Prof. Sabrina Pricl

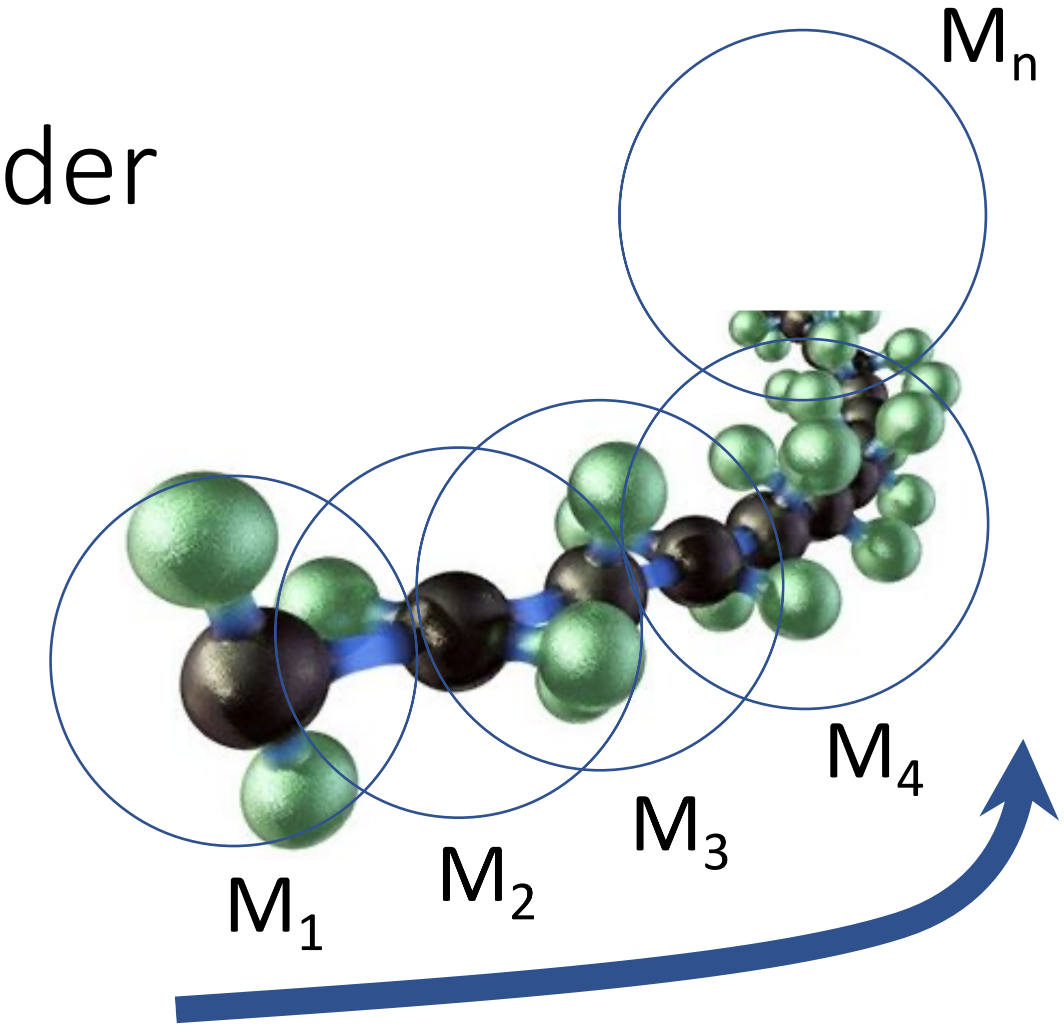
A.Y. 2021-2022

Lesson 3

Nucleic acid polarity and structure

Macromolecules’ Law & Order

- Macromolecules carry information as:
    - They have two ends (starting and terminal end)
    - They have a direction (from start to end)

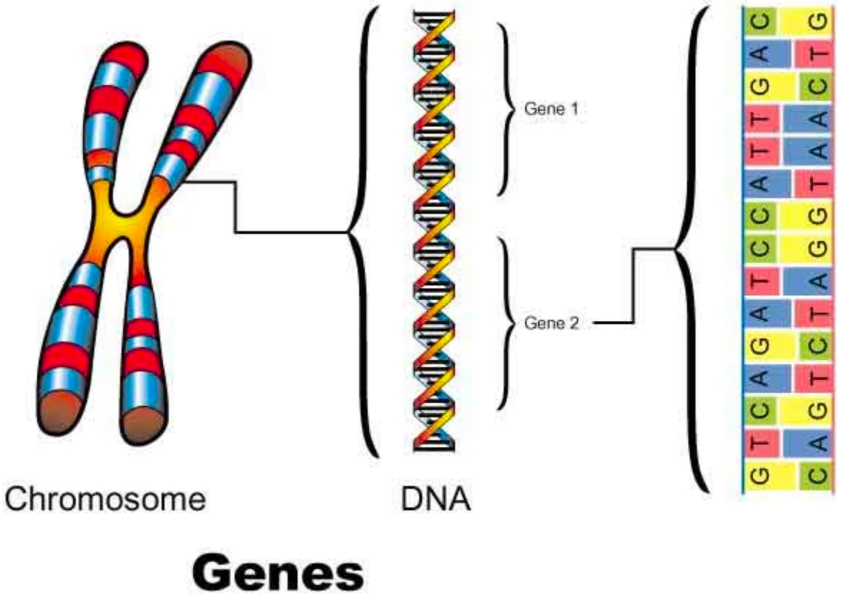


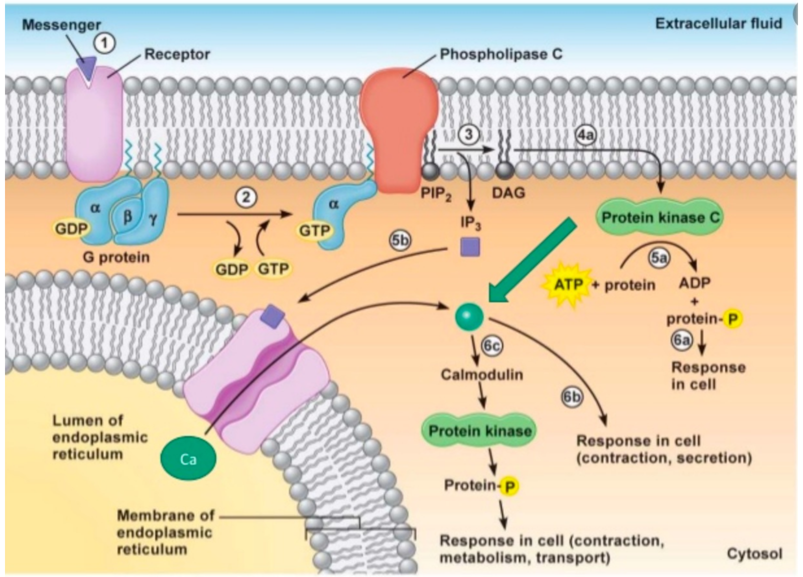
Macromolecules’ Law & Order

- Macromolecules carry information as:
  - They have two ends (starting and terminal end)
  - They have a direction (from start to end)
- Macromolecules possess ORDER and POLARITY
  - These two features constitute the FUNDAMEMTAL INFORMATION cellules can read and understand

Macromolecules’ Law & Order

- Macromolecules carry information as:
  - They have two ends (starting and terminal end)
  - They have a direction (from start to end)
- Macromolecules possess ORDER and POLARITY
  - These two features constitute the FUNDAMEMTAL INFORMATION cellules can read and understand
- NUCLEIC ACIDS = carries of hereditary information
- PROTEINS = all other info/instructions



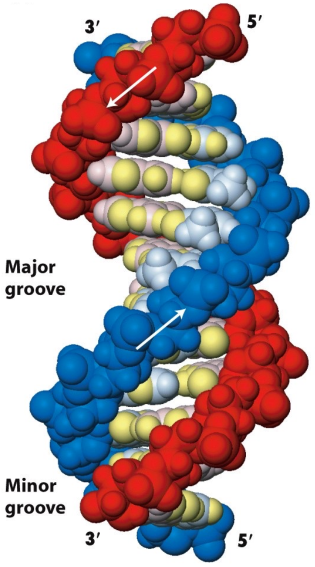


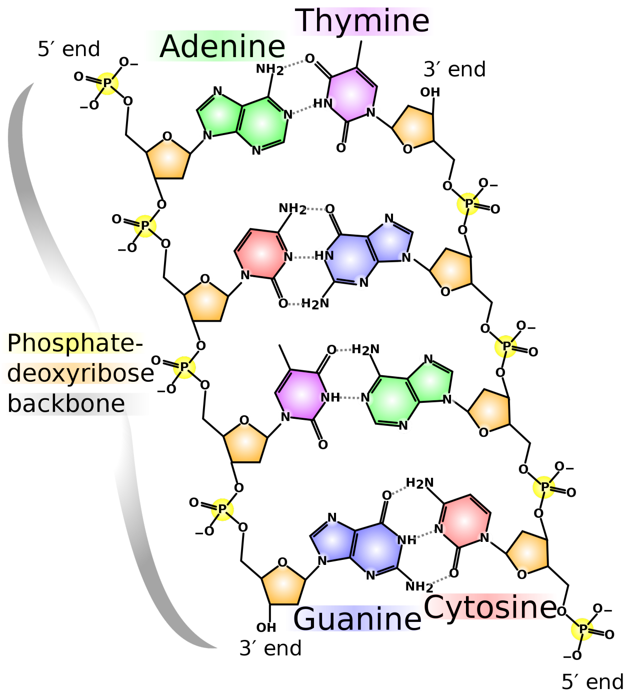
Nucleic acid polarity

- Have two hands: 5’ e 3’

5’P-S-P-S-P-S3’

B1 B2 B3



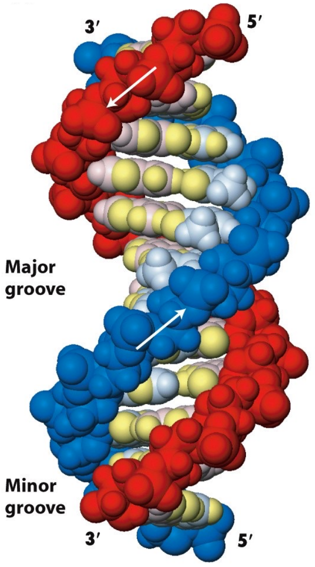


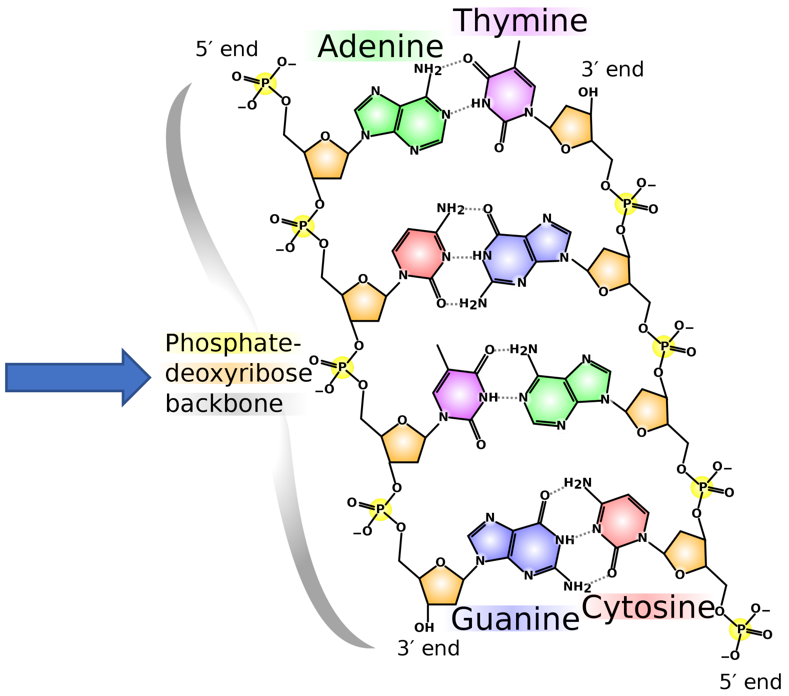
Nucleic acid polarity

- Have two hands: 5’ e 3’

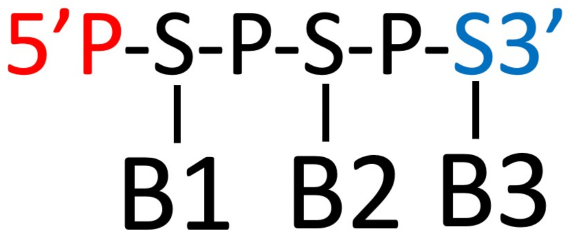
5’P-S-P-S-P-S3’
B1 B2 B3

- P-S = sugar-phosphate backbone joined by phosphodiester bonds





Nucleic acid polarity

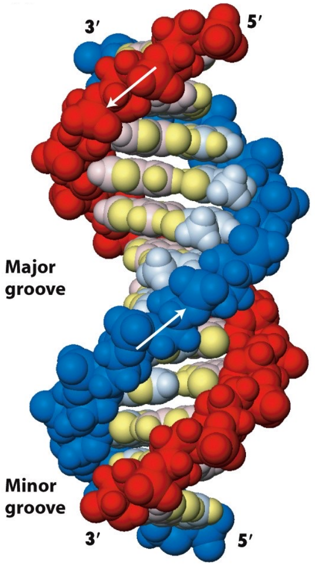

5'P-S-P-S-P-S3'

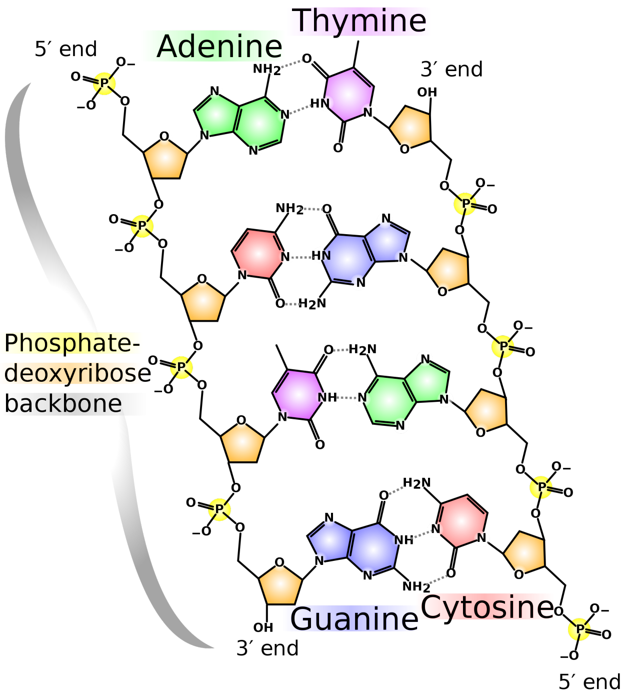
B1 B2 B3

- Have two hands: 5' e 3'

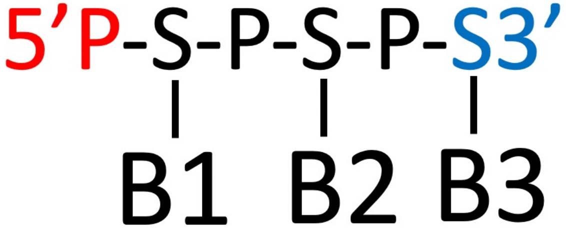
- P-S = sugar-phosphate backbone joined by phosphodiester bonds

- 5' and 3' ends are **CHEMICALLY DIFFERENT ENDS** and cells can distinguish them from one another

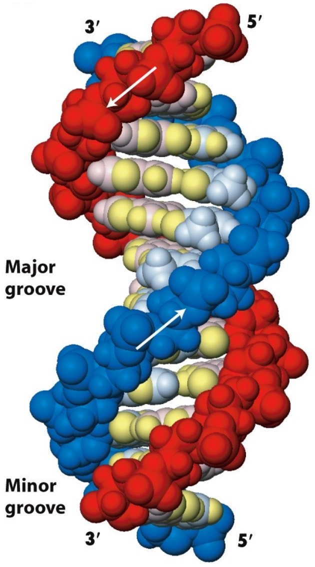


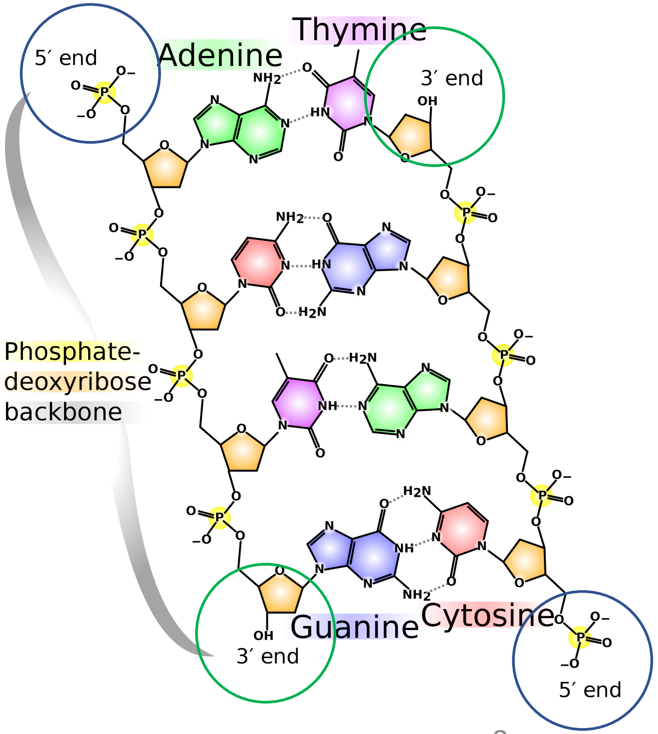


Nucleic acid polarity



- Have two hands: 5’ e 3’
- P-S = sugar-phosphate backbone joined by phosphodiester bonds
- 5’ and 3’ ends are **CHEMICALLY DIFFERENT ENDS** and cells can distinguish them from one another
- Polarity:
  - 5’end = P-5’C on sugar
  - 3’end = 3’OH on sugar



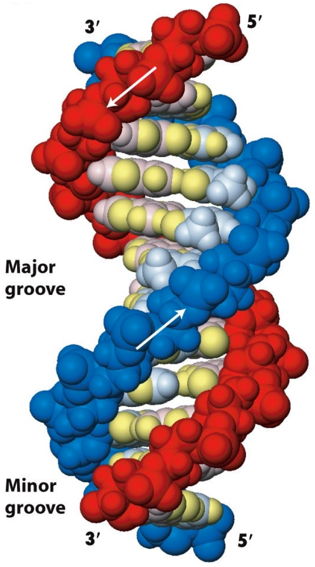


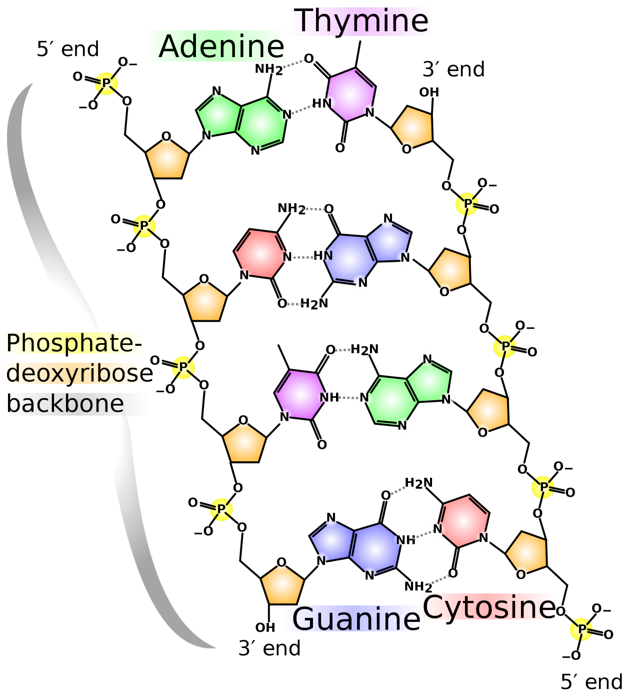
Nucleic acid polarity

- Have two hands: 5’ e 3’

5’P-S-P-S-P-S3’
B1 B2 B3

- P-S = sugar-phosphate backbone joined by phosphodiester bonds
- 5’ and 3’ ends are **CHEMICALLY DIFFERENT ENDS** and cells can distinguish them from one another
- Polarity:
  - 5’end = P-5’C on sugar
  - 3’end = 3’OH on sugar
- Base order along the polymer



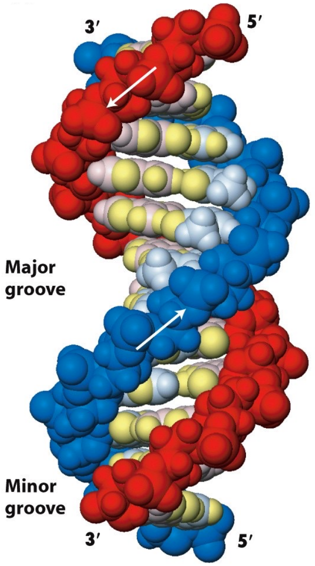


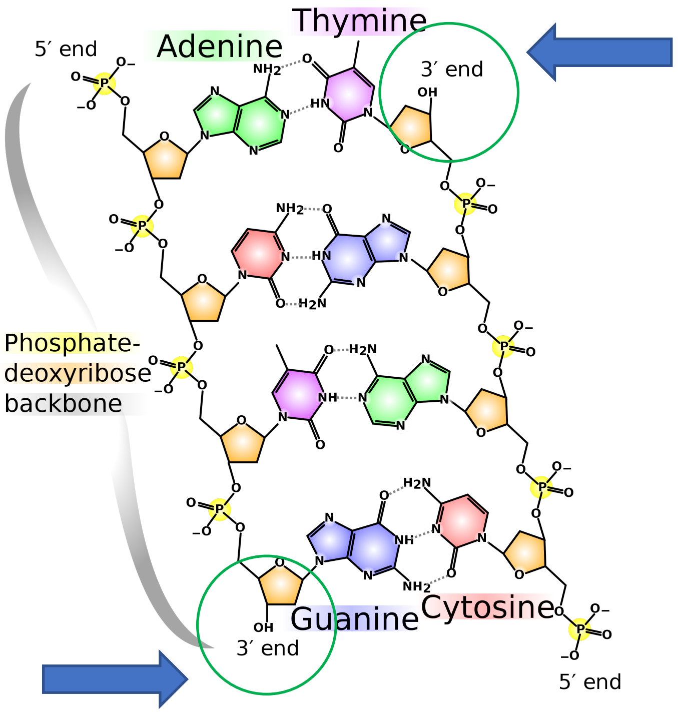
Nucleic acid polarity

- Have two hands: 5’ e 3’

5’P-S-P-S-P-S3’
| | |
B1 B2 B3

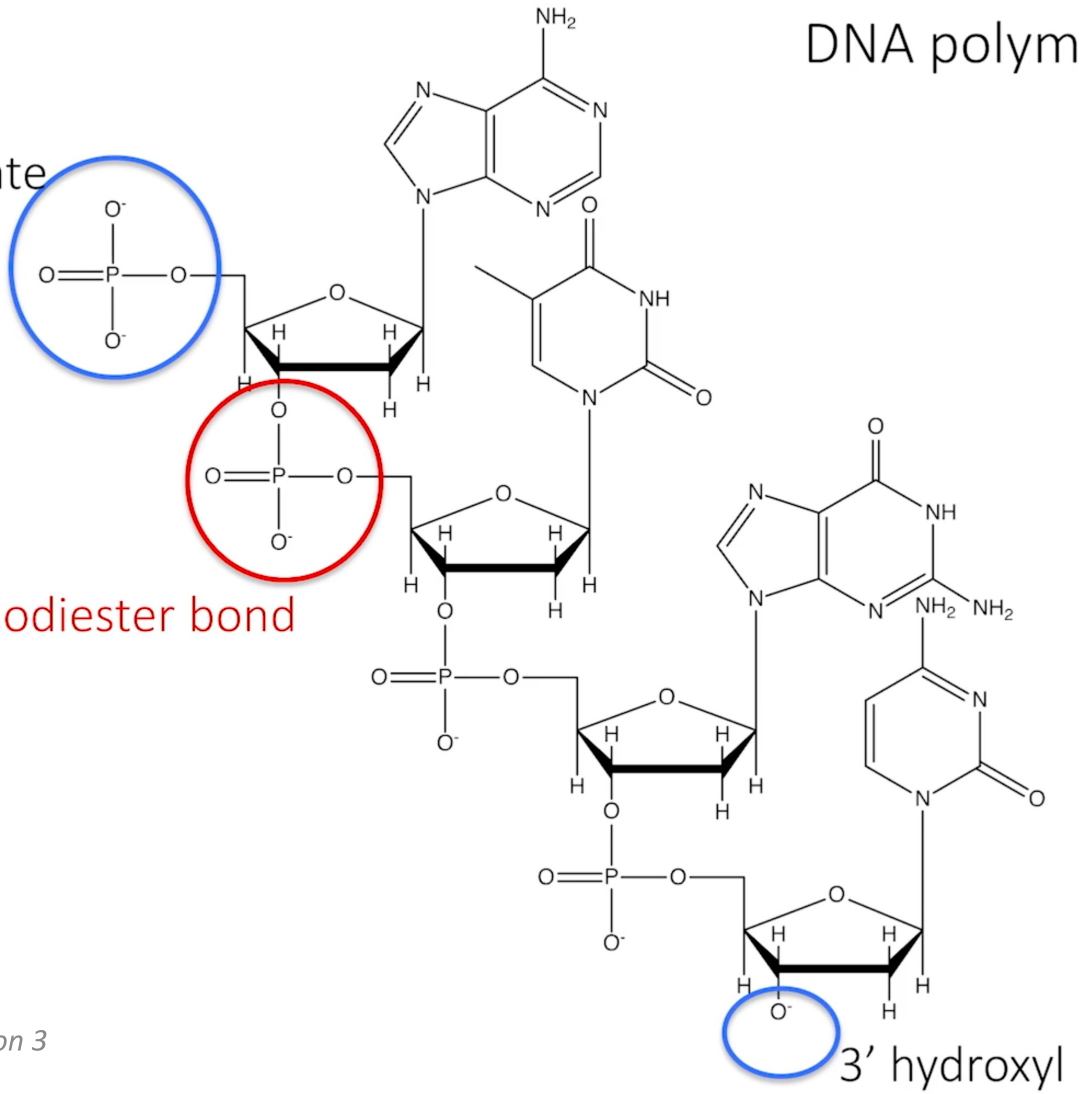
- P-S = sugar-phosphate backbone joined by phosphodiester bonds
- 5’ and 3’ ends are **CHEMICALLY DIFFERENT ENDS** and cells can distinguish them from one another
- Polarity:
  - 5’end = P-5’C on sugar
  - 3’end = 3’OH on sugar
- Base order along the polymer
- 3’ is the last base added (any new incoming base will be added to 3’OH)





Nucleic acids

DNA polymer



5’ phosphate

phosphodiester bond

3’ hydroxyl

Nucleic acids polarity

- S-P backbone is not written, just the bases + polarity

Nucleic acids polarity

- S-P backbone is not written, just the bases + polarity
- **ALWAYS write 5’ and 3’ on each nucleic acid strand**

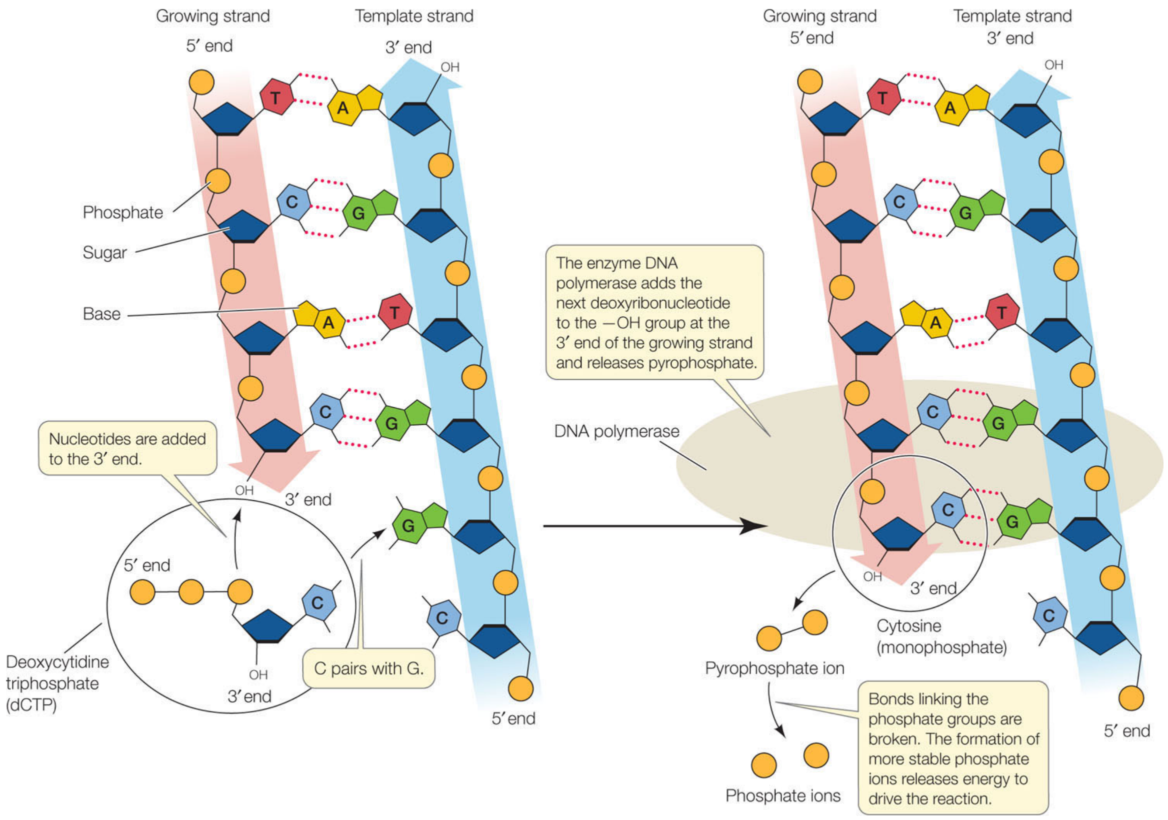
$5'B_1B_2B_3B_4B_5B_6 3' = 5'GAATCC3'$

Nucleic acids polarity

- S-P backbone is not written, just the bases + polarity
- **ALWAYS write 5’ and 3’ on each nucleic acid strand**

  $5'B_1B_2B_3B_4B_5B_6 3'$ = 5’GAATCC3’

- Base order = INFORMATION
- Polarity = 5’ and 3’ ends: shows
  - First to last nucleotide added
  - Direction to read information



Nucleotides are added to the 3′ end.

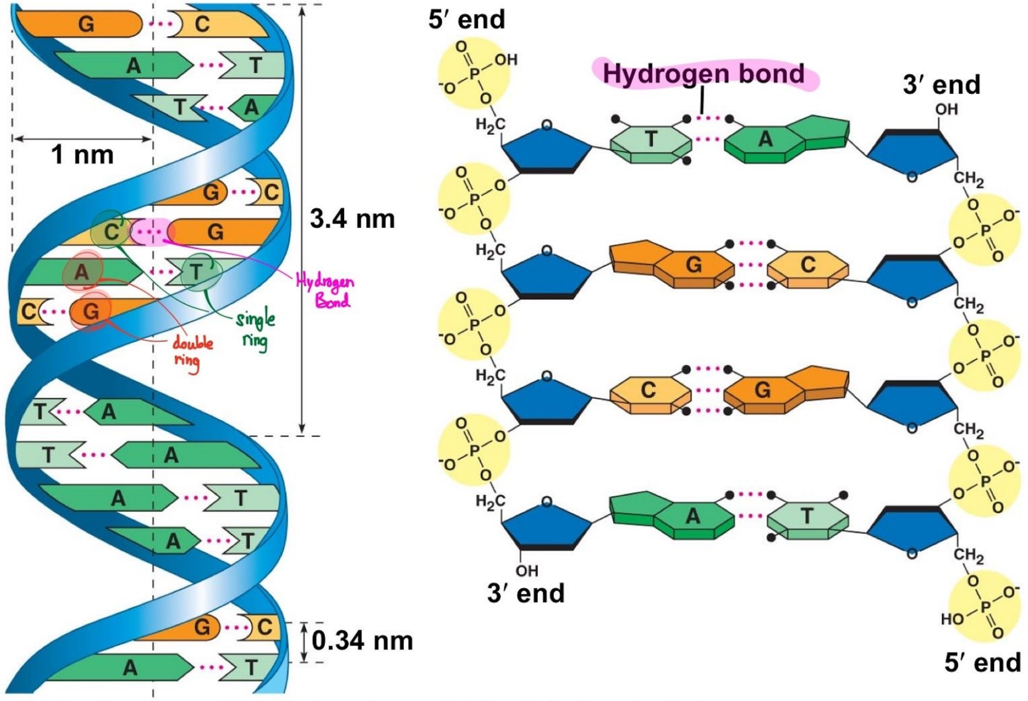
C pairs with G.

The enzyme DNA polymerase adds the next deoxyribonucleotide to the —OH group at the 3′ end of the growing strand and releases pyrophosphate.

Bonds linking the phosphate groups are broken. The formation of more stable phosphate ions releases energy to drive the reaction.

Get to know your DNA structure

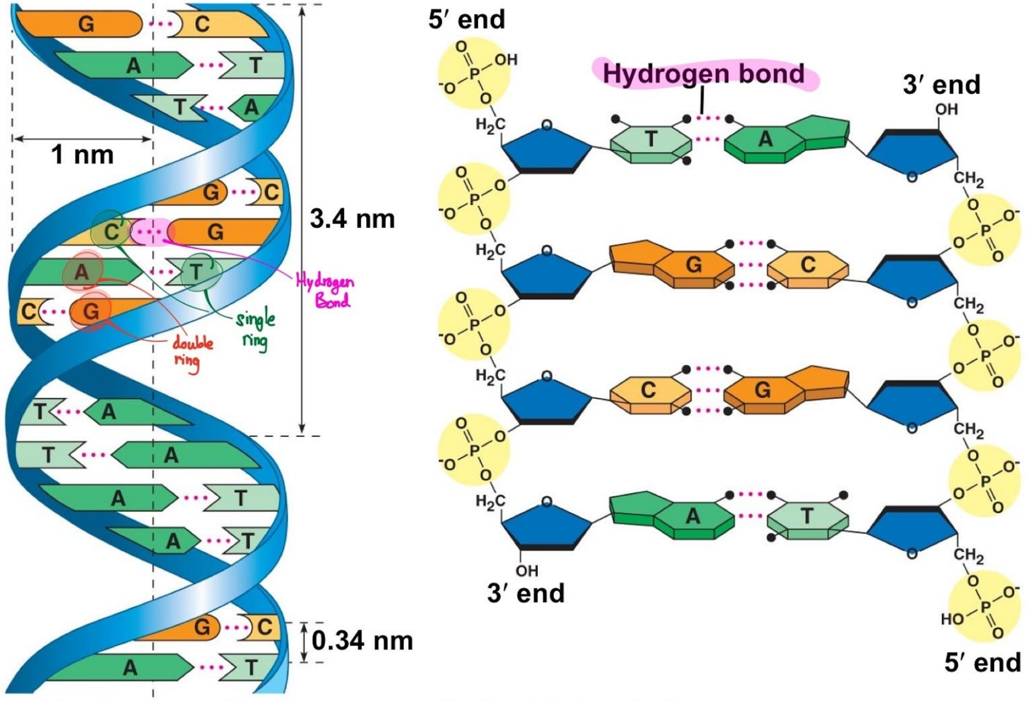
- DNA has a right-handed double-helix (DH) structure (2 nm diameter)
  - Ss and Ps lie on the outside of the helix (backbone)
  - Bs are stacked in the interior, in pairs
    - B pairs (BPs) are bound to each other by H-bonds
    - Every BP in the DH is separated from the next base pair by 0.34 nm (axial rise)
    - There are 10.4 BPs per helical trun
  - The distance to complete one helical turn (helical pitch) = 3.4 nm



(a) Key features of DNA structure (b) Partial chemical structure

DNA structure

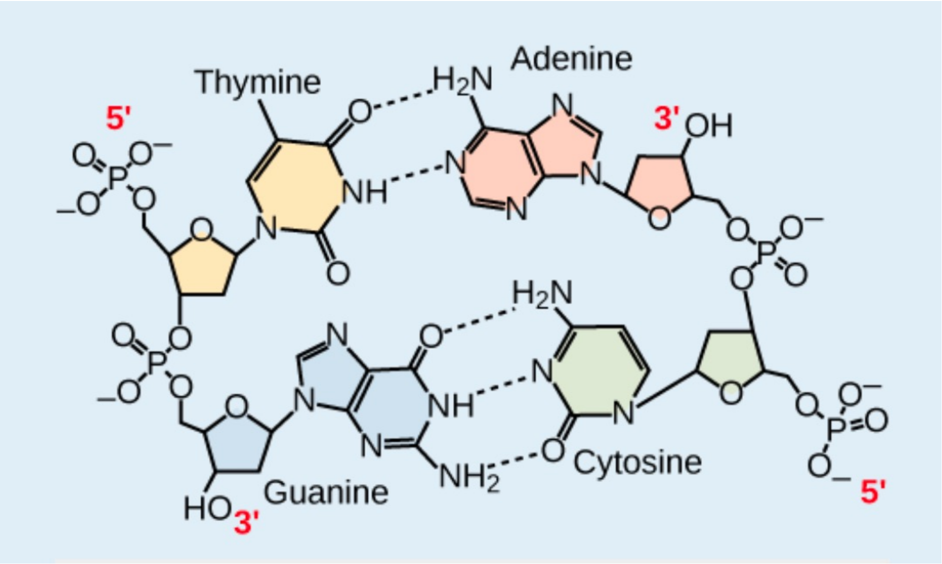
- DNA has a right-handed double-helix (DH) structure (2 nm diameter)
    - Ss and Ps lie on the outside of the helix (backbone)
    - Bs are stacked in the interior, in pairs
        - B pairs (BPs) are bound to each other by H-bonds
        - Every BP in the DH is separated from the next base pair by 0.34 nm (axial rise)
        - There are 10.4 BPs per helical trun
    - The distance to complete one helical turn (helical pitch) = 3.4 nm
- The two strands of the helix run in opposite directions
    - the 5′ carbon end of one strand will face the 3′ carbon end of its matching strand
- This is referred to as **antiparallel orientation**
    - Key DNA PROPERTY (for DNA replication and in many nucleic acid interactions)



(a) Key features of DNA structure (b) Partial chemical structure

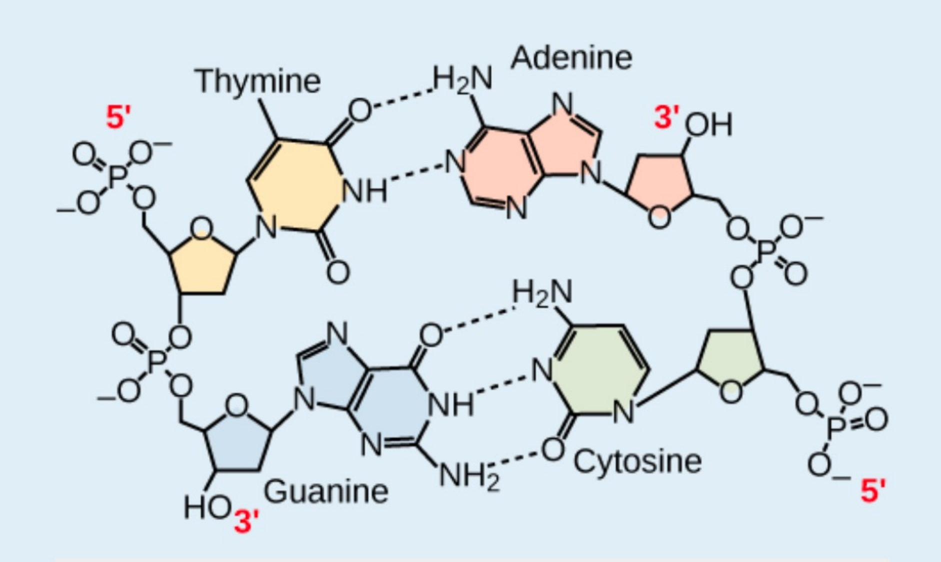
DNA structure

- Only certain types of base pairing are allowed:
- Specifically: A can only pair with T and G can only pair with C (**base complementary rule**)



DNA structure

- Only certain types of base pairing are allowed:
- Specifically: A can only pair with T and G can only pair with C (**base complementary rule**)
- In other words, the DNA strands are complementary to each other
  - If the sequence of one DNA strand is **5’AATTGGCC3’**, the complementary strand would have the sequence **3’TTAACCGG5’**

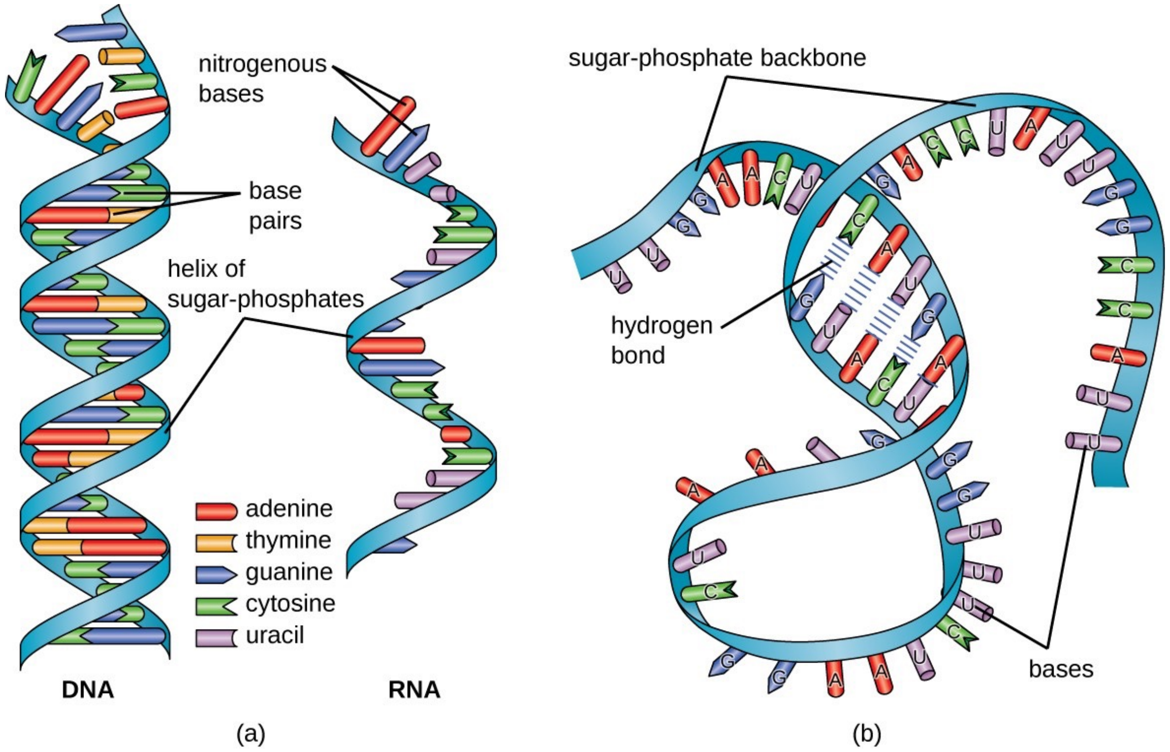


RNA structure

- RNA (ribonucleic acid) → mainly involved in the process of protein synthesis under the direction of DNA

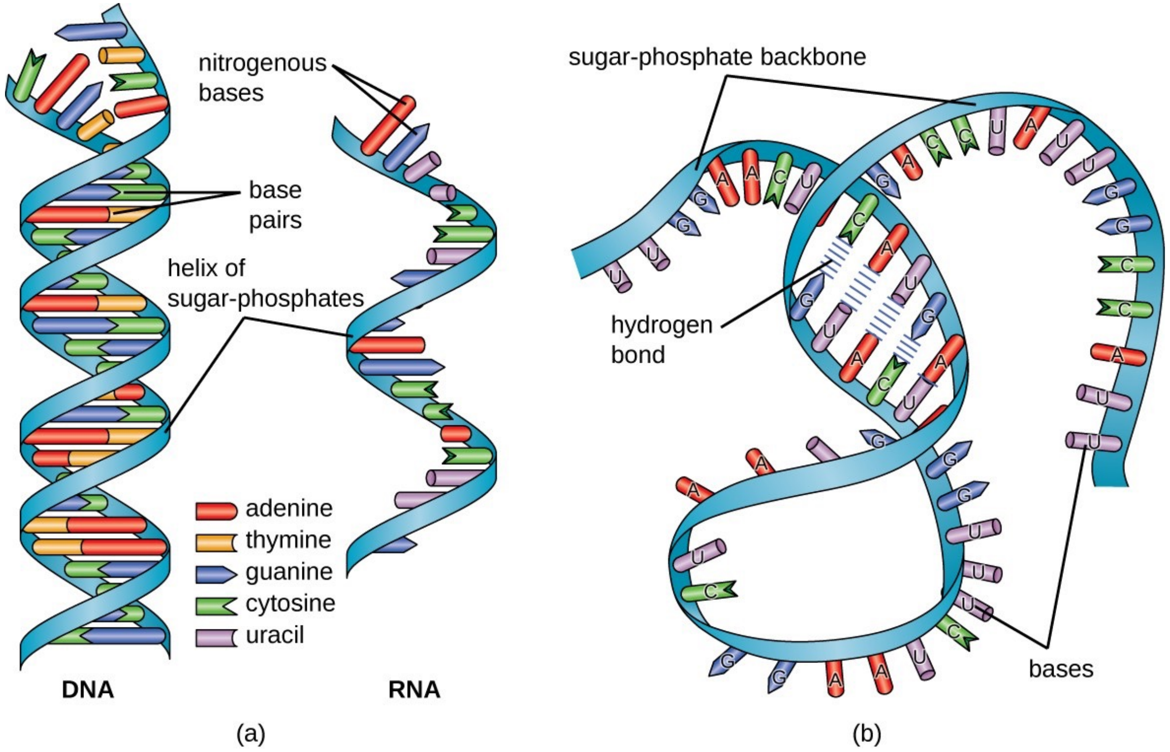
RNA structure

- RNA (ribonucleic acid) → mainly involved in the process of protein synthesis under the direction of DNA
- RNA is **usually single-stranded**
- The RNA four nitrogenous bases are A, **U**, G, and C



RNA structure

- RNA (ribonucleic acid) → mainly involved in the process of protein synthesis under the direction of DNA
- RNA is **usually single-stranded**
- The RNA four nitrogenous bases are A, **U**, G, and C
- There are four major types of RNA
  - messenger RNA (mRNA), ribosomal RNA (rRNA), transfer RNA (tRNA), and microRNA (miRNA) (more later)



RNA structure

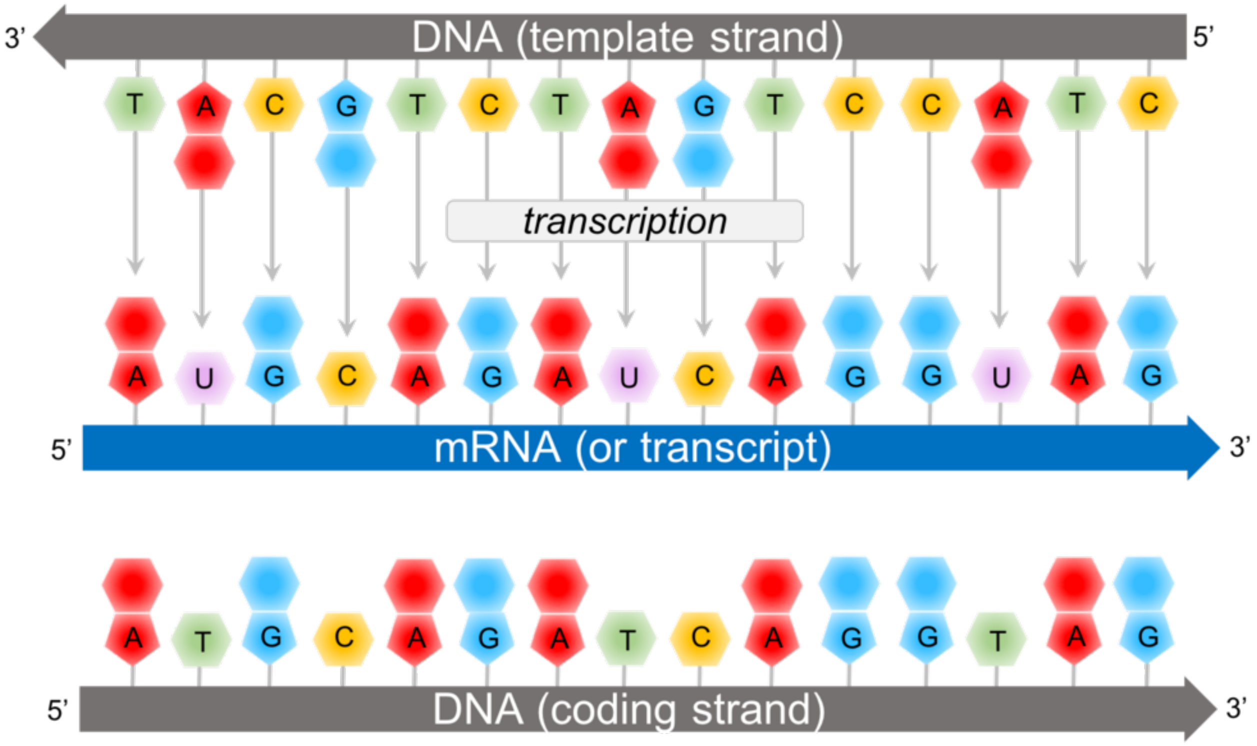
- The mRNA carries the message from DNA
  - If a cell requires a certain protein to be synthesized, the gene for this product is “turned on” and the messenger RNA is synthesized in the cellular nucleus (more later in the course)

RNA structure

- The mRNA carries the message from DNA
  - If a cell requires a certain protein to be synthesized, the gene for this product is “turned on” and the messenger RNA is synthesized in the cellular nucleus (more later in the course)
- **The RNA base sequence is complementary to the coding sequence of the DNA which it has been copied from but**

RNA structure

- The mRNA carries the message from DNA
  - If a cell requires a certain protein to be synthesized, the gene for this product is "turned on" and the messenger RNA is synthesized in the cellular nucleus (more later in the course)
- **The RNA base sequence is complementary to the coding sequence of the DNA which it has been copied from but**
- If the DNA strand to be copied (template strand) has a sequence **3'TACGTCTA…3'**, the sequence of the complementary mRNA strand (transcript) is **5'AUGCAGAU…3'**



Note: template strand reading is 3' → 5'
mRNA synthesis is 5' → 3'
(more later)

Nucleic acid polarity and structure

- Take assignment 3: Nucleic acid polarity and structure