

# Gene Expression

## The Flow of Genetic Information

DNA → RNA → Protein

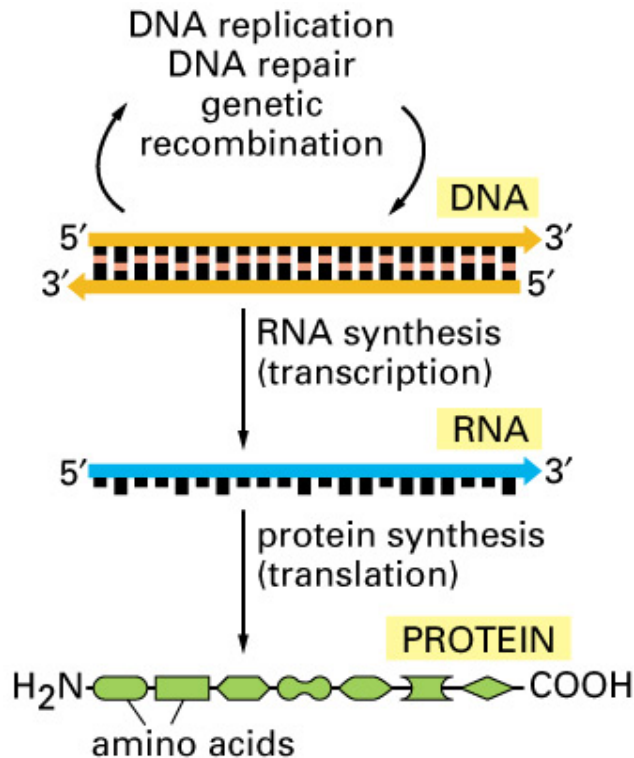


Figure 6-2. Molecular Biology of the Cell, 4th Edition.

# RNA differs from DNA

1. RNA nucleotides contain ribose, while DNA nucleotides contain deoxyribose, which lacks a 2' hydroxyl on the sugar.
2. RNA uses uracil instead of thymine, U specifically pairs with A.
3. RNA is single stranded, while DNA is double stranded.

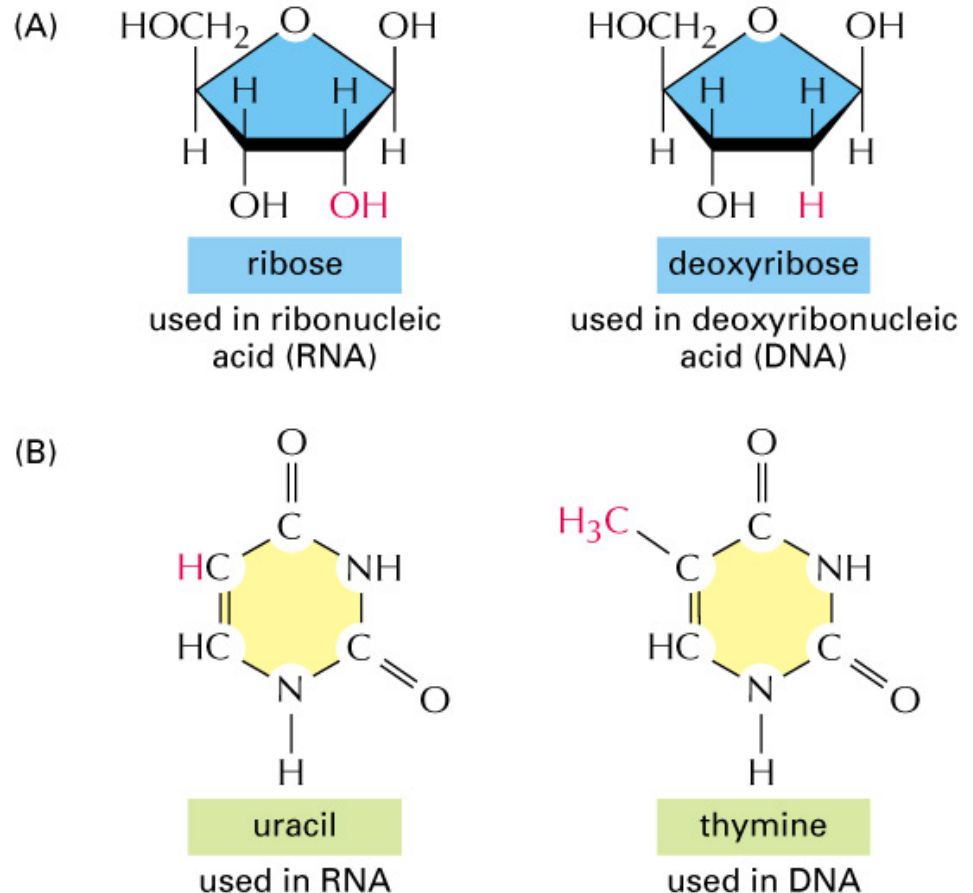


Figure 6-4 part 1 of 2. Molecular Biology of the Cell, 4th Edition.

# Types of RNA

1. **mRNA** (messenger RNA) encodes a polypeptide.
2. **tRNA** (transfer RNA) is an adaptor that helps the ribosome decode mRNA.
3. **rRNA** (ribosomal RNA) plays structural and catalytic roles in the ribosome.
4. **Small RNAs** play multiple roles in mRNA processing and gene regulation.

# RNA can fold into specific shapes (RNA 2<sup>o</sup> structure) by basepairing with itself

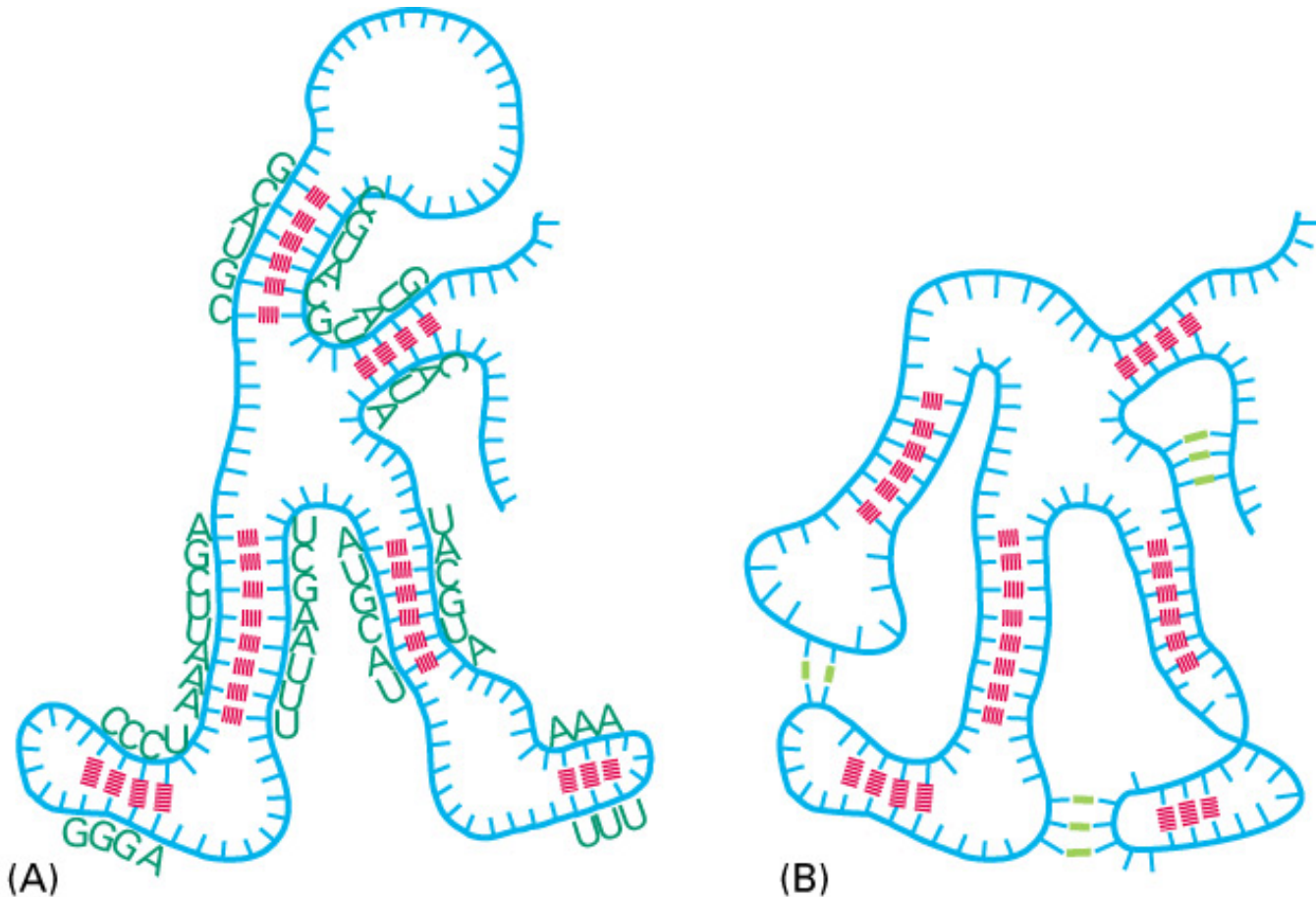


Figure 6-6 part 1 of 2. Molecular Biology of the Cell, 4th Edition.

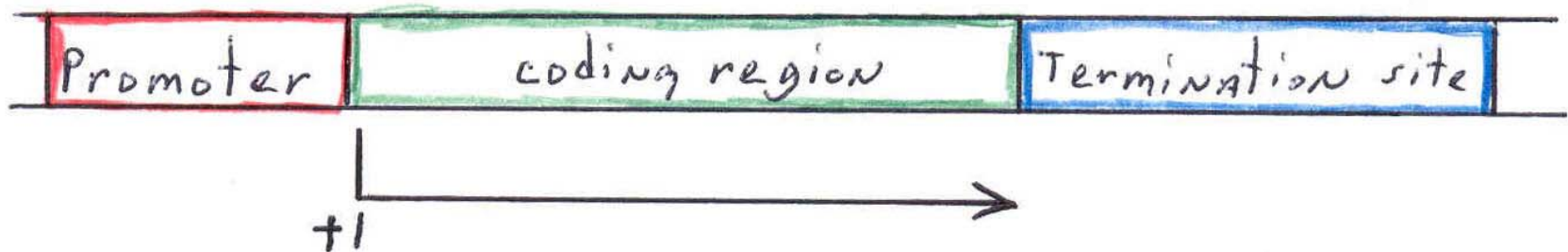
What is a Gene?

# What is a Gene?

- A gene is a length of DNA that encodes a specific polypeptide

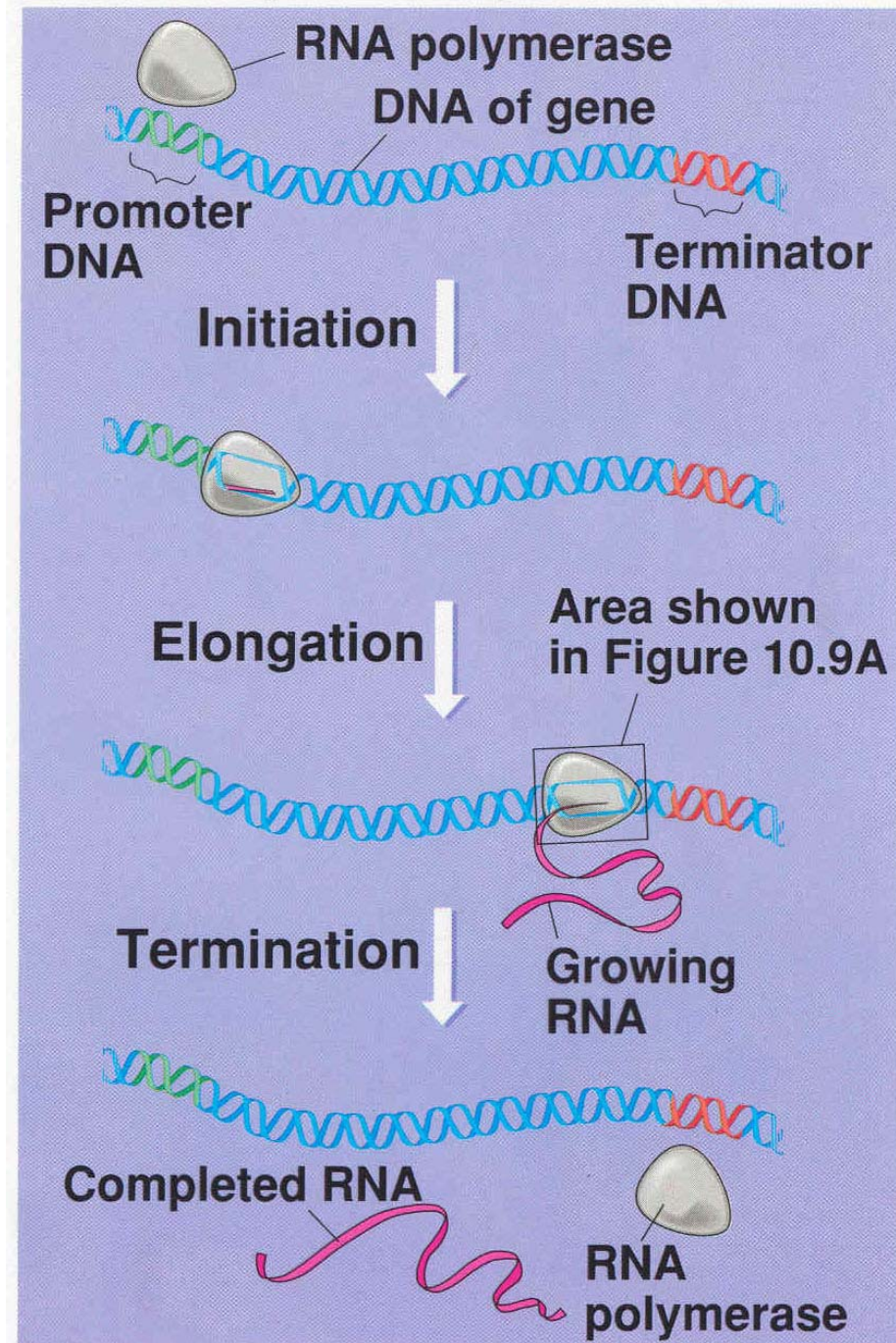
# Gene Structure

1. Promoter – defines the start and controls the rate of transcription
2. Coding region – encodes the polypeptide
3. Termination site signals RNA polymerase to stop transcription



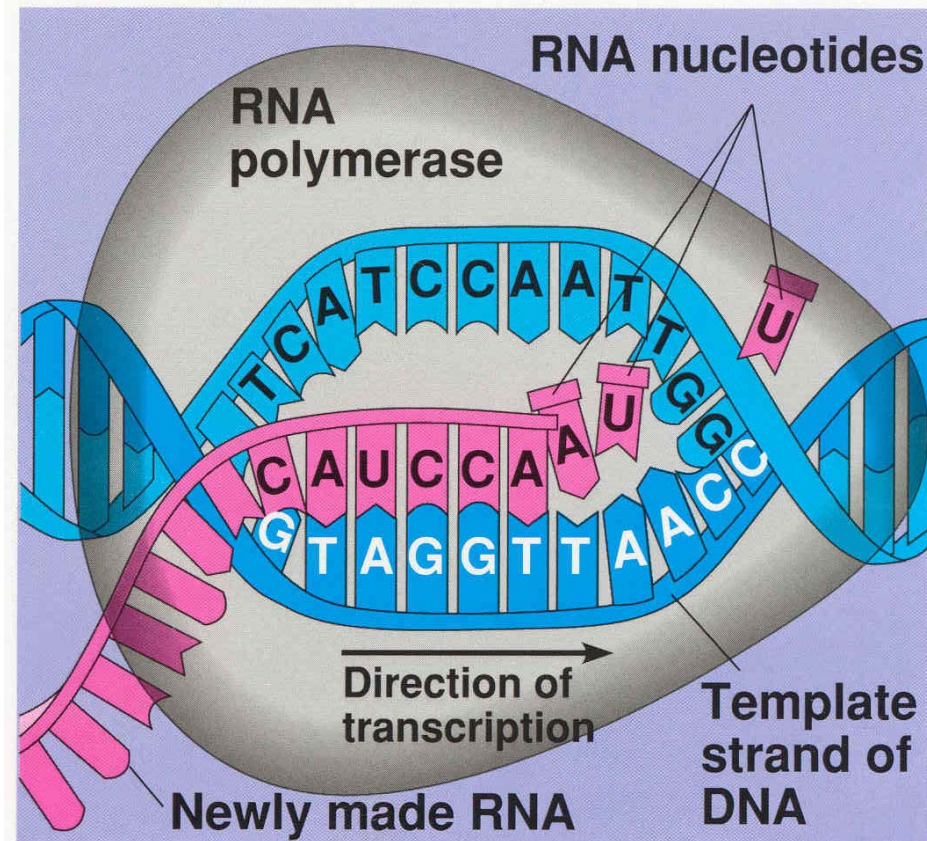
# Transcription

1. DNA is copied into RNA
2. Catalyzed by RNA Polymerase
3. Occurs in 3 steps
  - Initiation
  - Elongation
  - Termination



# Transcription – Copying Mechanism

- The DNA helix is pulled apart.
- RNA Polymerase uses a single DNA template strand to synthesize a complementary RNA strand.
- RNA synthesis is in the 5' to 3' direction



# Transcription in Prokaryotes

- Draw from the board
- Prokaryotic promoters contain several elements:
  1. +1 nucleotide is the start site
  2. -10 sequence (TATAAT) and -35 sequence (TTGACA) are binding sites for RNA Polymerase and function to position the start of transcription

# Initiation and Elongation of Transcription in Prokaryotes

- RNA Polymerase (Pol) binds to the promoter with the help of the sigma ( $\sigma$ ) factor.
- RNA Pol unwinds the double helix, reads the template strand and synthesizes a complementary strand of mRNA about 9 nucleotides long.
- The  $\sigma$  factor dissociates from RNA Pol, completing initiation.
- Elongation involves the extension of the complementary RNA

# Termination of Transcription in Prokaryotes occurs in 2 ways

1. Rho-independent termination
2. Rho-dependent termination

# Rho-independent Termination of Transcription in prokaryotes

- Draw from the board
- RNA in the termination site forms a hairpin stem-loop, which disrupts weak A-U bonds between the DNA template and the terminal region of RNA.
- This causes dissociation of RNA from DNA and termination transcription.

# Rho-dependent Termination of Transcription in prokaryotes

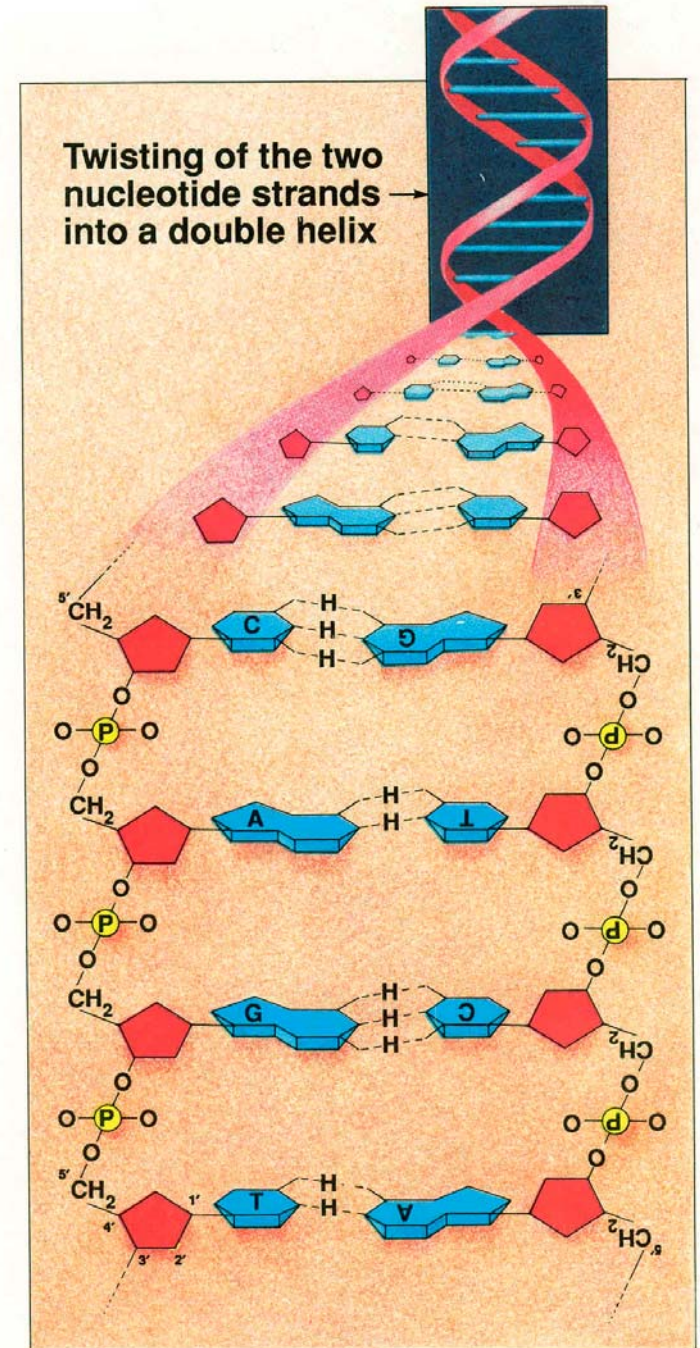
- Draw from the board
- The Rho factor is a helicase that unwinds the growing RNA from the DNA template, thus terminating transcription

# Cracking the Genetic Code

- How scientists determined that the genetic code was based on non-overlapping nucleotide triplets.
- Draw from the board.

# Genetic code

- The code is a language
- A Codon is a nucleotide triplet (like CAG)
- Codons specify particular amino acids (CAG specifies glutamine )



# Genetic code

- There are 64 possible codons ( $4^3$ ), but only 20 amino acids.
- The Genetic code is redundant

|     |     |     |     |     |     |     |     |     |     |      |
|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|
| GCA | AGA |     |     |     |     |     |     |     |     |      |
| GCC | AGG |     |     |     |     |     |     |     |     |      |
| GCG | CGA |     |     |     |     |     | GGA |     |     |      |
| GCU | CGC |     |     |     |     |     | GGC |     | AUA |      |
|     | CGG | GAC | AAC | UGC | GAA | CAA | GGG | CAC | AUC |      |
|     | CGU | GAU | AAU | UGU | GAG | CAG | GGU | CAU | AUU |      |
| Ala | Arg | Asp | Asn | Cys | Glu | Gln | Gly | His | Ile |      |
| A   | R   | D   | N   | C   | E   | Q   | G   | H   | I   |      |
| UUA |     |     |     |     |     |     |     |     |     |      |
| UUG |     |     |     |     |     |     | AGC |     |     |      |
| CUA |     |     |     | CCA | UCA | ACA |     |     | GUA |      |
| CUC |     |     |     | CCC | UCC | ACC |     |     | GUC | UAA  |
| CUG | AAA |     | UUC | CCG | UCG | ACG |     | UAC | GUG | UAG  |
| CUU | AAG | AUG | UUU | CCU | UCU | ACU | UGG | UAU | GUU | UGA  |
| Leu | Lys | Met | Phe | Pro | Ser | Thr | Trp | Tyr | Val | stop |
| L   | K   | M   | F   | P   | S   | T   | W   | Y   | V   |      |