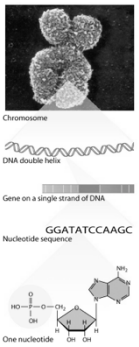
DNA

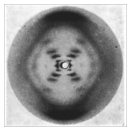
Genetics & DNA

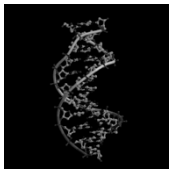


DNA: Picture 51

http://info.bio.cmu.edu/courses/03231/ProtStruc/ProtStruc.htm

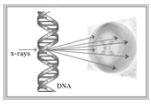
B-DNA: The advent of modeling





12 base sequence

(1953-2003)

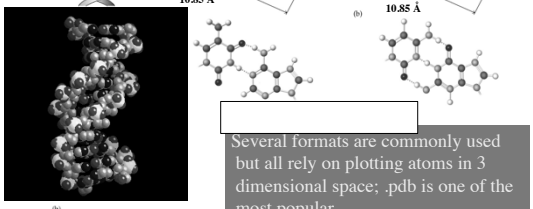


http://molvis.sdsc.edu/pdb/dna_b_form.pdb

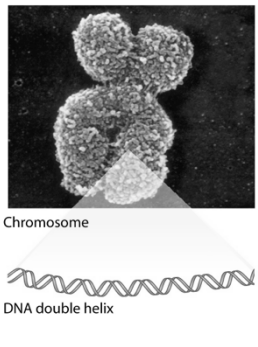
DNA: Size, Shape & Self Assembly

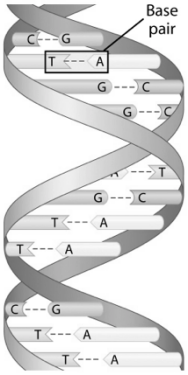
http://www.umass.edu/microbio/chime/betatpc_alpha/atlas/atlas.htm

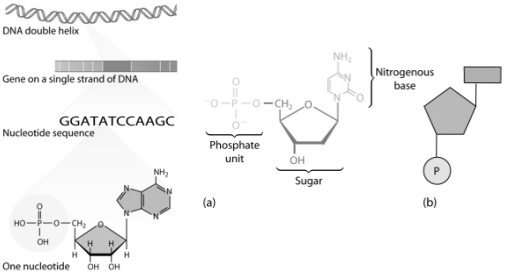
Views & Algorithms

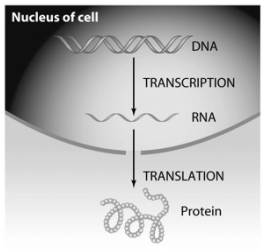


Several formats are commonly used but all rely on plotting atoms in 3 dimensional space; .pdb is one of the most popular.









Pyrimidines and Purines

Pyrimidines and Purines

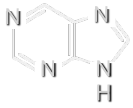
In order to understand the structure and properties of DNA and RNA, we need to look at their structural components.

We begin with certain heterocyclic aromatic compounds called pyrimidines and purines.

Pyrimidines and Purines

Pyrimidine and purine are the names of the parent compounds of two types of nitrogen -containing heterocyclic aromatic compounds.

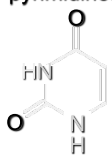
Pyrimidine



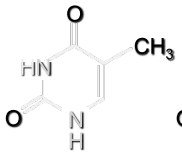
Purine

Important Pyrimidines

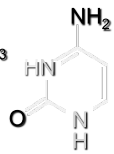
Pyrimidines that occur in DNA are cytosine and thymine. Cytosine and uracil are the pyrimidines in RNA.



Uracil



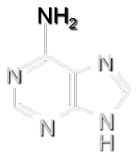
Thymine



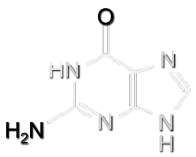
Cytosine

Important Purines

Adenine and guanine are the principal purines of both DNA and RNA.



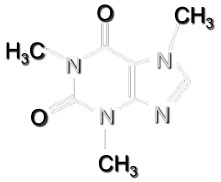
Adenine



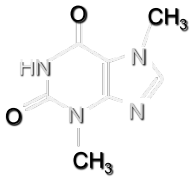
Guanine

Caffeine and Theobromine

Caffeine (coffee) and theobromine (coffee and tea) are naturally occurring purines.



Caffeine



Theobromine

Question

How many pyrimidines and purines in total occur in DNA and RNA?

A) 2, 2
B) 2, 3
C) 3, 2
D) 4, 1

Nucleosides

Nucleosides

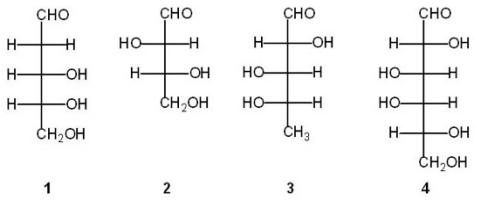
The classical structural definition is that a nucleoside is a pyrimidine or purine N-glycoside of D-ribofuranose or 2-deoxy-D-ribofuranose.

Informal use has extended this definition to apply to purine or pyrimidine N-glycosides of almost any carbohydrate.

The purine or pyrimidine part of a nucleoside is referred to as a *purine or pyrimidine base*.

Question

Which of the following carbohydrates are classified as deoxy sugars?

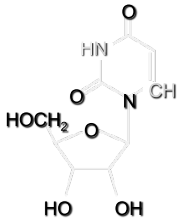


1 2 3 4

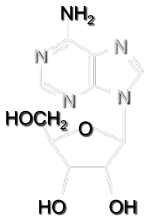
A) 1 only
B) 1 and 2
C) 1 and 3
D) 1, 3, and 4

Uridine and Adenosine

Uridine and adenosine are pyrimidine and purine nucleosides respectively of D-ribofuranose.



Uridine
(a pyrimidine nucleoside)

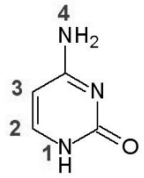


Adenosine
(a purine nucleoside)

Question

To which atom(s) of the pyrimidine is the anomeric carbon of a sugar attached?

A) 1
B) 2
C) 3
D) 4



Question

Which of the following bases is only found in **DNA**?

A) Cytosine
B) Thymine
C) Adenine
D) Uracil

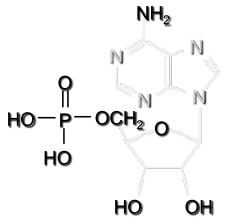
Nucleotides

Nucleotides

Nucleotides are phosphoric acid esters of nucleosides.

Adenosine 5'-Monophosphate (AMP)

Adenosine 5'-monophosphate (AMP) is also called 5' -adenylic acid.



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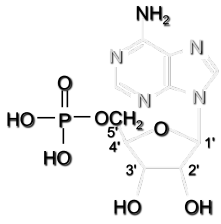
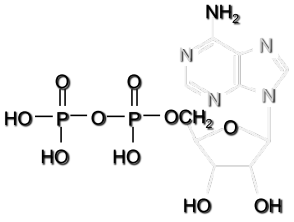
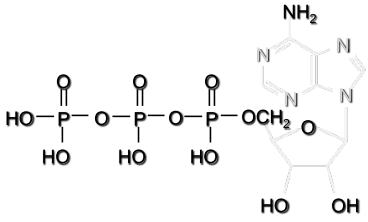


Adenosine Diphosphate (ADP)



Adenosine Triphosphate (ATP)



Question

The bond that joins two nucleotides together is called a

A) amide bond.
B) peptide bond.
C) phosphodiester bond.
D) hydrogen bond.

ATP Stores Energy

http://chemconnections.org/organic/Movies%20Org%20Flash/flash-amines-genetic%20bases/NADH-redox.swf

ATP
↑
ADP
↑
AMP

Each step is endothermic.

Energy for each step comes from carbohydrate metabolism (glycolysis).

Reverse process is exothermic and is the source of biological energy.

$\Delta G°$ for hydrolysis of ATP to ADP is –35 kJ/mol

Nucleic Acids

Nucleic Acids

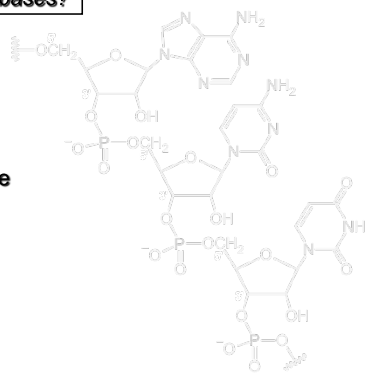
Nucleic "acids", RNA and DNA, are polymeric nucleotides (*polynucleotides)*.

The 5' oxygen atom of one nucleotide's saccharide is linked to the 3' oxygen of another.

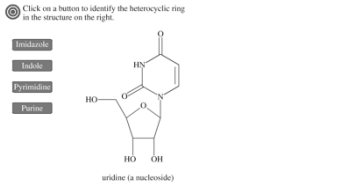
Nucleotides are commonly referred to by an abbreviation of the heterocylic nitrogen bases that define them. (C, G, A, T, U)

What are the bases?

A section of a polynucleotide chain.



Heterocyclic Bases



http://chemconnections.org/organic/Movies%20Org%20Flash/flash-amines-genetic%20bases/purine-N-hetero-ID.swf

Structure and Replication of DNA:
The Double Helix

Composition of DNA

Erwin Chargaff (Columbia Univ.) studied DNAs from various sources and analyzed the distribution of purines and pyrimidines in them.

The distribution of the bases adenine (A), guanine (G), thymine (T), and cytosine (C) varied among species.

But the total purines (A and G) and the total pyrimidines (T and C) were always equal.

Moreover: %A = %T, and %G = %C

Composition of Human DNA

For example:

Purine	Pyrimidine
Adenine (A) 30.3%	Thymine (T) 30.3%
Guanine (G) 19.5%	Cytosine (C) 19.9%
Total purines: 49.8%	Total pyrimidines: 50.1%

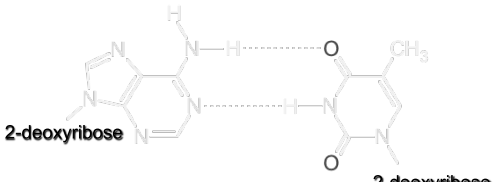
Question

Estimate the guanine content of turtle DNA if adenine = 28.7% and cytosine = 21.3%.

A) 28.7%
B) 21.3%
C) 57.4%
D) 42.6%

Base Pairing

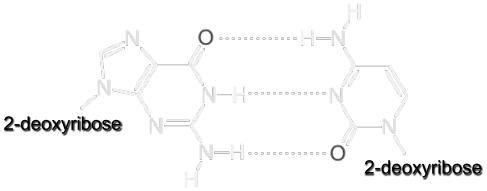
Watson and Crick proposed that A and T were equal because of complementary hydrogen bonding.



A T

Base Pairing

Likewise, the amounts of G and C were equal because of complementary hydrogen bonding.



G C

Question

The base pairs present in DNA are:

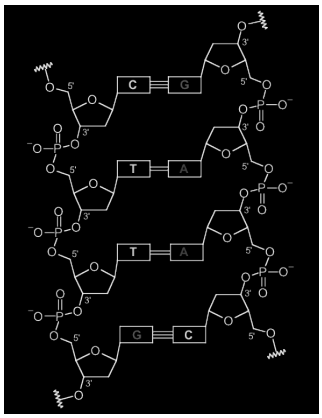
A) A---C and C---T
B) A---C and G---T
C) A---U and C---C
D) A---T and G---C

The DNA Duplex

Watson and Crick proposed a double-stranded structure for DNA in which a purine or pyrimidine base in one chain is hydrogen bonded to its complement in the other.

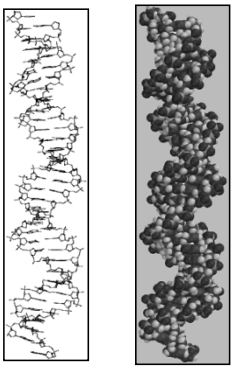
DNA

Two antiparallel strands of DNA are paired by hydrogen bonds between purine and pyrimidine bases.



DNA

Helical structure of DNA. The purine and pyrimidine bases are on the inside, sugars and phosphates on the outside.



Question

The base pairs present in DNA are:

A) A---C and C---T

B) A---C and G---T

C) A---U and C---C

D) A---T and G---C

DNA Replication

As the do
unwinds
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DNA Replication

DNA-Directed Protein Biosynthesis

DNA and Protein Biosynthesis

According to Crick, the "central dogma" of molecular biology is:
"DNA makes RNA makes protein."

Three kinds of RNA are involved.
messenger RNA (mRNA)
transfer RNA (tRNA)
ribosomal RNA (rRNA)

There are two main stages.
transcription
translation

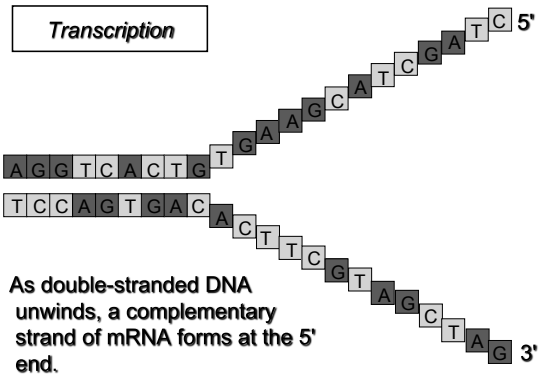
Transcription

Transcription is the formation of a strand of mRNA using one of the DNA strands as a template.

The nucleotide sequence of the mRNA is complementary to the nucleotide sequence of the DNA template.

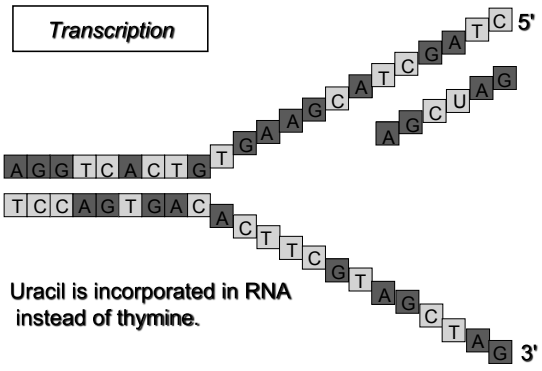
Transcription begins at the 5' end of DNA and is catalyzed by the enzyme *RNA polymerase*.

Transcription



As double-stranded DNA unwinds, a complementary strand of mRNA forms at the 5' end.

Transcription



Uracil is incorporated in RNA instead of thymine.

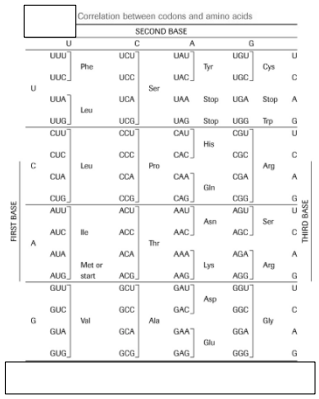
Translation

The nucleotide sequence of mRNA codes for the different amino acids found in proteins.

There are three nucleotides per codon.

There are 64 possible combinations of A, U, G, and C.

The genetic code is redundant. Some proteins are coded for by more than one codon.



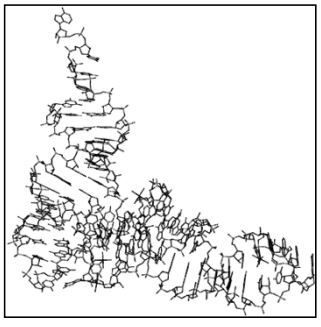
Transfer tRNA

There are 20 different tRNAs, one for each amino acid.

Each tRNA is single stranded with a CCA triplet at its 3' end.

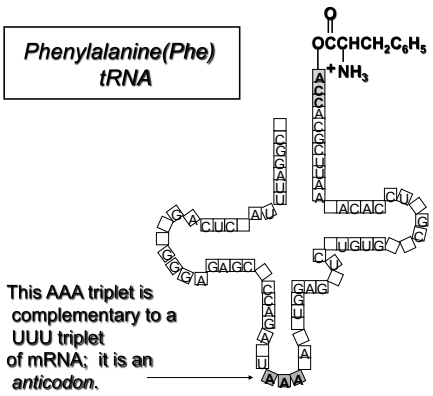
A particular amino acid is attached to the tRNA by an ester linkage involving the carboxyl group of the amino acid and the 3' oxygen of the tRNA.

Phenylalanine(Phe) tRNA



Codon = UUU

Phenylalanine(Phe) tRNA



This AAA triplet is complementary to a UUU triplet of mRNA; it is an *anticodon*.

Protein Synthesis

http://chemconnections.org/organic/Movies%20Org%20Flash/proteins-enzymes-DNA/transcription.swf