(s) that form hydrogen bond(s) with a nitrogenous base on the complementary strand of DNA or RNA. Identify the base in DNA and in RNA.

*The base shown in the schematic is Adenosine (or just A), which is a part of both DNA and RNA. DNA has A, T, G and C whereas RNA has A, U, G and C.*

e) If a double stranded DNA has 30% A, give the percentages of G, C, T in this molecule.

*T= 30%, G= 20%, C=20%*

2. The following diagram represents a complex three-dimensional conformation of a RNA molecule.



a) Within Region 2, what bonds/interactions are **primarily involved** in stabilizing the RNA structure?

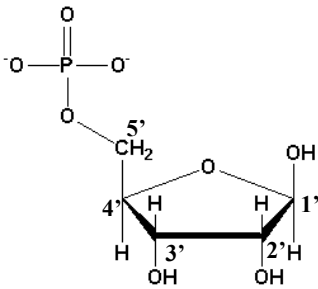
*Hydrogen bonds between complementary bases and phosphodiester bonds between the adjacent bases are involved in stabilizing the structure.*

b) In Region 1, if the sequence of the top region is AUUUGUAA, can you predict the % of bases i.e. %A, %U %C and %G of the bottom region? **Explain.** *No, since it is existing as a single stranded RNA in this region with no hydrogen bonding between complementary bases.*

c) In the Region 2, where you see complementary base pairing, if the sequence of the top region is AUUUGUAA, can you predict the % of bases i.e. %A, %U %C and %G of the bottom region? **Explain.** *Yes, since it is existing as double stranded RNA in this region with hydrogen bonding between complementary bases. There will 3Us, 2As, 2Cs and 1G to give the sequence 3'UAAACAUU5' which will be complementary to the sequence given above.*

d) Why is RNA more reactive compared to DNA? *Due to the -OH group at 2'C position of ribose sugar*

3. Consider the structure of the following monomer.

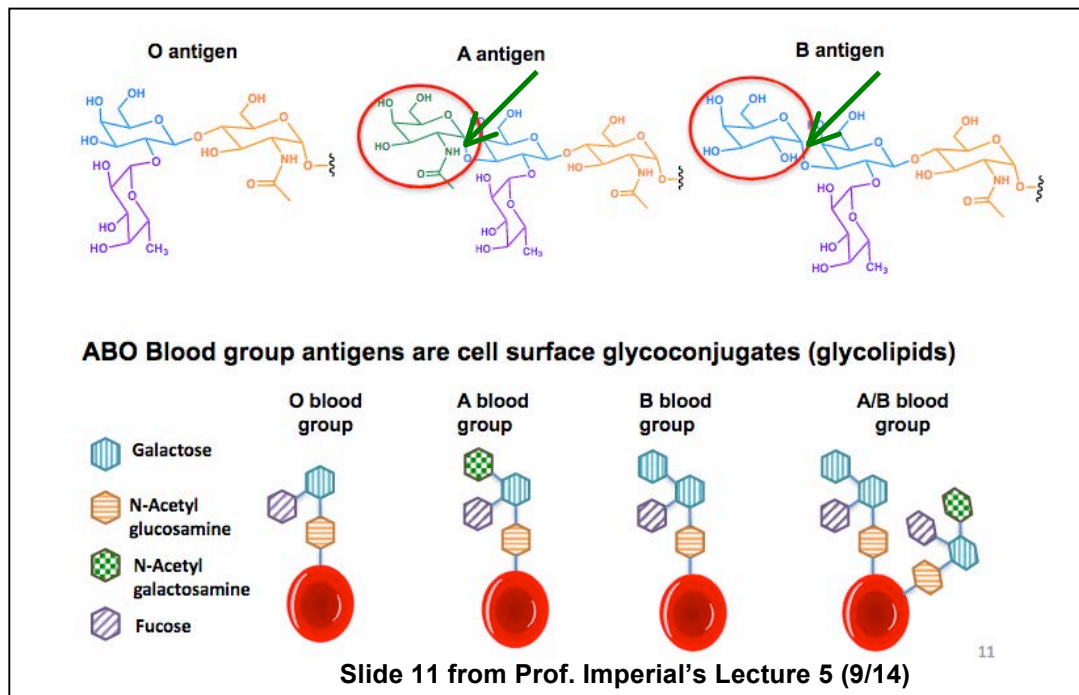


a) Classify this monomer as a carbohydrate/ lipid/ protein.

b) Circle **ALL** the options that classify this molecule. **Explain** why you selected these options.

hydrophobic polar hydrophilic nonpolar  
charged uncharged

4. Many patients often need blood transfusions. We have four major blood groups based on the type of antigen located on the surface of circulating RBCs: Type A, Type B, Type O (universal donor) and Type AB (universal acceptor). The structure of A, B and O antigens are shown below. Matching blood groups is critical for successful blood transfusions.



a) You want to use glycosidases to hydrolyze the bonds indicated by the arrows in the A and B antigen. Would you use the same enzyme for both antigens? **Why or why not?**

*You would likely use different glycosidases since antigen A and Antigen B are two different substrates.*

b) Assuming you are successful, can the modified RBCs be given to any patient irrespective of the patient's blood group type? **Why or why not?**

*Yes, since this would produce Antigen O as the product of the hydrolysis reaction, which is a universal donor.*

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