Bioinformatics

CS300

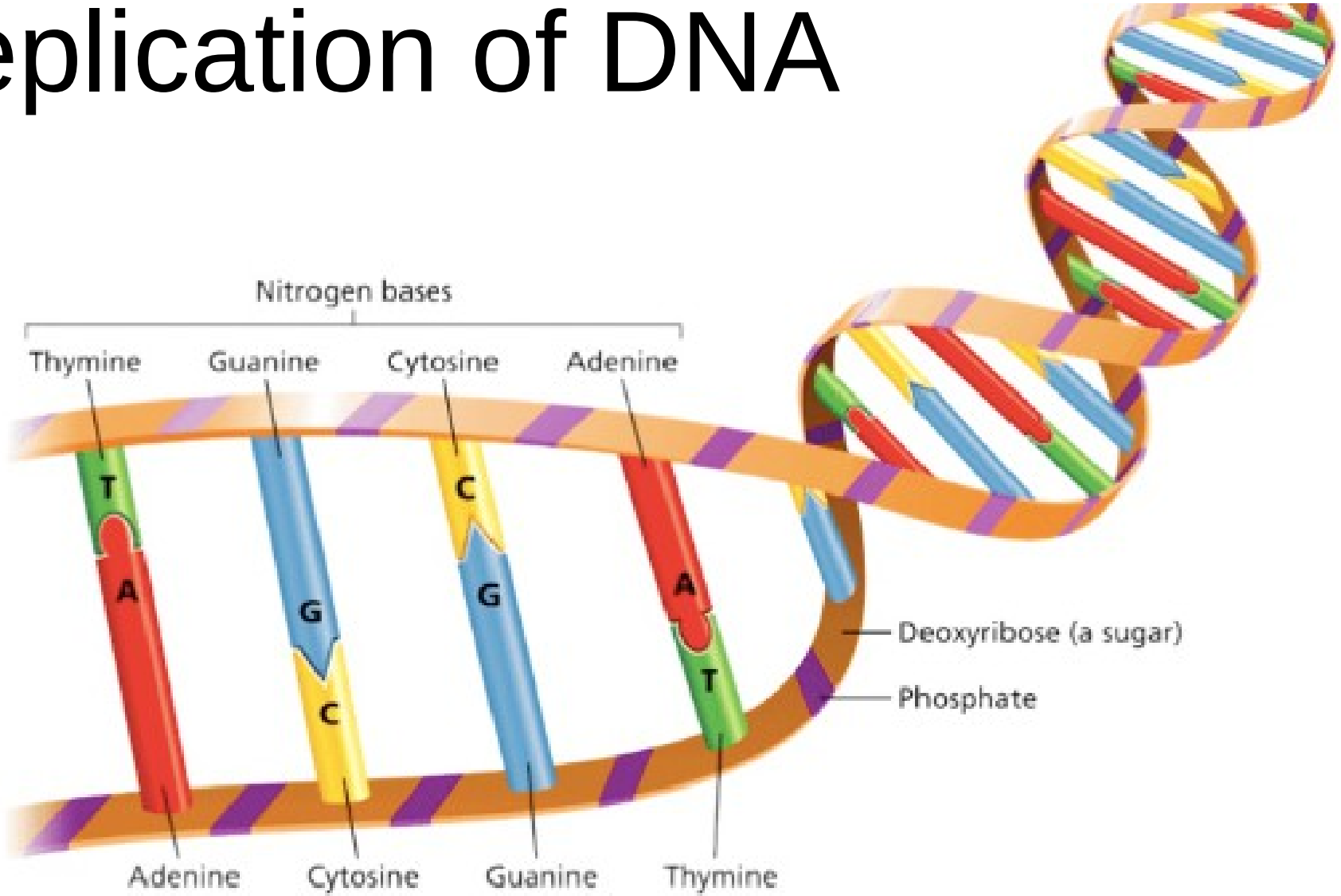
Crash course:

Structure and Replication of DNA

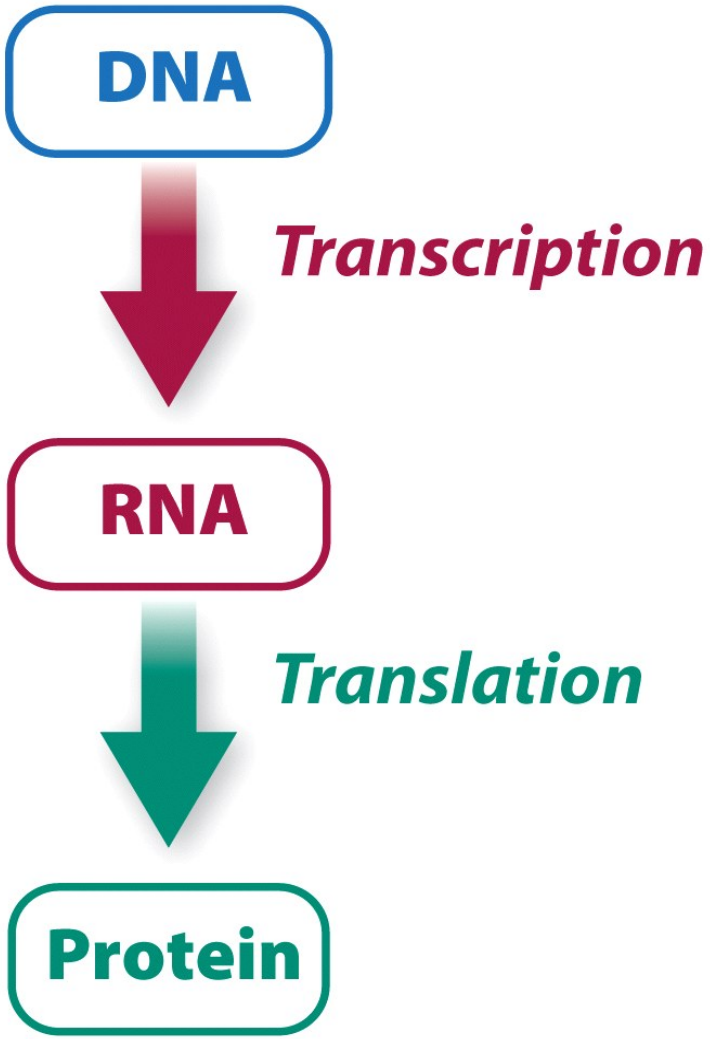
Fall 2017

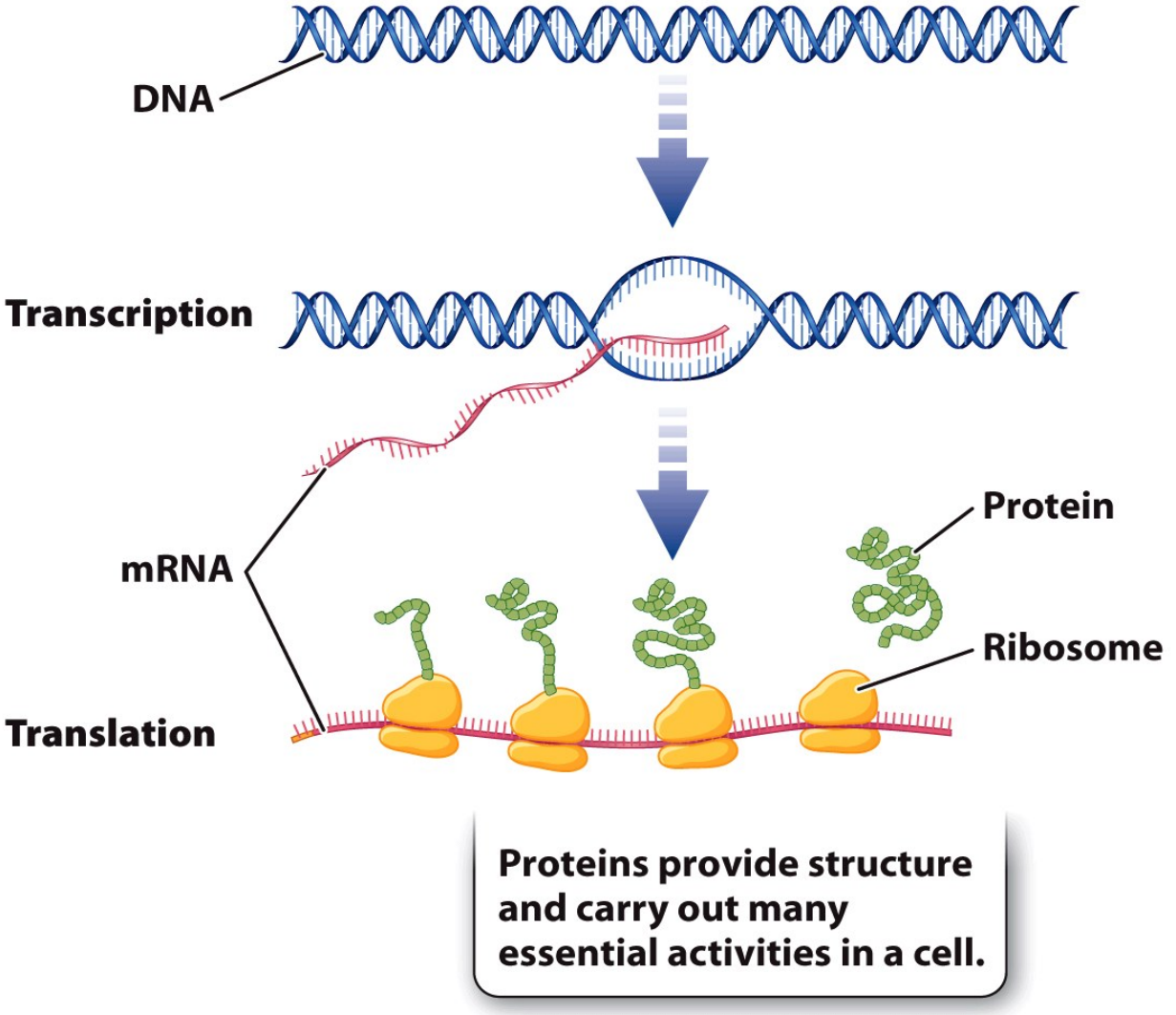
Oliver Bonham-Carter

The Structure and Replication of DNA



Central Dogma of Molecular Biology

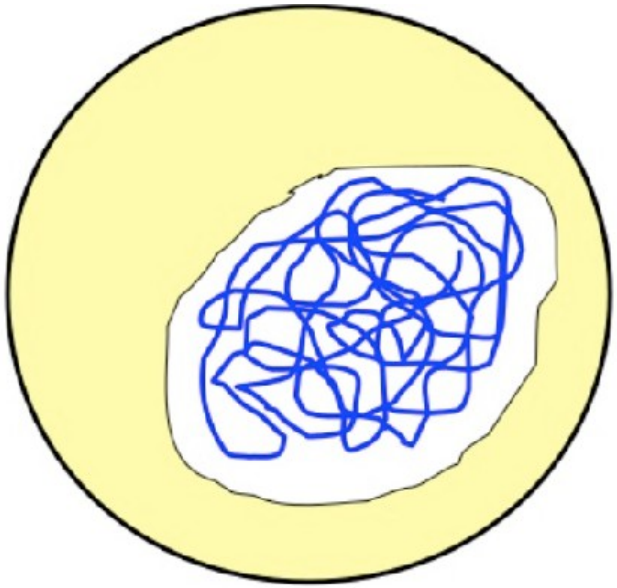


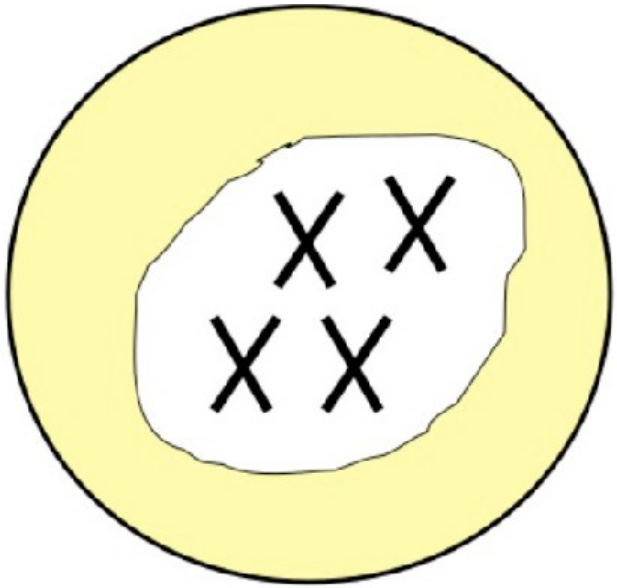


Central Dogma: *The framework of a process.*

What is DNA?

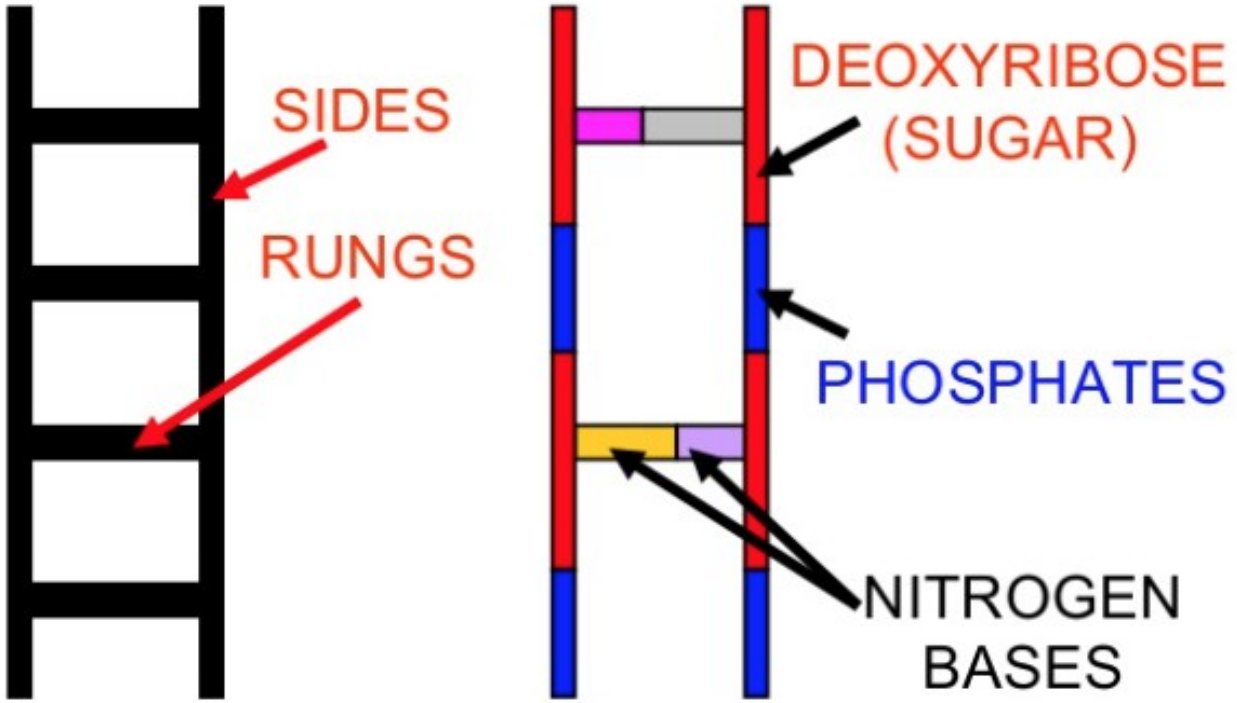
- Found in the nucleus of a cell in two different structures: chromatin and chromosomes
- Genetic Material (Life's *blue prints*)
- *Written* inherited characteristics (genes)





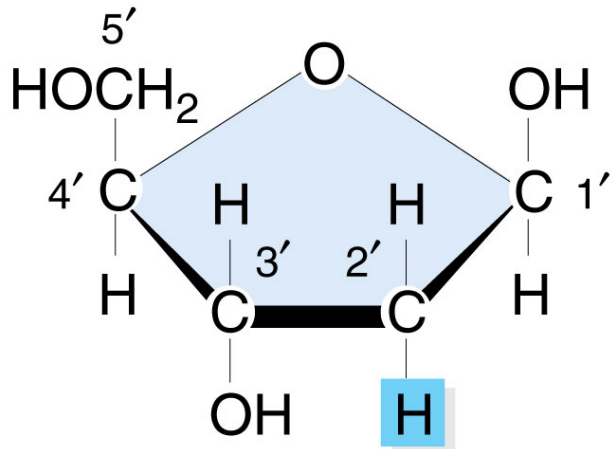
DNA Structure

- Formed like a twisted ladder
- There are two sides of the ladder
- Sugar (deoxyribose)
- Phosphates
- Alternating
- Rungs of the ladder
- Nitrogenous bases



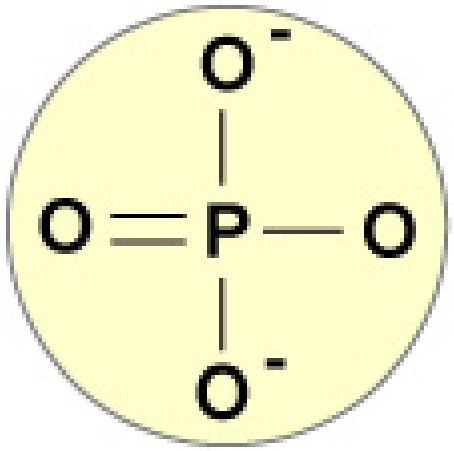
DNA Structure

Deoxyribose sugar



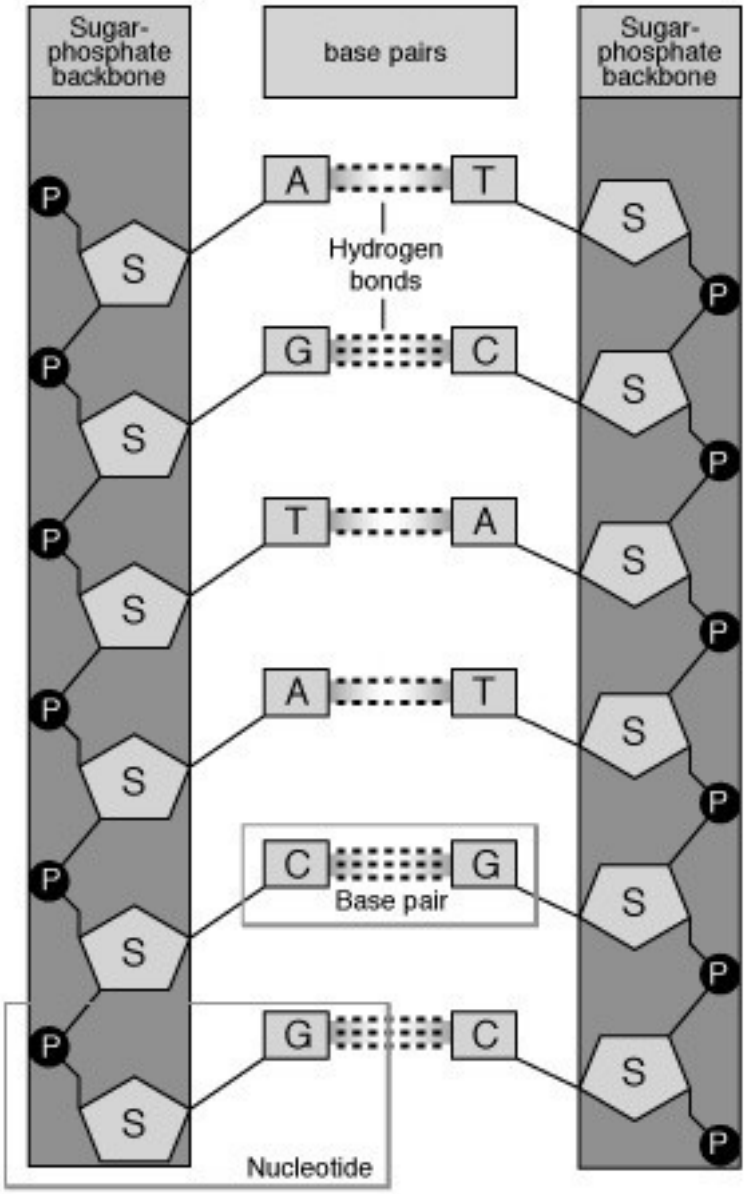
Deoxyribose

Phosphate



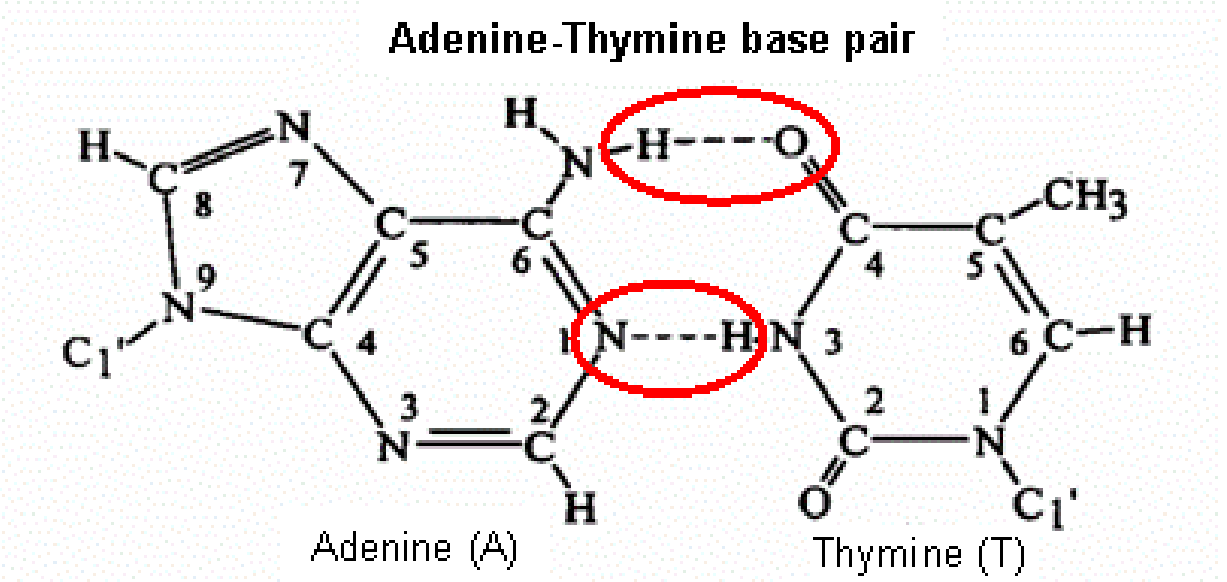
Phosphate group

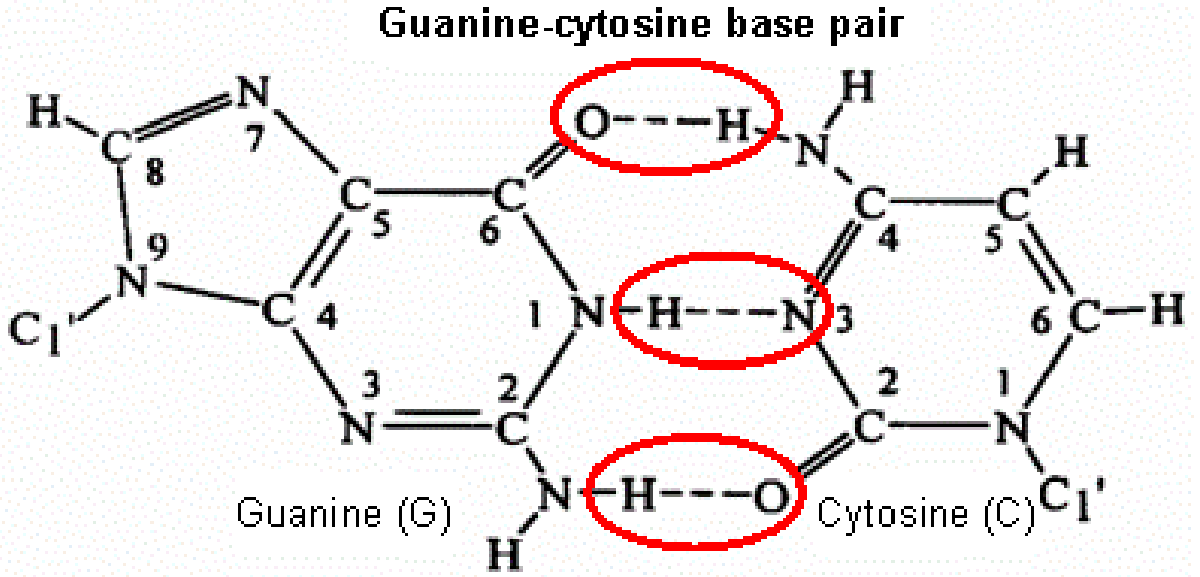
Phosphorus surrounded by oxygens



Base to Base Bonds: How do nitrogenous bases pair?

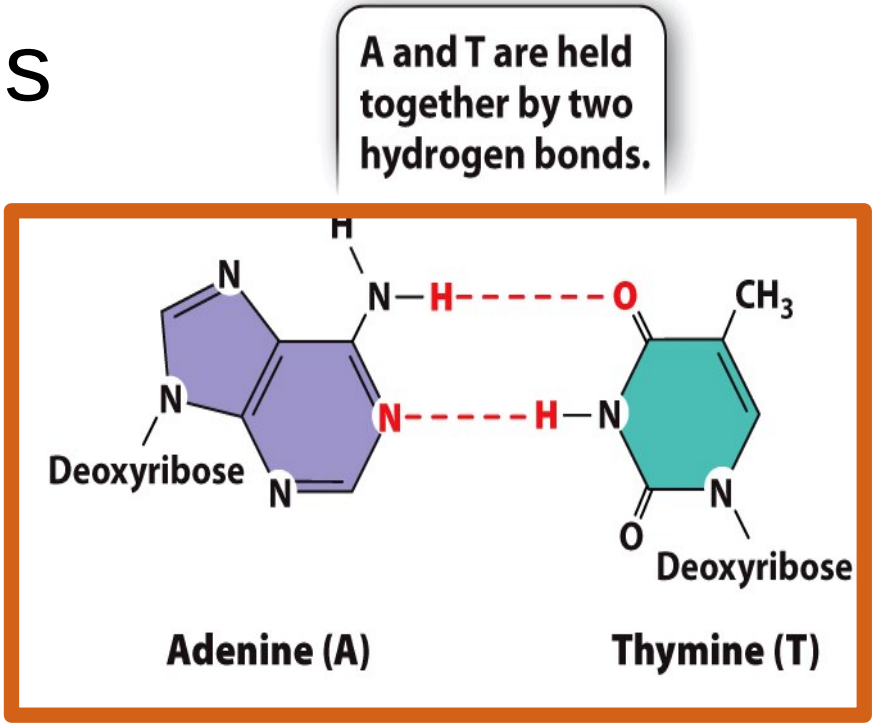
- Base-Specific bonding
- Preserves distance between (DNA's) backbones
- Hydrogen bonds
- Key to replication

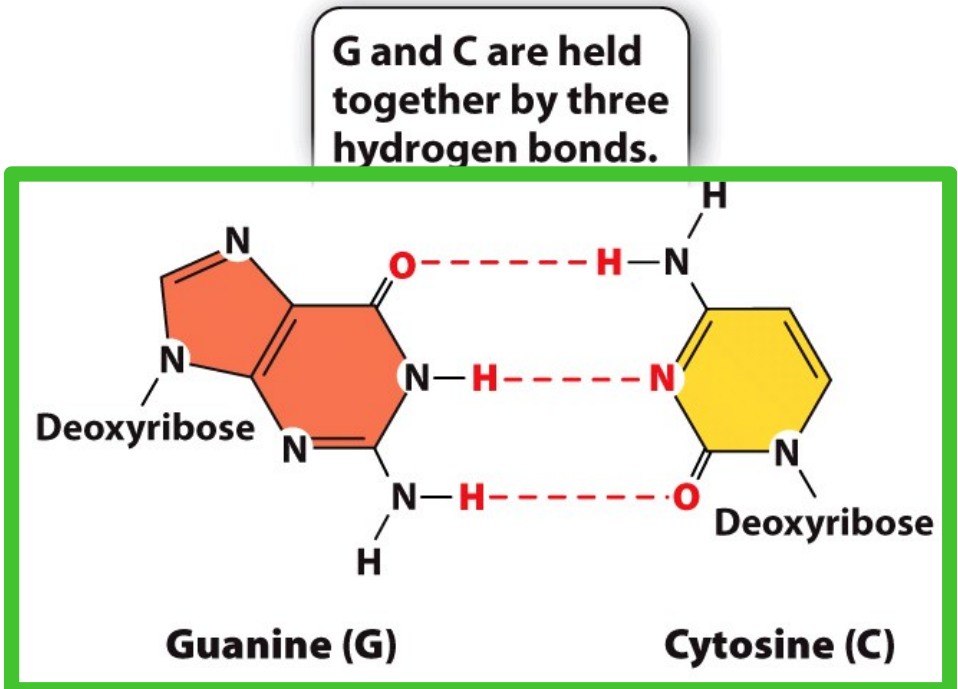




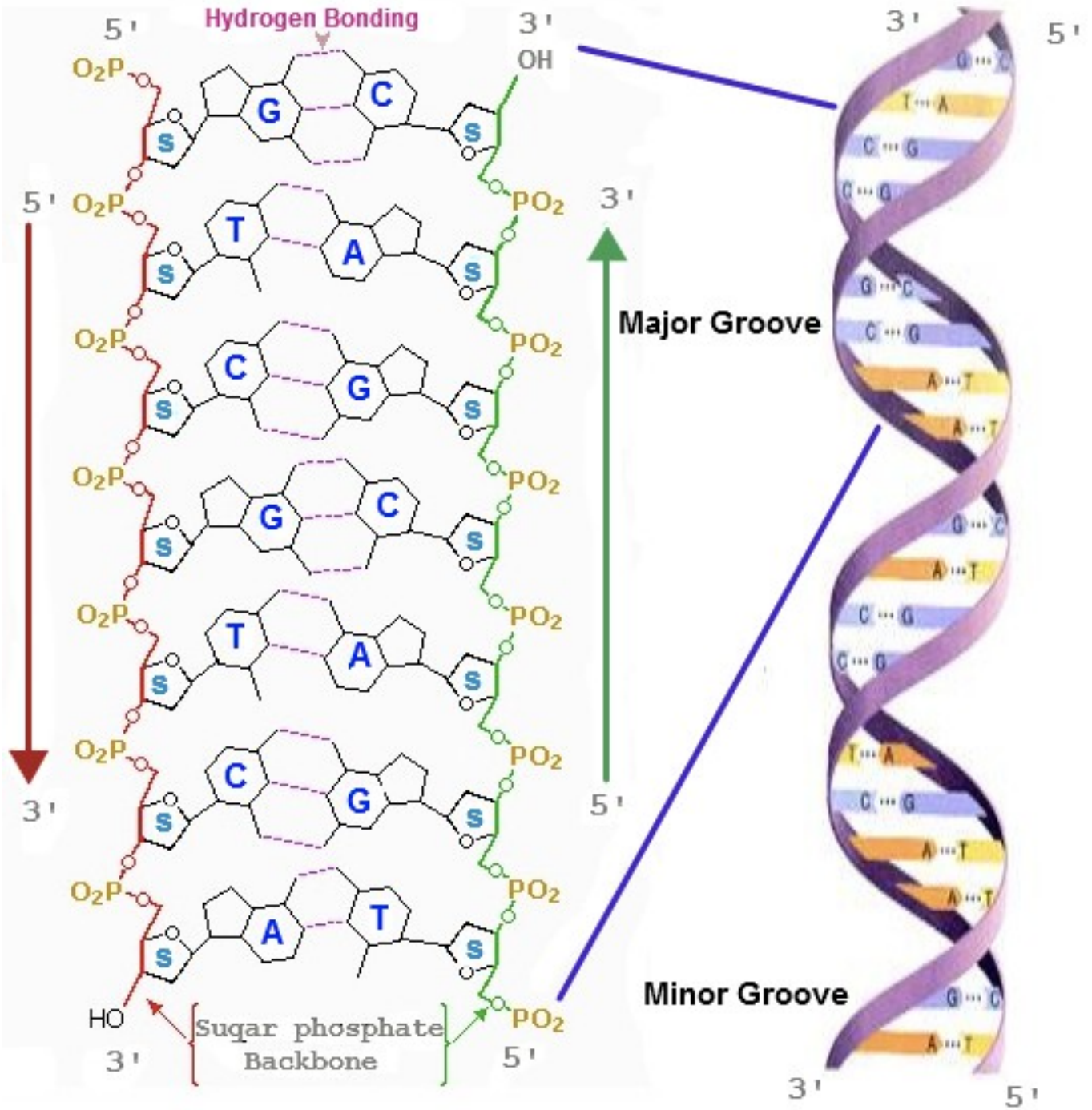
Purines and Pyrimidines

- **Purines**: adenine and guanine
- **Pyrimidine**: thymine, cytosine, and uracil
- Purines include a number of biologically important compounds, such as adenosine, caffeine, uric acid, and the two bases adenine and guanine, which are components of DNA and RNA.
- Only 3 pyrimidine bases (thymine, cytosine, and uracil) and 2 purine bases (adenine and guanine) are needed to produce the incredible diversity of species that inhabit the earth.

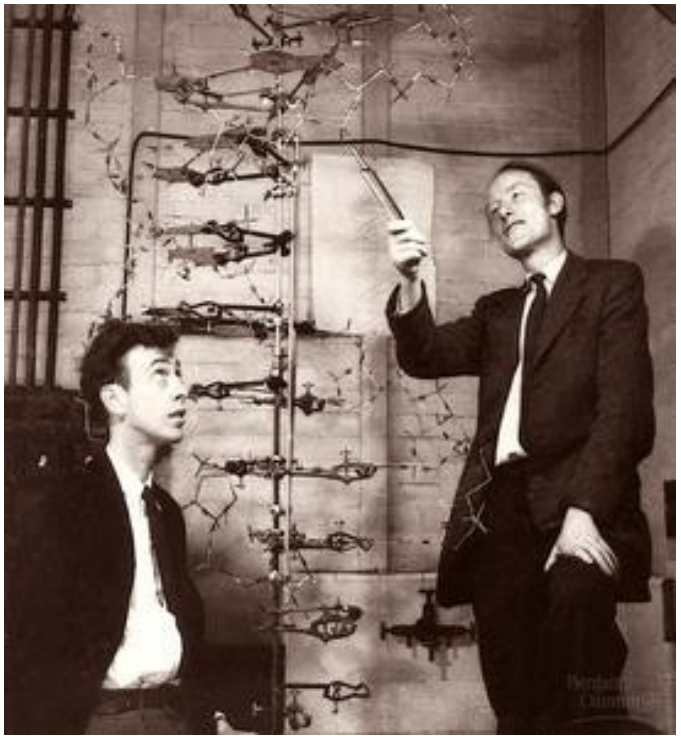




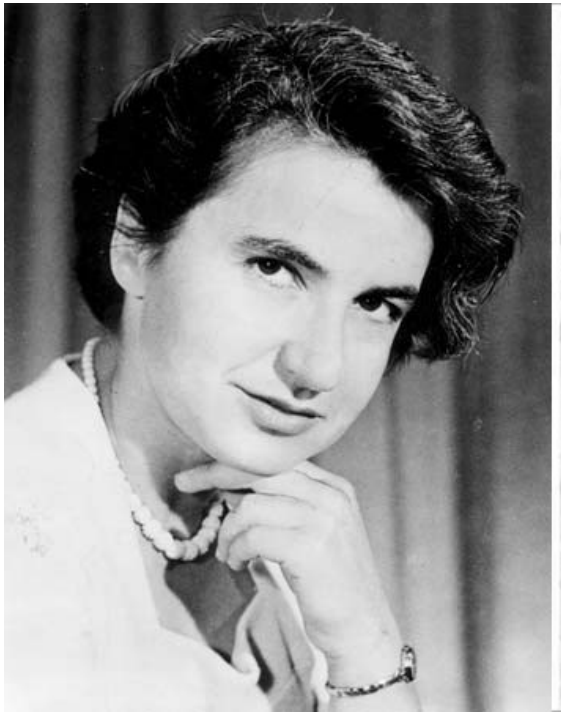
DNA as a model and by its atomic elements

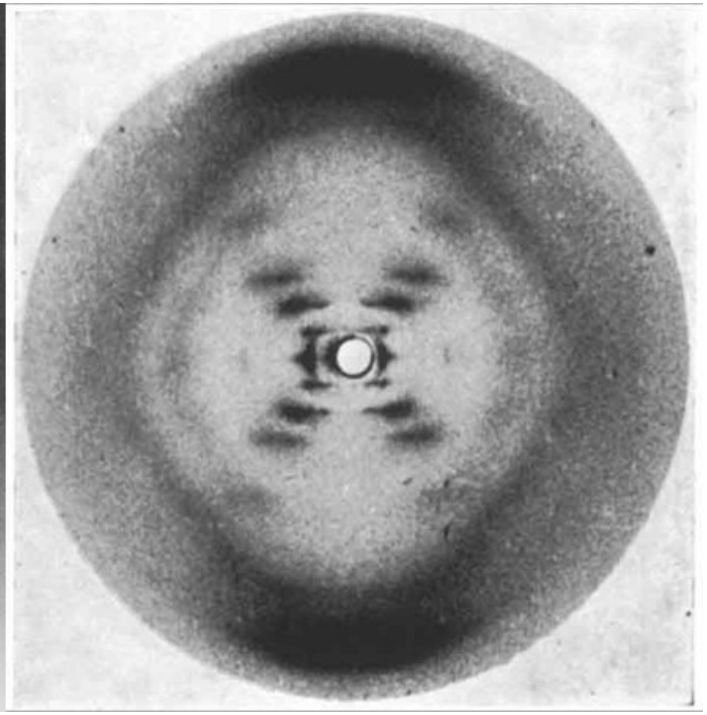


DNA Double Helix: Discovery of Structure

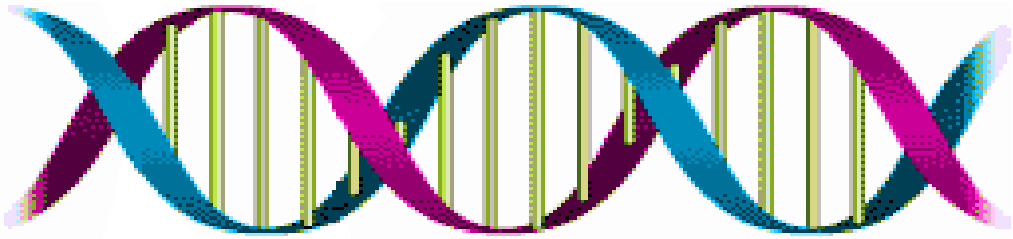


Watson and Crick, 1953



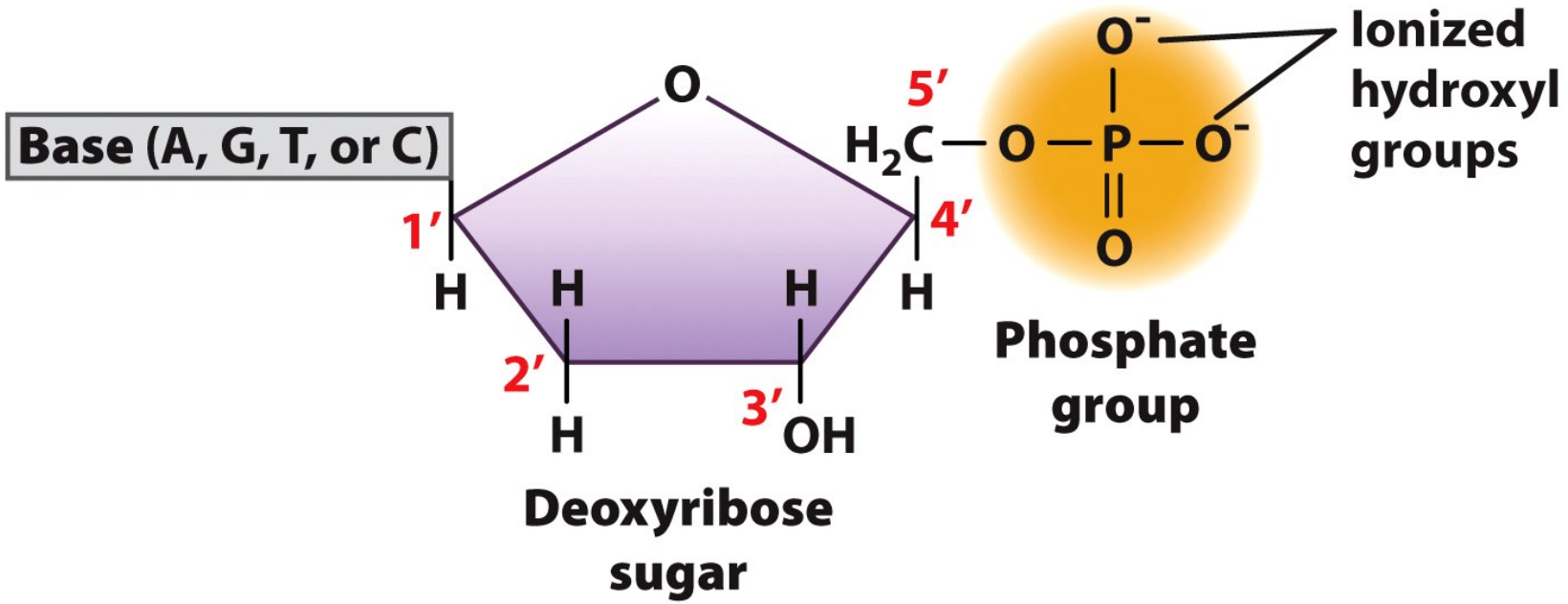


Rosalind Franklin and her data from x-ray crystallography



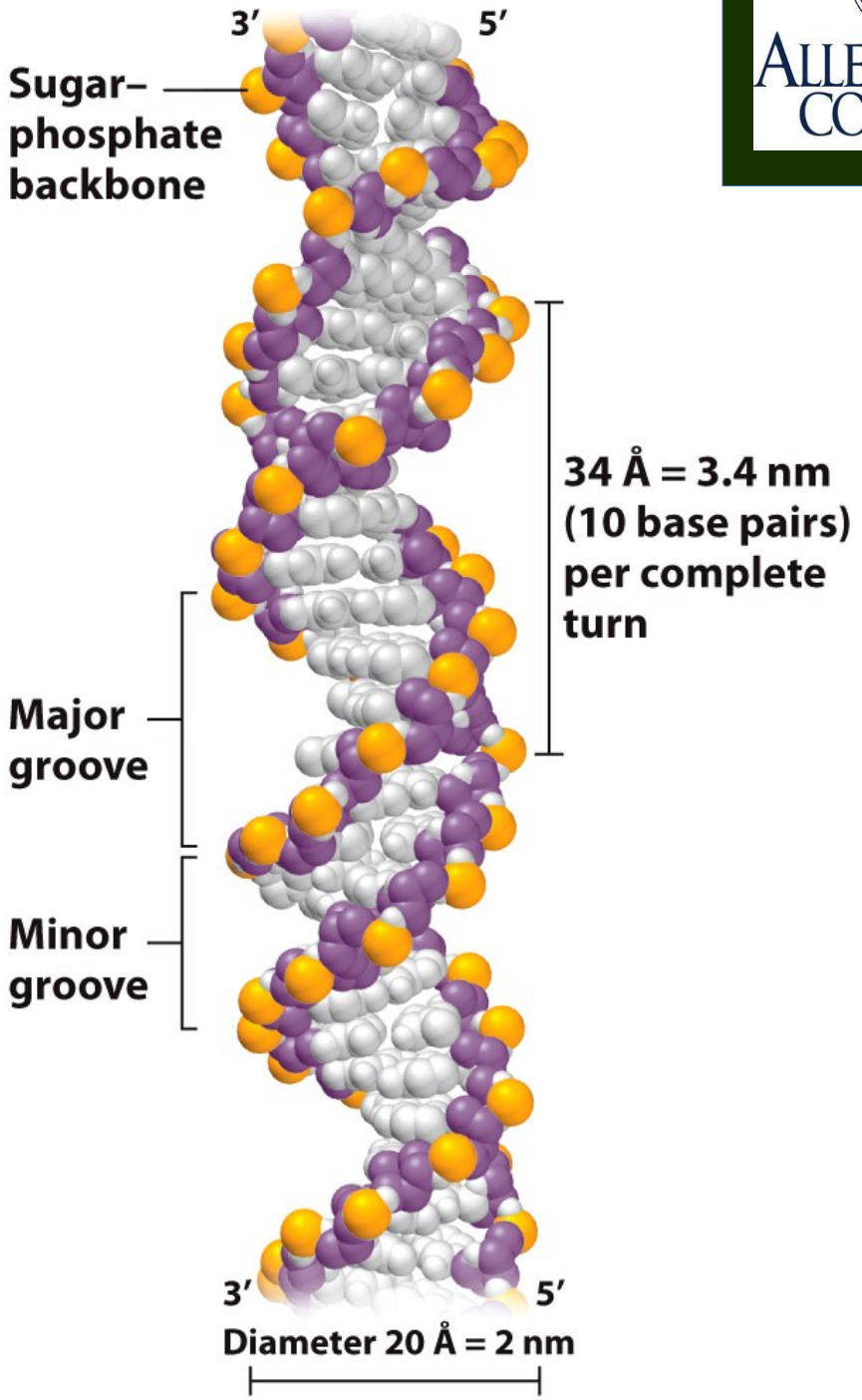
Nucleotide Structure

- *The support of rungs in the ladder.*
- One sugar
- One phosphate group
- One base (purine or pyrimidine)



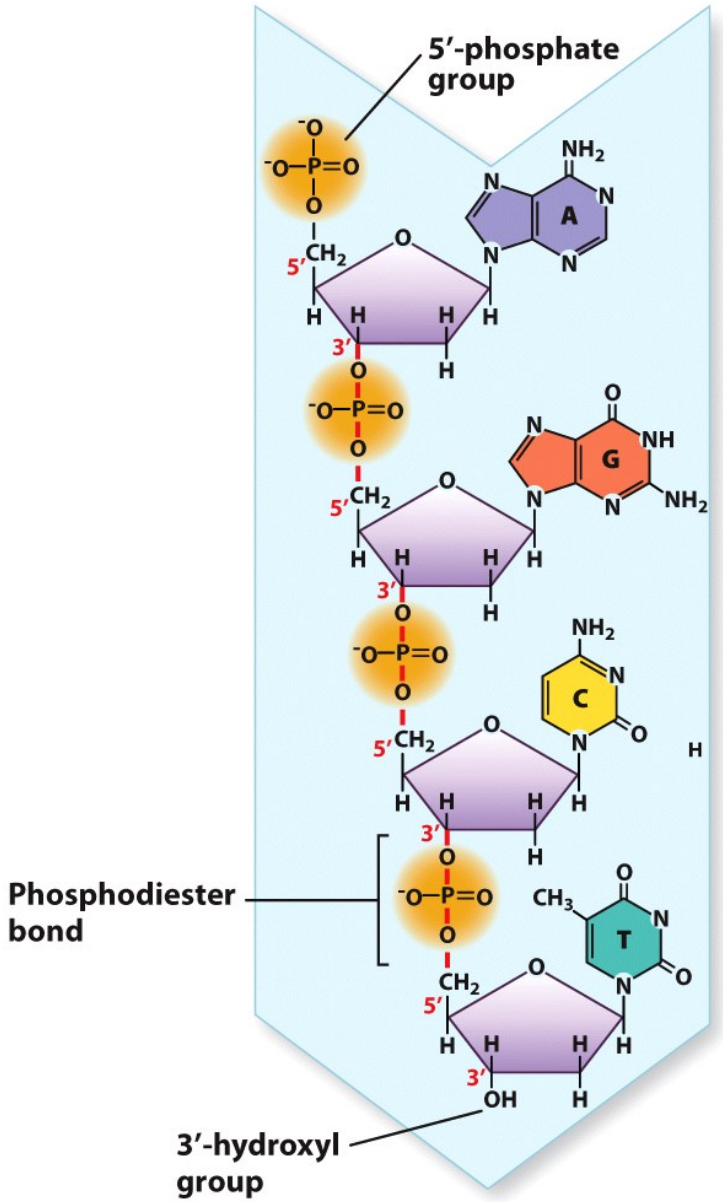
Structure of DNA

- Double-stranded
- Diameter – 2nm
- Helix
  - Complete turn = 10bp, 3.4nm
  - Major groove
  - Minor groove



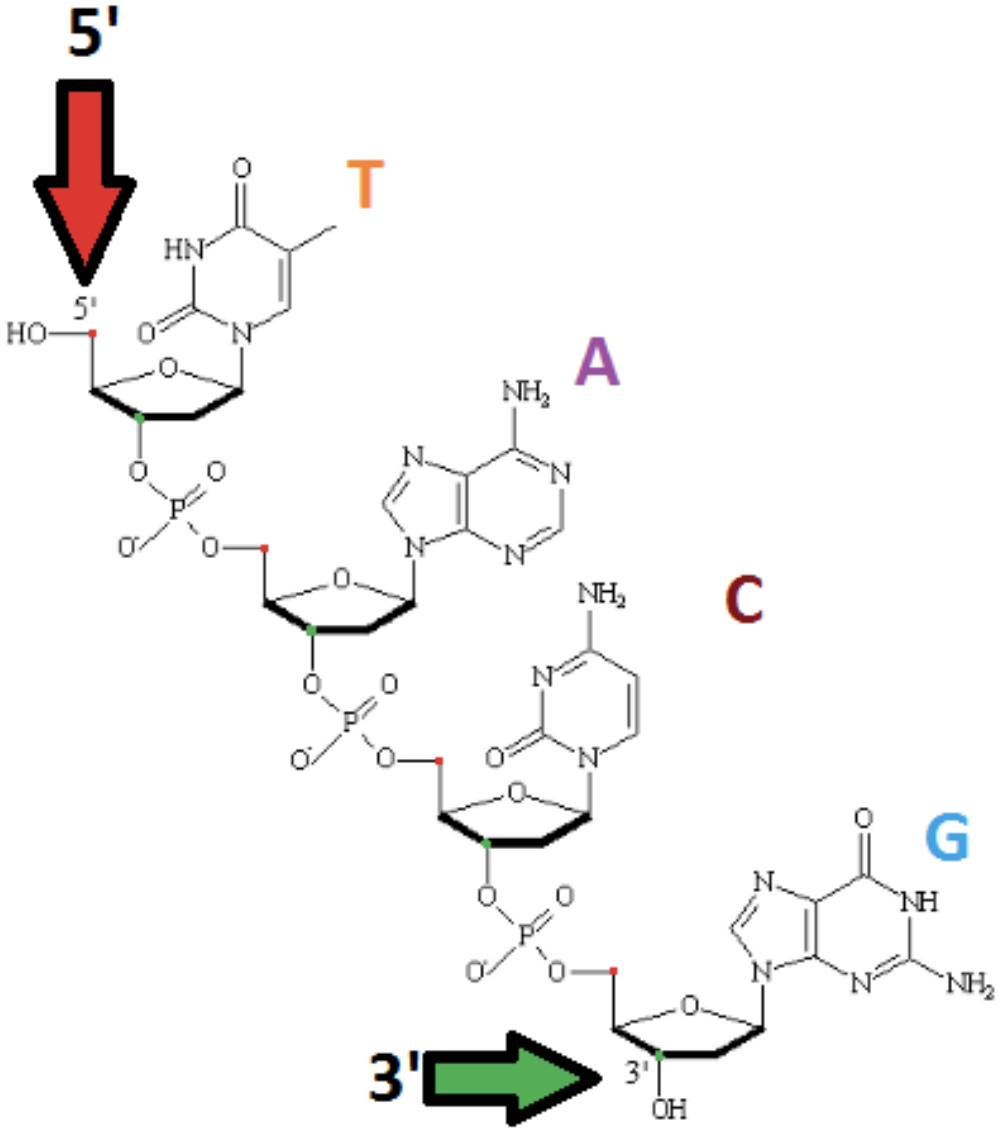
Structure of DNA

- Nucleotides are joined by phosphodiester bonds
  - phosphate to sugar
  - covalent bonds
- Polarity
  - 5’ end – phosphate group
  - 3’ end – hydroxyl group
- DNA created in 5’ -> 3’ direction



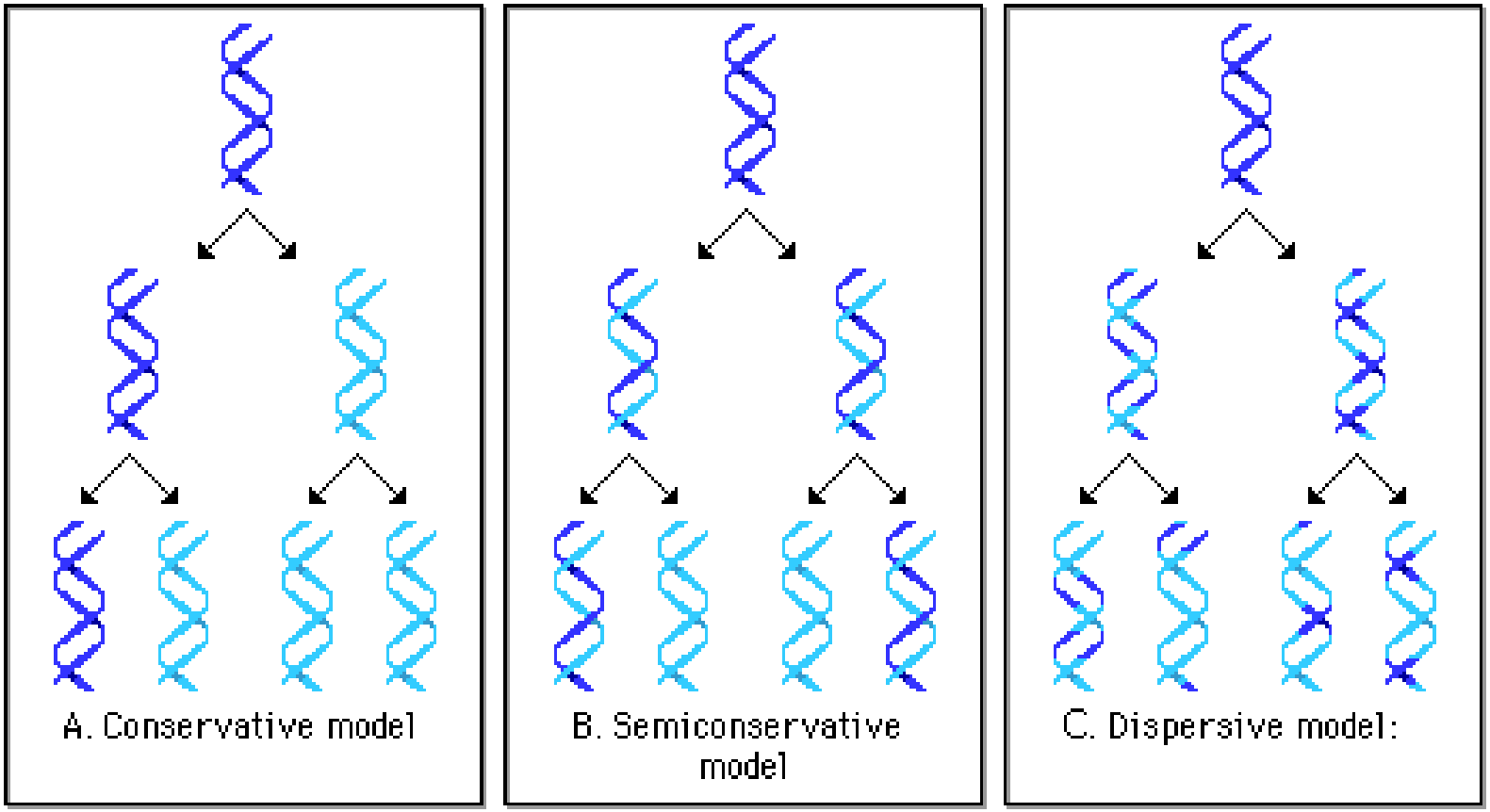
Five and Three Prime Ends

- A key feature of all nucleic acids is that they have two distinctive ends: **The 5' (5-prime) and 3' (3-prime) ends.**
- This terminology refers to the 5’ and 3’ carbons on the sugar.
- For both DNA and RNA, the 5' end bears a phosphate, and the 3' end a hydroxyl group.

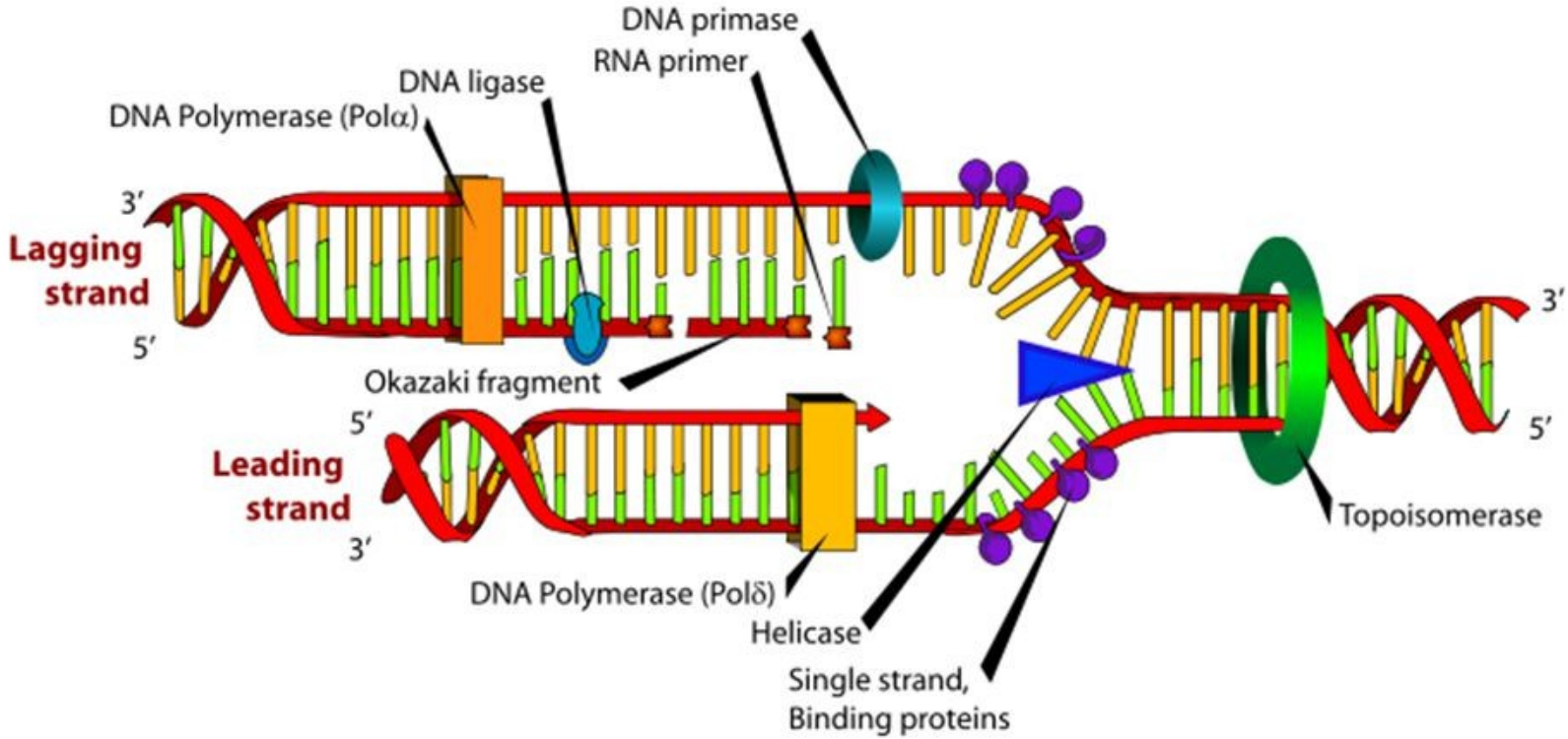


DNA Replication Process

1. The two sides of the parent molecule unwind/unzip
2. Daughter strands are synthesized using parent strands as templates
3. Parent/daughter duplex winds back together
   - **Semi-conservative: a 2nd gen helix composed of parental strand and one daughter.**

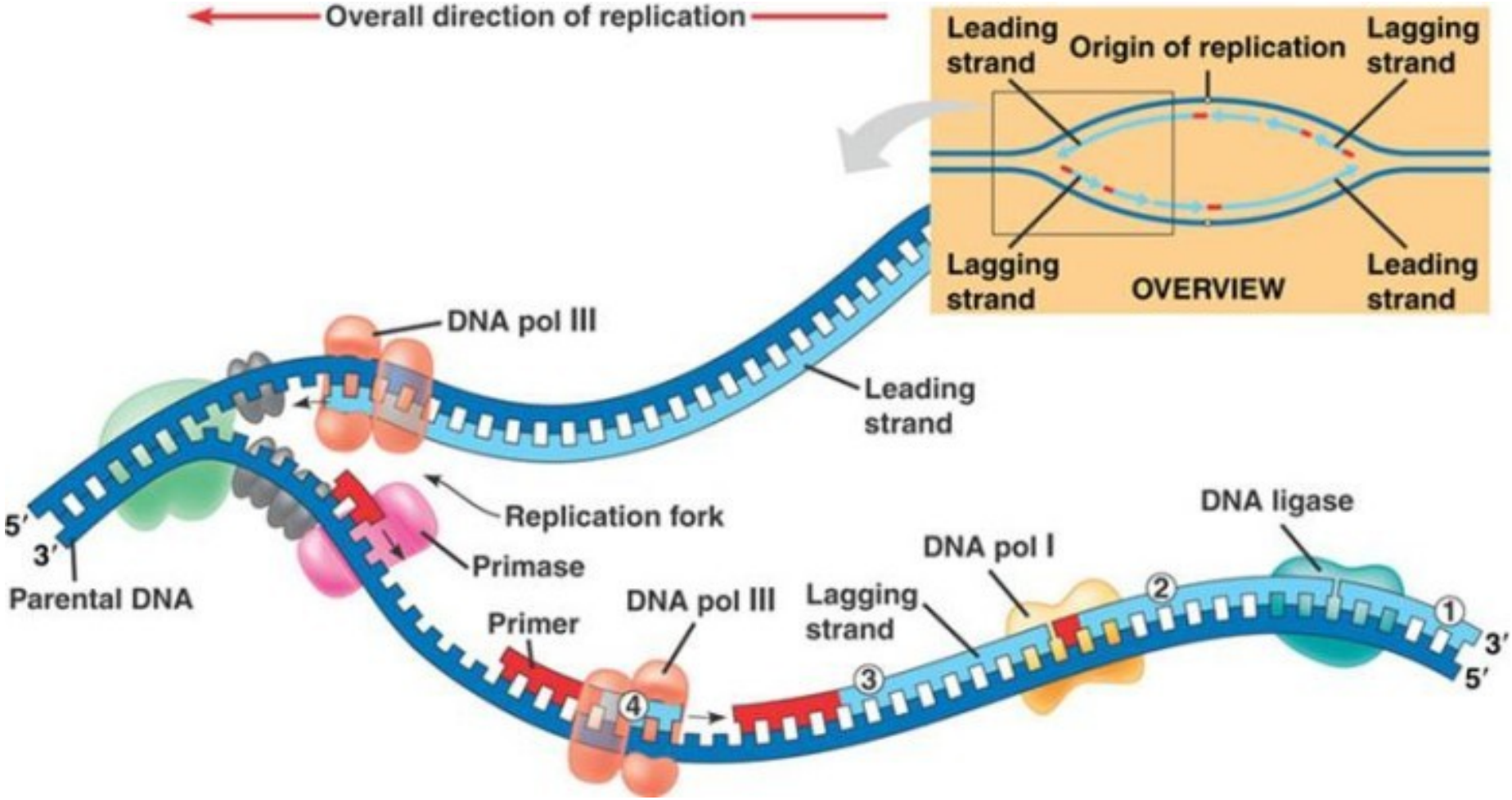


DNA Replication Process



http://www.hhmi.org/biointeractive/dna-replication-schematic

DNA Replication Enzymology



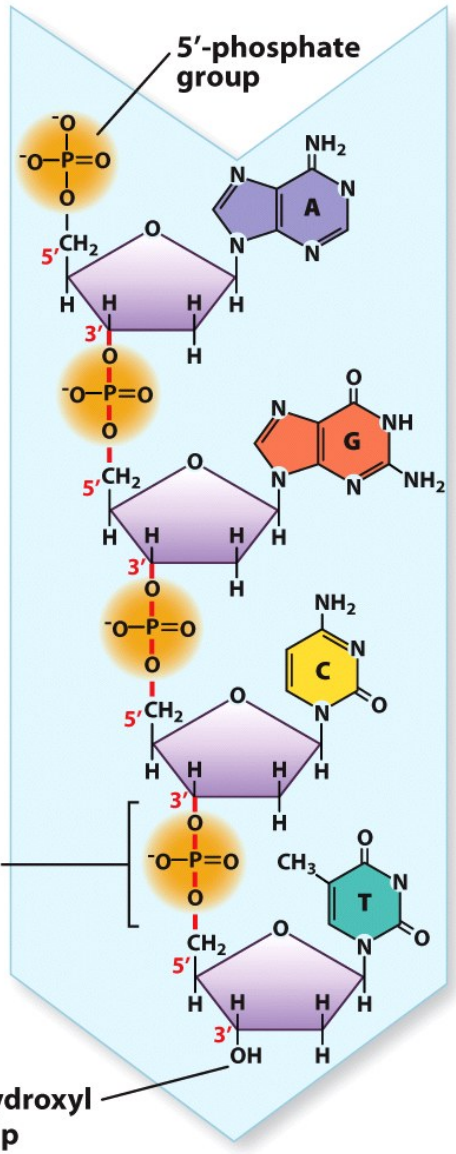
http://www.hhmi.org/biointeractive/dna-replication-basic-detail

http://highered.mheducation.com/sites/0073525324/student_view0/chapter20/dna_replication_fork.html

Review Question 1

In the DNA sequence 5'–TGAC–3', the phosphodiester linkage between the guanine and the adenine connects:

A. the 3' end of the guanine to the 5' end of the adenine.
B. the 2' end of the adenine to the 3' end of the guanine.
C. the 5' end of the guanine to the 1' end of the adenine.
D. the 3' end of the adenine to the 5' end of the guanine.
E. the 5' end of the guanine to the 2' end of the adenine.



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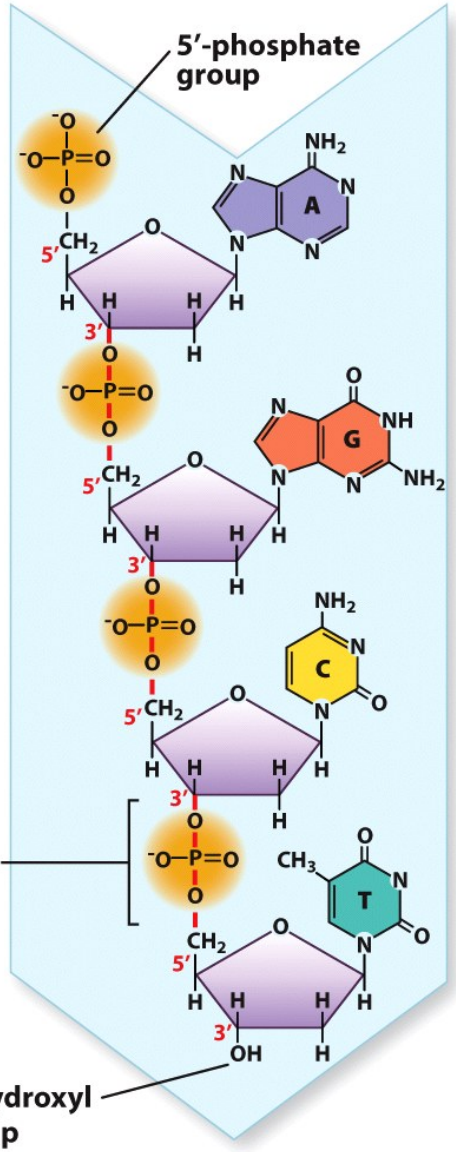


Review Question 2

In the DNA of certain bacterial cells, 16% of the nucleotides are adenine. What are the percentages of the other nucleotides in the bacterial DNA?

A. 34% thymidine, 34% guanine, 16% cytosine

B. 34% uracil, 16% guanine, 16% cytosine

C. 16% thymidine, 34% guanine, 34% cytosine

D. 34% thymidine, 16% guanine, 34% cytosine

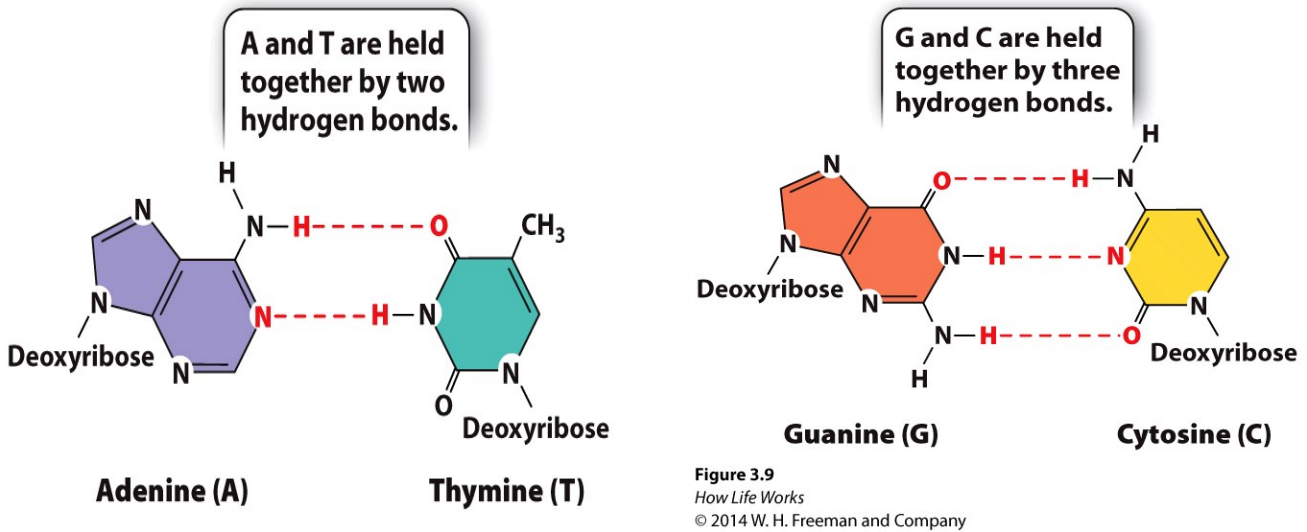
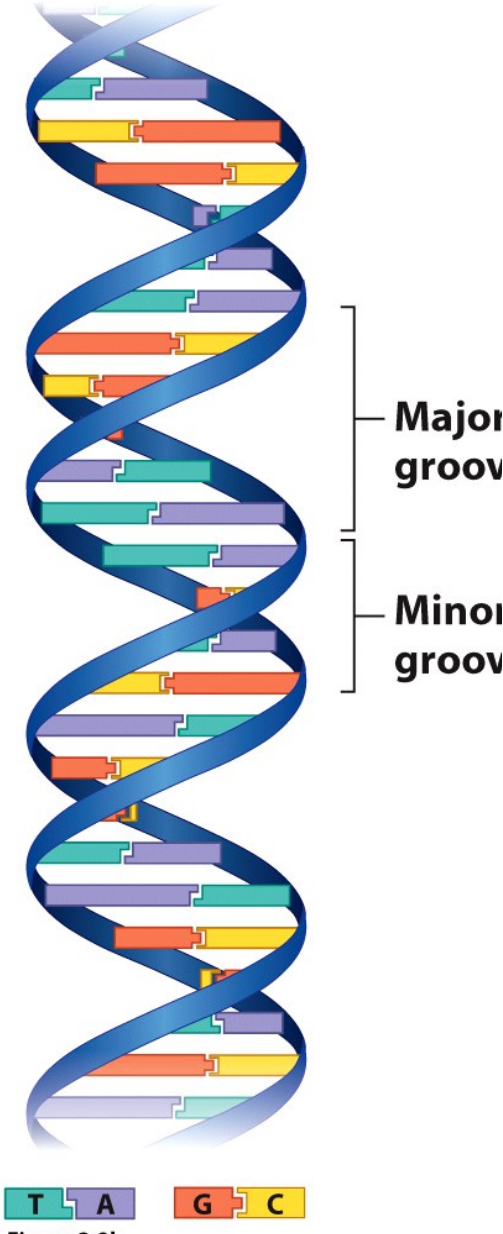


Figure 3.9
How Life Works



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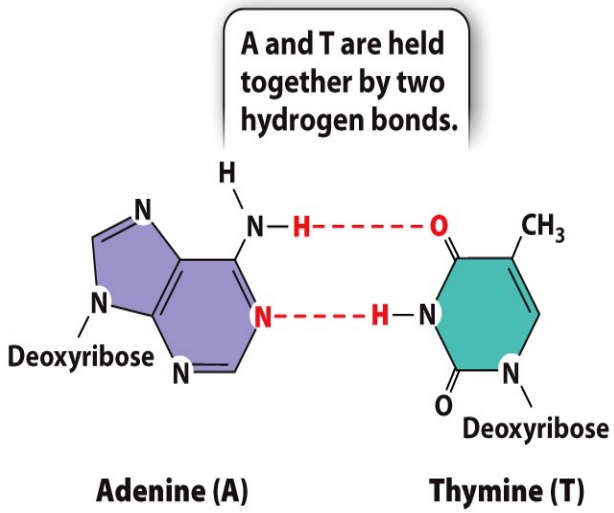

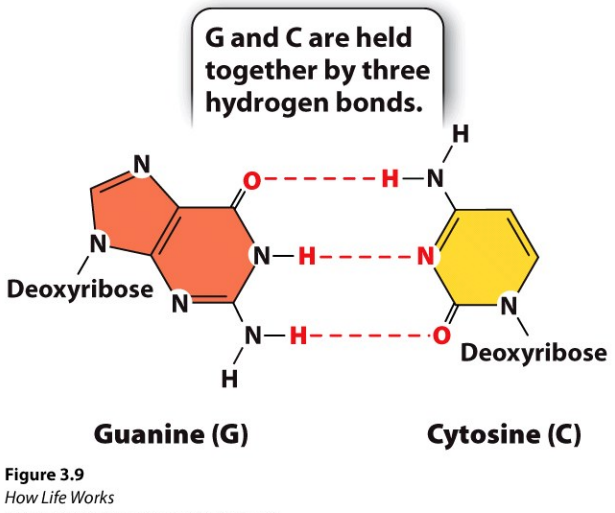

Figure 3.9
How Life Works
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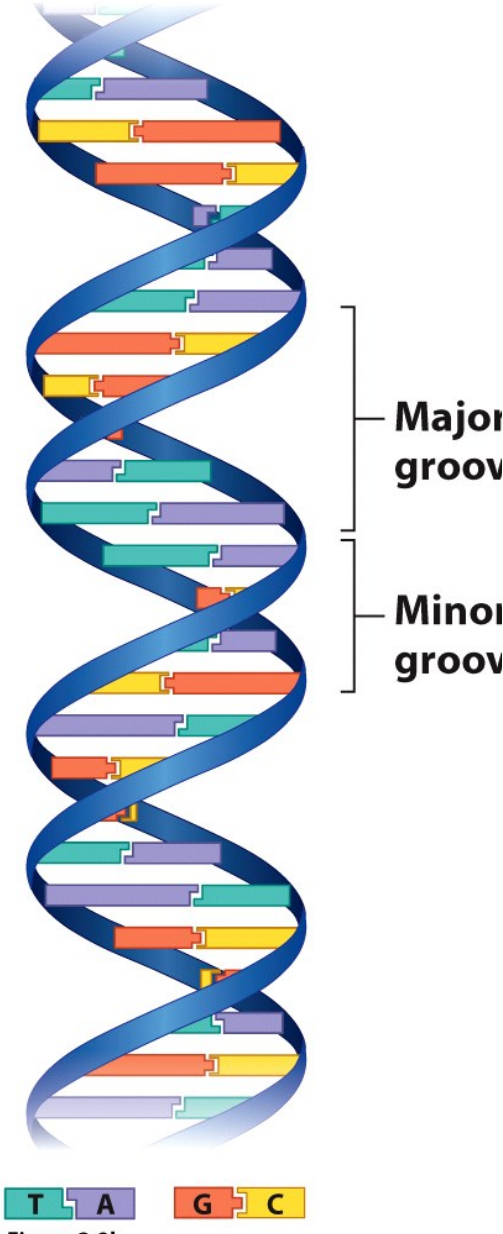


Review Question 3

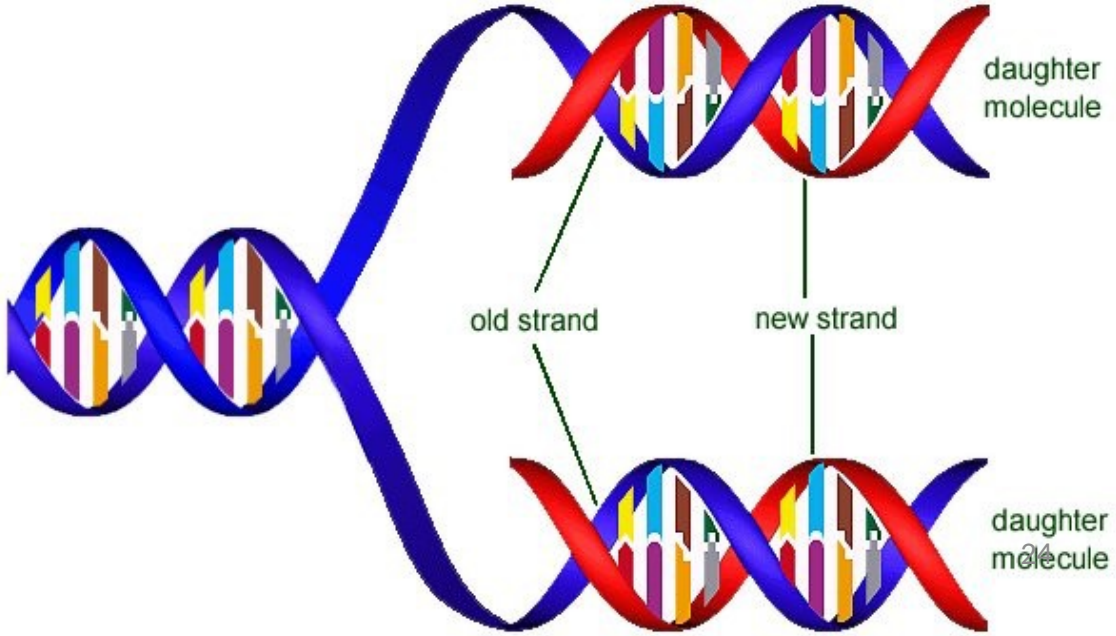
1. DNA replicates in a semi-conservative manner. This means

   a) one daughter strand is synthesized as a large fragment while the other is synthesized in smaller fragments, both in the 5'-3' direction
   b) every newly formed double-stranded DNA molecule consists of one parental strand and one daughter strand
   c) every newly formed double-stranded DNA molecule is comprised of two new daughter strands
   d) one daughter strand is synthesized as a large fragment in the 5'-3' direction while the other is synthesized in smaller fragments in the 3'-5' direction

Review Question 3

1. DNA replicates in a semi-conservative manner. This means

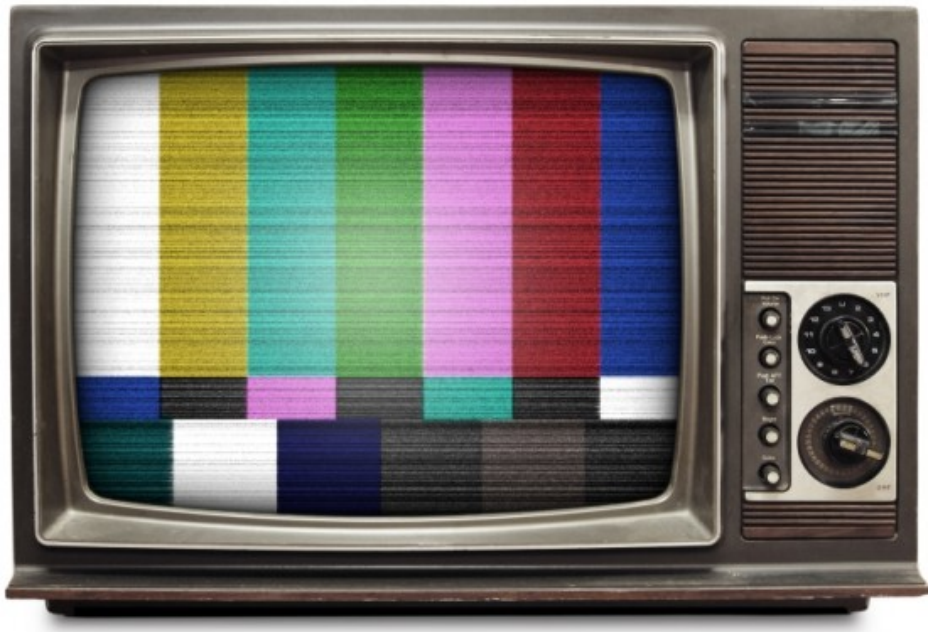
   b) every newly formed double-stranded DNA molecule consists of one parental strand and one daughter



Supporting Videos

- The DNA Double Helix (17 mins)
- http://media.hhmi.org/biointeractive/films/Double_Helix.html

- The Chemical Structure of DNA (3 mins)
- http://www.hhmi.org/biointeractive/chemical-structure-dna



Python Programming

ALLEGHENY COLLEGE

- How to start up Python interactive mode?
- How to add numbers?
- How to create variables?
- How to make print statements
- Strings:
  - How to work with strings
  - How to count characters
  - How to find characters.

Follow along in class and save your notes in a text file!!

python