Molecular biology (Zoo-342)

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Aims of the Molecular Biology course

- To study the properties of genetic material.
- To understand the structure of DNA and its organization in chromatin.
- To understand the structure of RNA and its types.
- To understand the of DNA replication.
- To understand the key features of gene.
- To study the gene expression: Transcription in prokaryotic cells.
- To study the gene expression: Transcription in eukaryotic cells.
- To study the gene expression: Translation in prokaryotic cells.
- To study the gene expression: Translation in eukaryotic cells.

Time table for weekly planning for Molecular Biology

Lectures	Dates	Syllabus view
1	21/12/1437	National day holiday
2	28/12/1437	Structure of DNA and RNA
3	5/1/1438	DNA replication
4	12/1/1438	The eukaryotic chromosome and chromatin organization
5	19/1/1438	Centromeres and telomeres
6	26/1/1438	Changes in chromosome structure and number
7	3/2/1438	Exam 1
9	10/2/1438	
8	17/2/1438	1^{st} term break
9	24/2/1438	Gene expression
10	2/3/1438	Prokaryotic transcription: The process
11	9/3/1438	Eukaryotic transcription
12	16/3/1438	Prokaryotic translation
13	23/3/1438	Eukaryotic translation
14	30/3/1438	Exam 2

Assessment

- Lecture
  - 2 lecture exams (25%)
  - Attendance, participation and homework (5%)
  - Final exam (40%)
  - 70% of total grade

- Laboratory
  - 30% of total grade

Required properties of a genetic material:

1) It must contain information that control the synthesis of protein and function.
2) It must be able to self-replicate.
3) It must be located in the chromosomes, which had been found to carry traits from one generation to the next.

Types of genetic materials:

1) DNA: is the genetic material in most organisms, such as humans, animals, plants, viruses, and bacteria.
2) RNA: in some viruses, RNA serves as the genetic material.

Examples of DNA and RNA containing viruses in the humans

Virus	Nucleic Acid
HIV	RNA
Influenza virus	RNA
HAV	RNA
HCV	RNA
HBV	DNA
Herpes virus	DNA

The basic structure of nucleic acids:

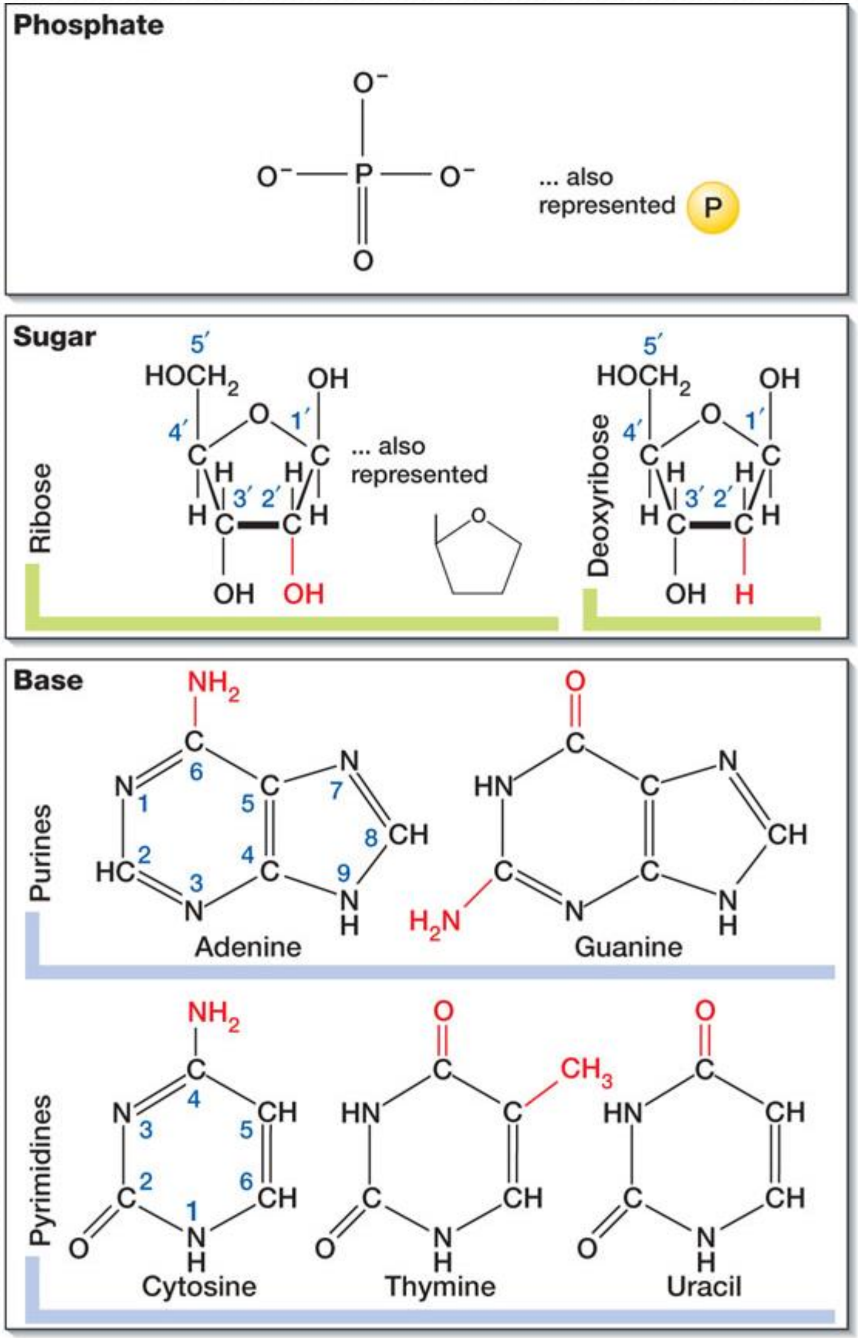
Two types of nucleic acid are found in living organisms:

1) **DNA** (**d**eoxyribo**n**ucleic **a**cid): Most DNA is located in the cell nucleus (it is called nuclear DNA), but a small amount of DNA can also be found in the mitochondria (it is called mitochondrial DNA or mtDNA).
2) **RNA** (**r**ibo**n**ucleic **a**cid)

- Nucleic acids are made of nucleotides.
- Nucleotides are composed of three components: (1) a phosphate (2) a sugar, and (3) a nitrogen base (Figure 1).

- In contrast, a nucleoside is a sugar-base compound that lacks phosphate (nucleoside= sugar + nitrogen base) (Figure 2).
- The sugars in DNA and RNA differ at a single position.
- In the DNA, the sugar is deoxyribose, which contains a hydrogen (H) at the second (2') carbon.
- The sugar in RNA is ribose, which contains a hydroxyl (OH) group at the 2' carbon.
- The carbons of the sugars are numbered 1 to 5. The primes are used to avoid confusing with the numbering system of the basses (Figure 1).

Figure 1: Components of nucleic acids



- Nucleoside= nitrogen base + sugar
- Nucleotide= nitrogen base + sugar + phosphte

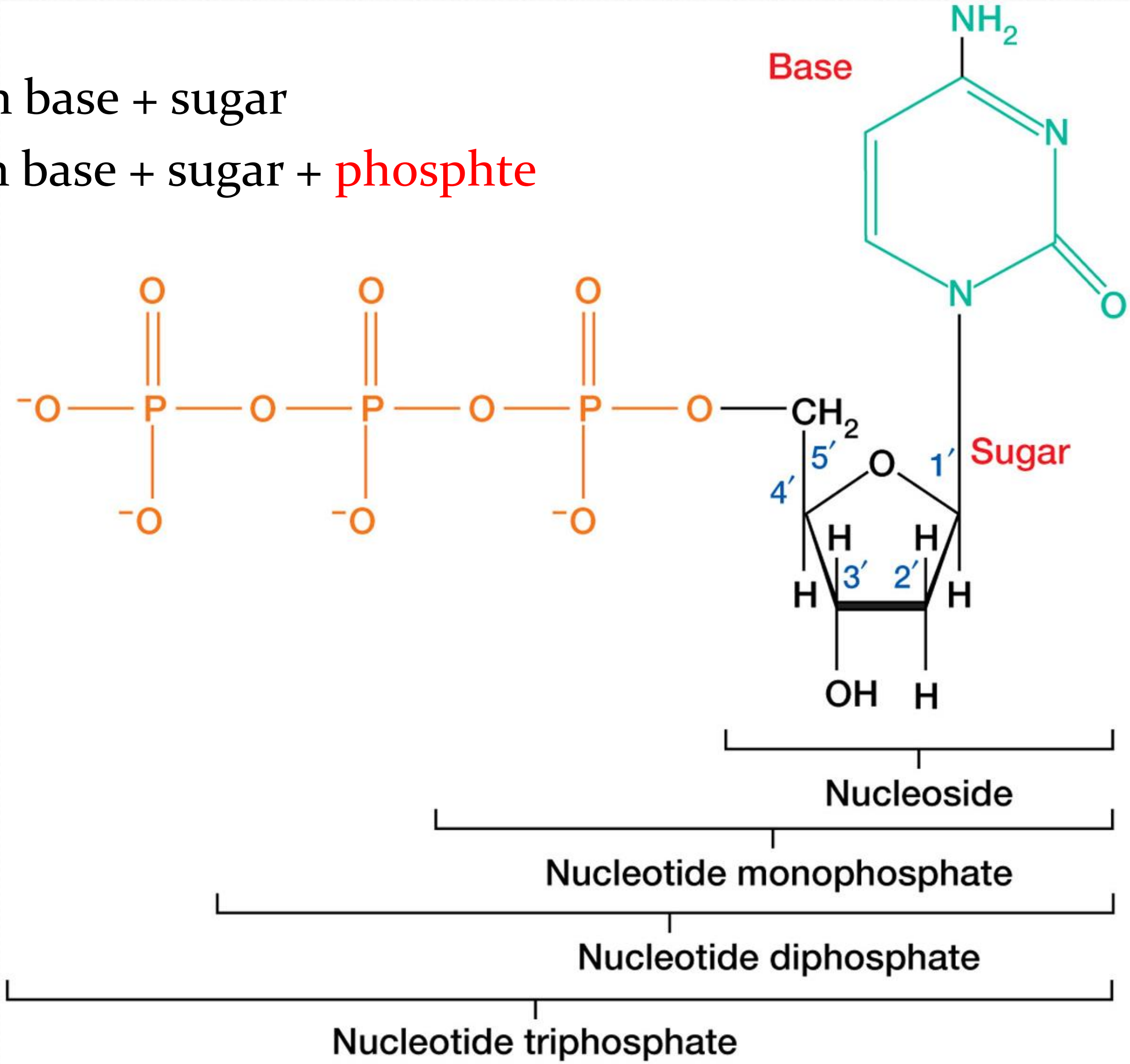


Figure 2: The structure of nucleoside and the three nucleotide

- DNA and RNA both have four nitrogen bases, two purines and two pyrimidines in their nucleotide chains.
- DNA has the purine adenine (A) and guanine (G) and the pyrimidines cytosine (C) and thymine (T).
- RNA has the purine adenine (A) and guanine (G) and the pyrimidines cytosine (C) and uracil (U).
- A nucleotide is formed in the cell when a base attaches to the 1' carbon of the sugar and a phosphate attaches to the 5' carbon of the same sugar (Figure 3).
- The name of the nucleotide is derived from the base.

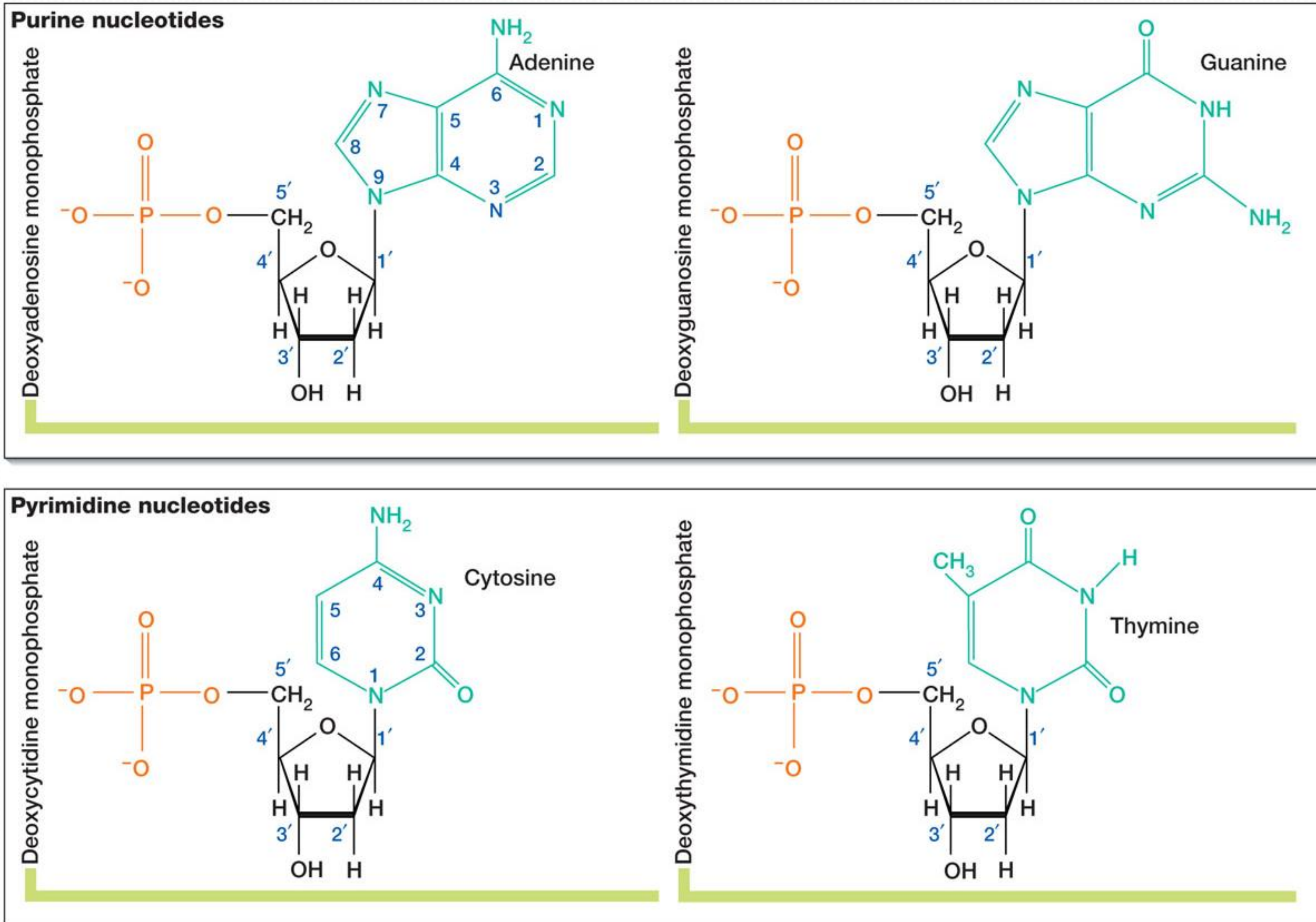


Figure 3: Structure of the four deoxyribose nucleotides

- Nucleotides are linked together by the formation of a bond between the phosphate at the 5' carbon of one nucleotide and the hydroxyl group at the 3' carbon of an adjacent sugar. A linked termed a phosphodiester bond (Figure 4).

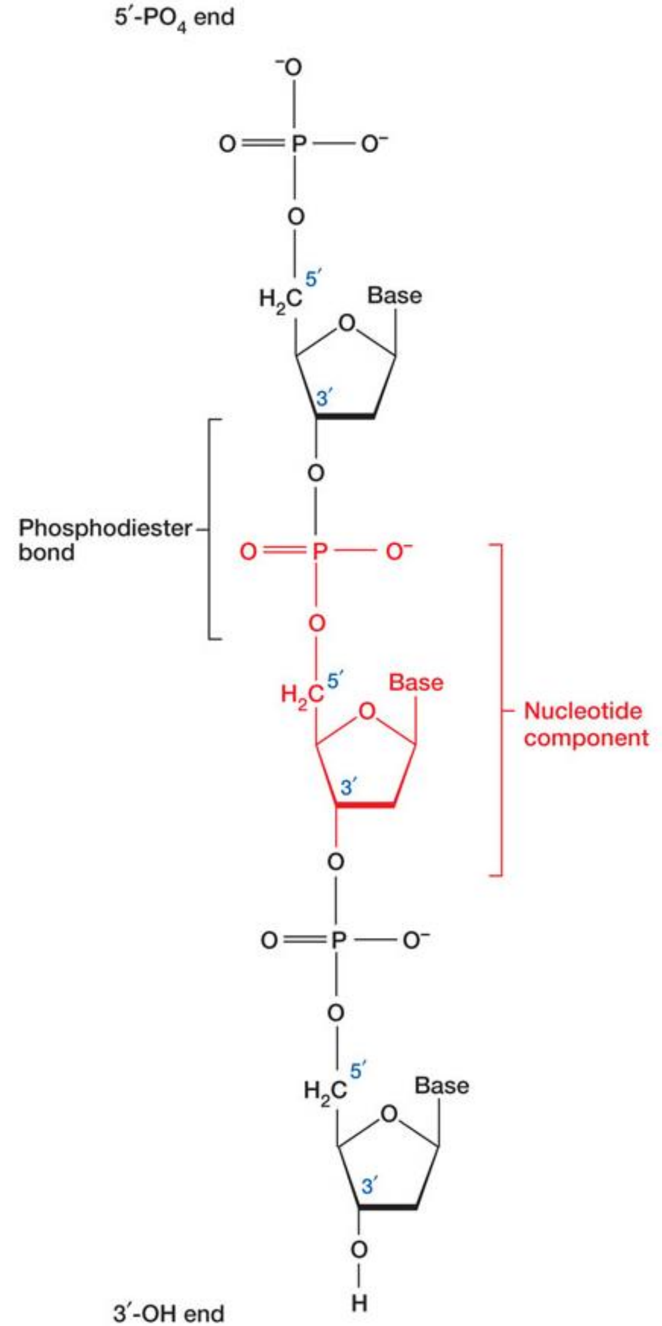


Figure 4: A polymer of nucleotides

Chargaff’s ratios:

Before Chargaff’s work, scientist proposed that DNA was made up of equal quantities of the four bases; however, Chargaff found that DNA from any cell of all organisms should have a 1:1 ratio of pyrimidine and purine bases.

- The amount guanine is equal to cytosine (G=C).
- The amount of adenine is equal to thymine (A=T).
- The amount of purine basses are equal to pyrimidine basses (A+G=T+C).

The Watson - Crick Model:

- The structure of DNA was discovered by Watson and Crick in 1953. They found the DNA is double helix with the sugar-phosphate backbones on the outside and the bases on the inside.
- DNA has antiparallel strands (Figure 5) that are held together by hydrogen bounding between the basses. Two hydrogen bonds connect adenine and thymine and three connect cytosine and guanine (Figure 6).

The Watson-Crick model

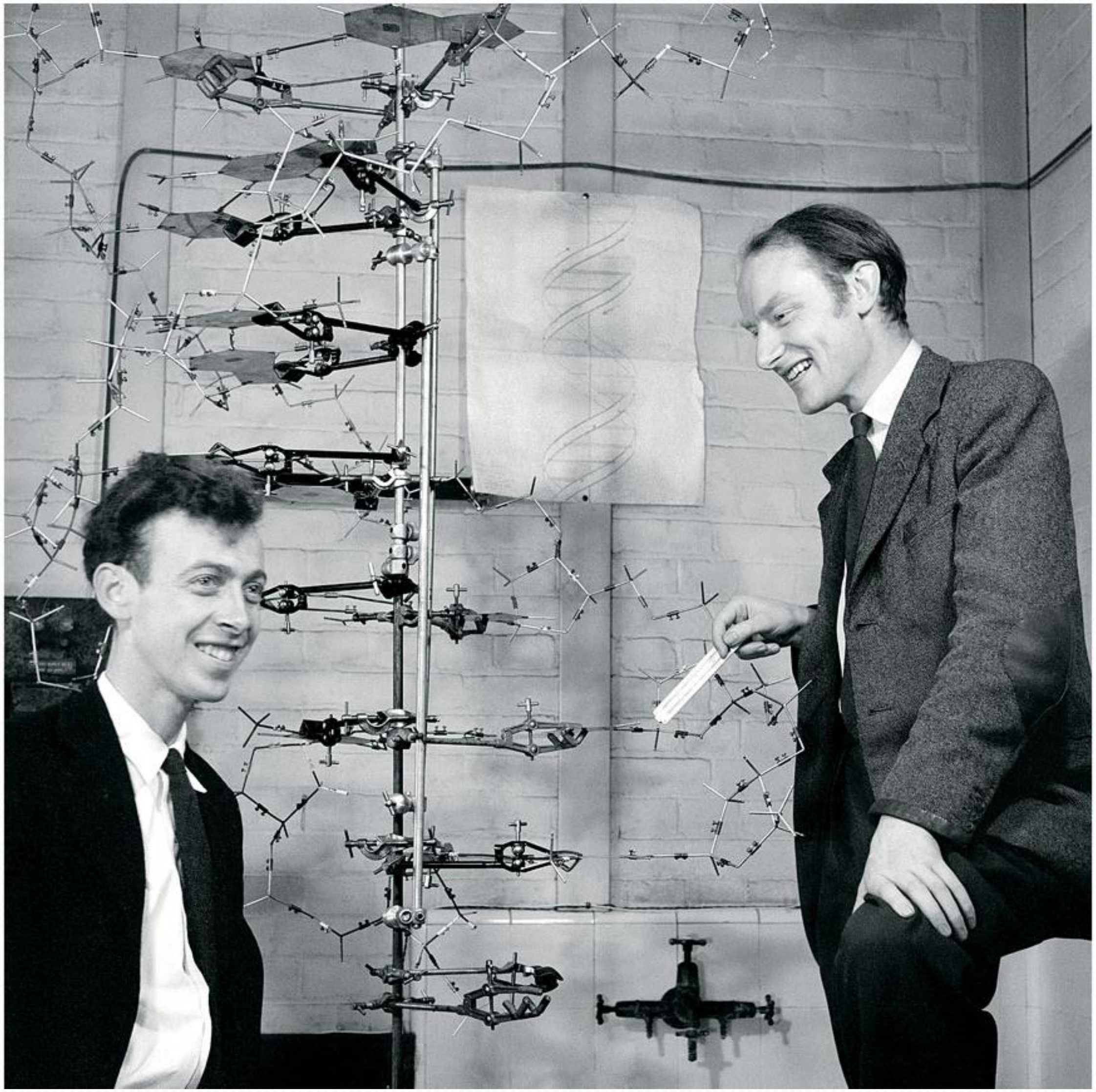


Figure 5: Polarity of the DNA strand

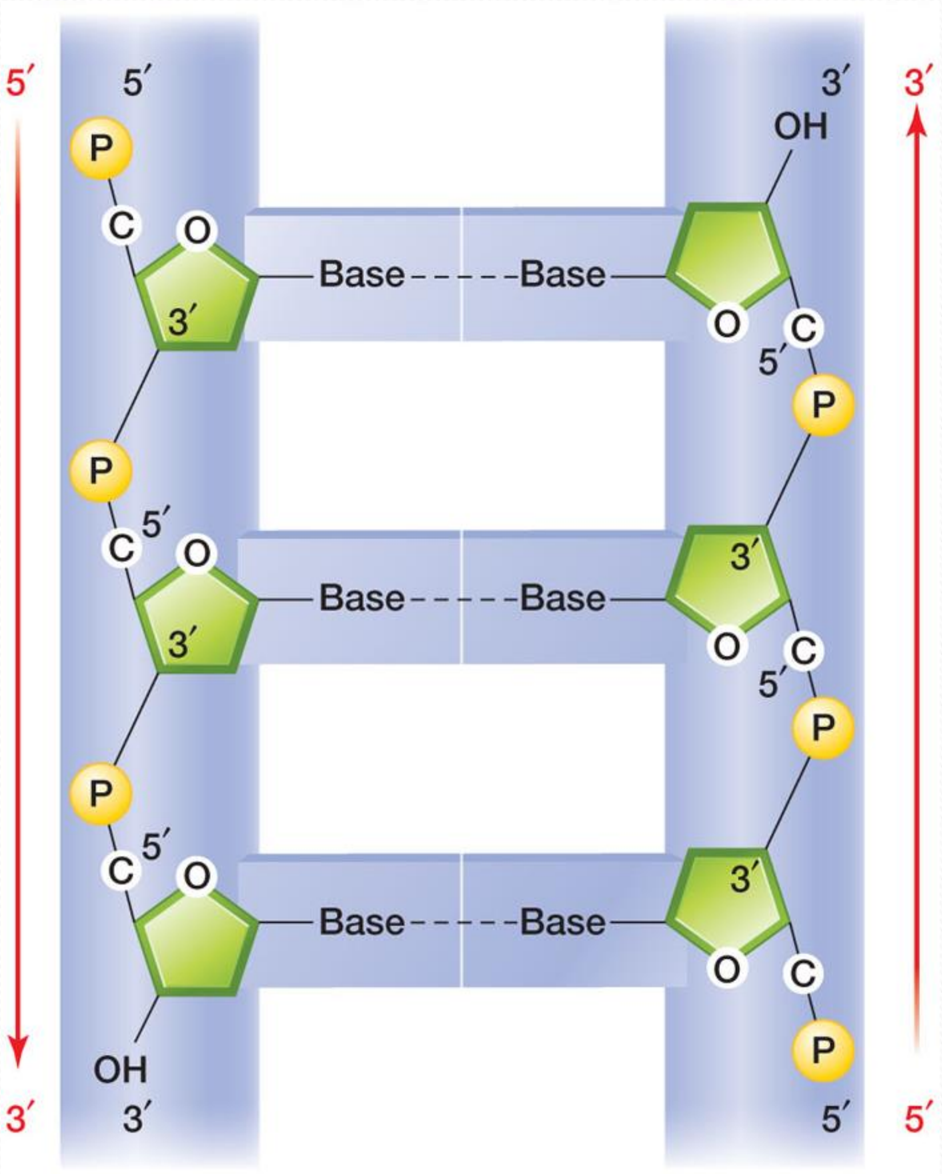
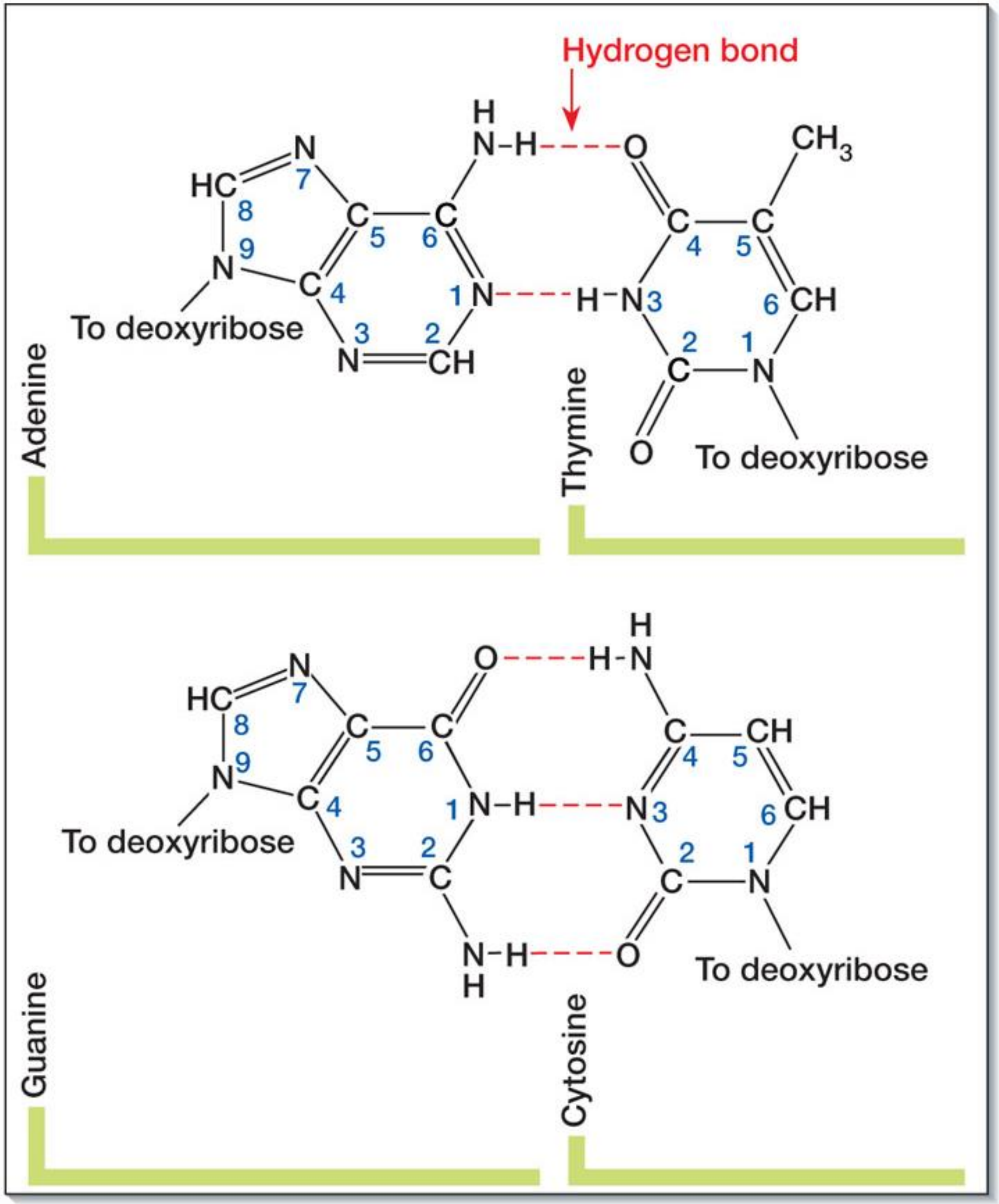


Figure 6: Hydrogen bonds



Exercises:

1) Deduce whether each of the nucleic acid molecules in the following table is DNA or RNA and single-stranded or double-stranded.

Nucleic acid molecule	%A	%T	%G	%C	U
a	28	28	22	22	0
b	31	0	31	17	21
c	15	15	35	35	0

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2) A double-stranded DNA molecule contains 28% guanine (G).

a) What is the complete base composition of this molecule?

b) Answer the same question, but assume the molecule is double-stranded RNA

3) For a double-stranded DNA molecule, the sequence of one strand is 5'-CATTAGACCGGTAGAC-3'. What is the sequence of the complementary strand? Label the 5' and 3'end?