MOLECULAR BIOLOGY

Objectives

1. Describe the structure and replication of DNA.
2. Contrast structures of RNA and DNA.
3. Describe information flow in the cell.
4. Describe transcription and translation.
5. Define redundancy of genetic code.
6. Classify the types of mutations and their severity.
7. List the levels of DNA packaging.
8. Explain how cells differentiate.

Outline

A. Deoxyribonucleic acid (DNA)
    1. Replication of DNA
B. Ribonucleic acid (RNA)
C. Central Dogma
    1. Transcription
    2. Translation
    3. Genetic Code
D. Mutations
    1. Mechanisms of Mutation
E. DNA Packaging
F. Differentiation

A. Deoxyribonucleic acid (DNA)

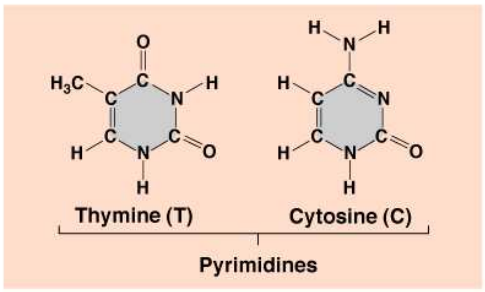
- Cells contain large amounts of DNA
    - *E. coli* – 4,700,000 bp
    - Humans – 3,000,000,000 bp

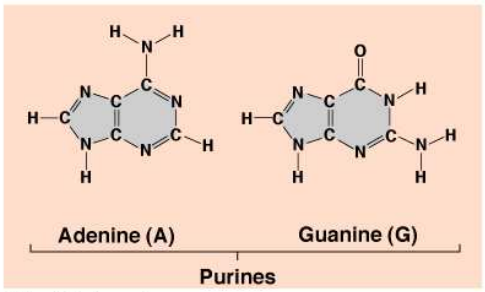
- Purpose
    - Structural information (genes)

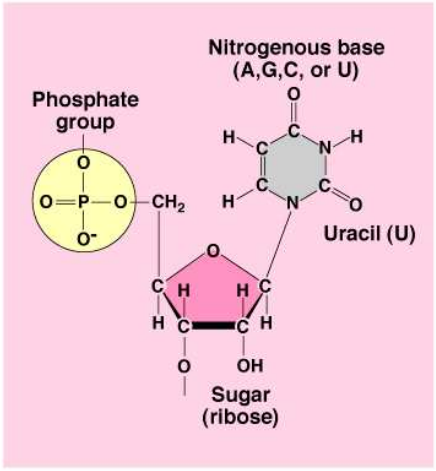
    - Regulatory signals

    - Centromeres, telomeres
        - only in eukaryotes

- Built from nucleotides
  - nitrogenous bases
    - purines (A,G) and pyrimidines (C,T)
  - deoxyribose (pentose)
  - phosphate







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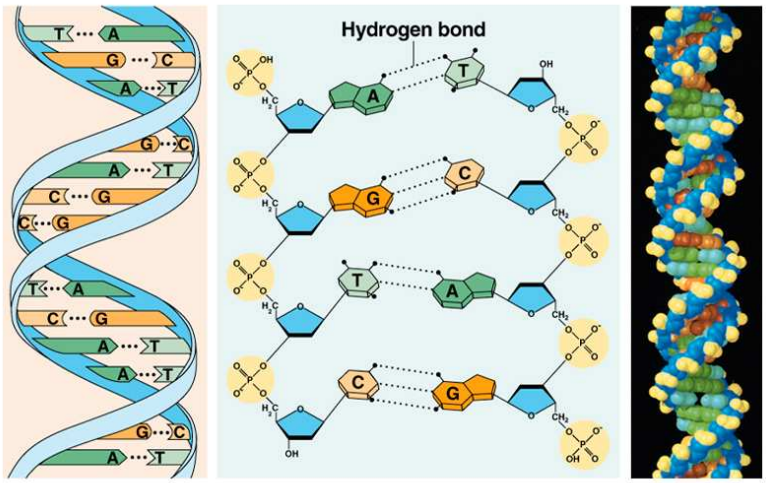
- Double helix
  - A paired with T, C paired with G
  - antiparallel DNA chains



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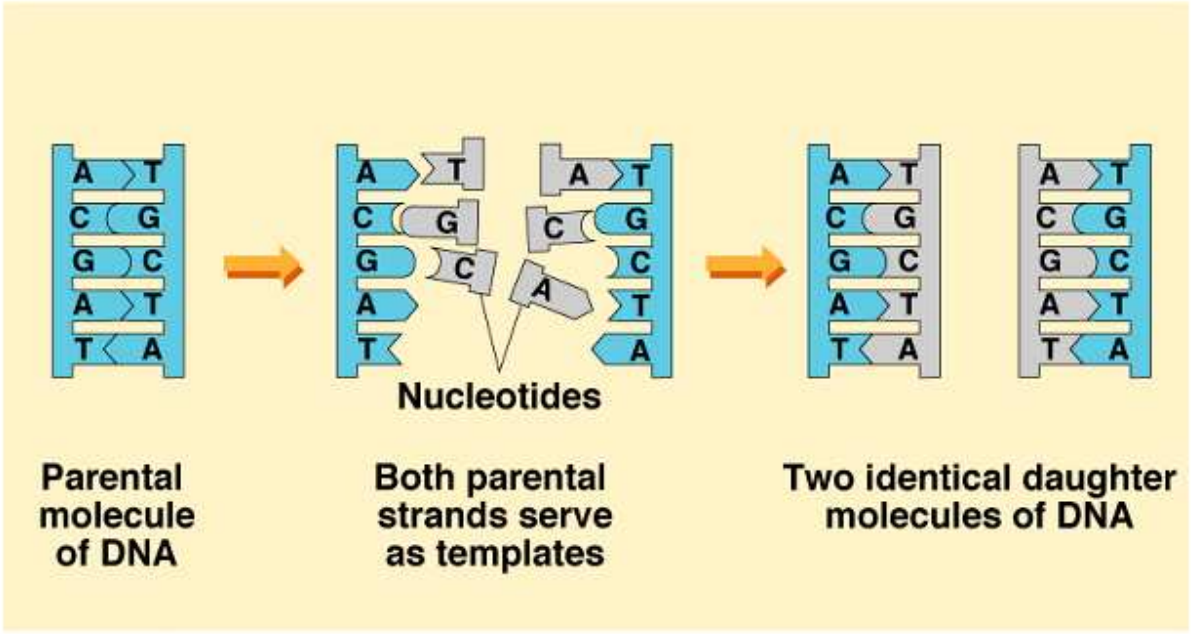
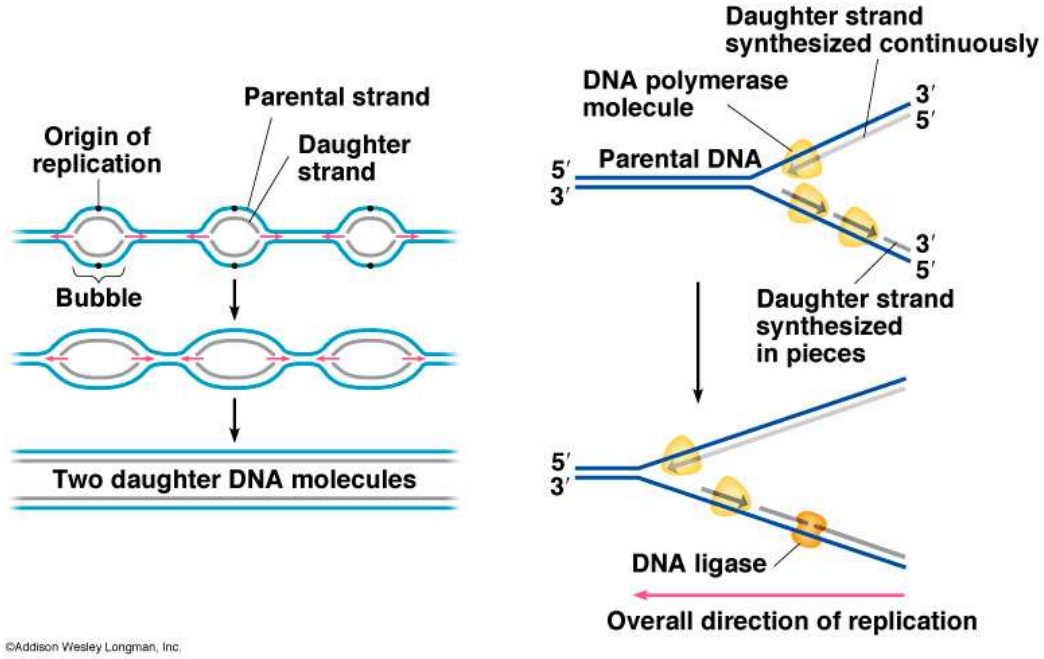
1. Replication of DNA

- Old strand acts as template for new
- Template DNA unwinds and unzips
- DNA polymerase adds bases

    - Complementary to other strand
    - Added in 5’ to 3’ direction
        - Based on carbon in deoxyribose



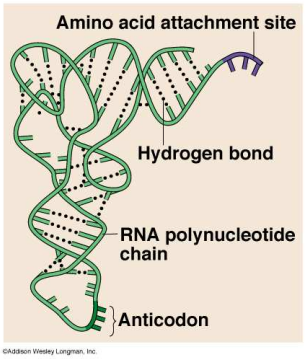
- Two strands are antiparallel
    - 5’ to 3’ run in opposite directions
    - DNA unwinds in one direction
- Semiconservative replication

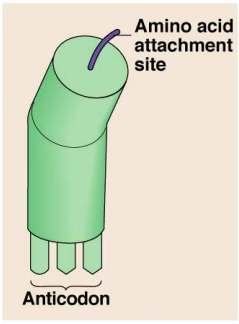


B. Ribonucleic acid (RNA)

- Similar to DNA
  - String of nucleotides
    - purine and pyrimidine bases
    - pentose
    - phosphate
  - Helical structure
- Different from DNA
  - Single-stranded, not double-stranded
  - Ribose, not deoxyribose
  - Uracil (U), not Thymine (T)
    - Pairs with A

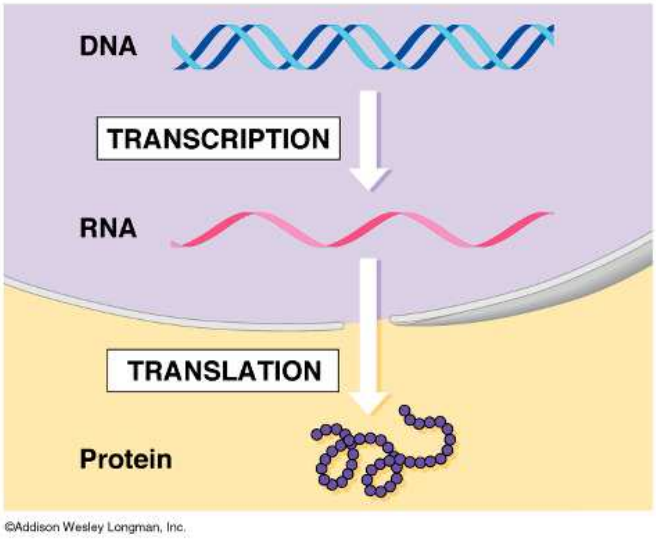
- Types
  - messenger RNA (mRNA)
  - ribosomal RNA (rRNA)
  - transfer RNA (tRNA)





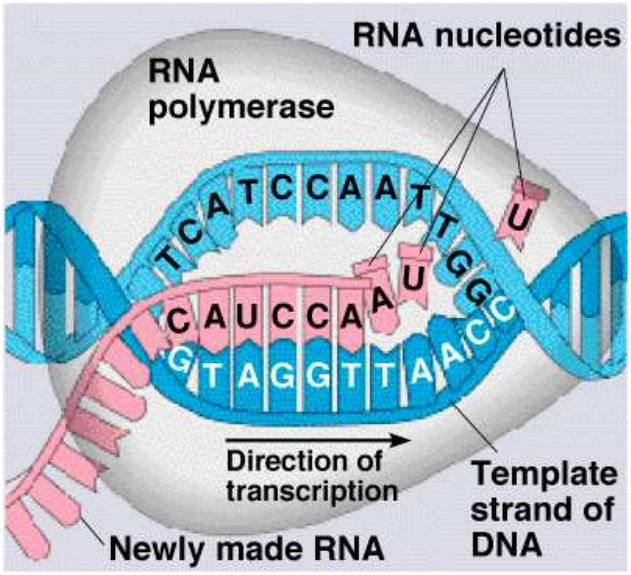
C. Central Dogma

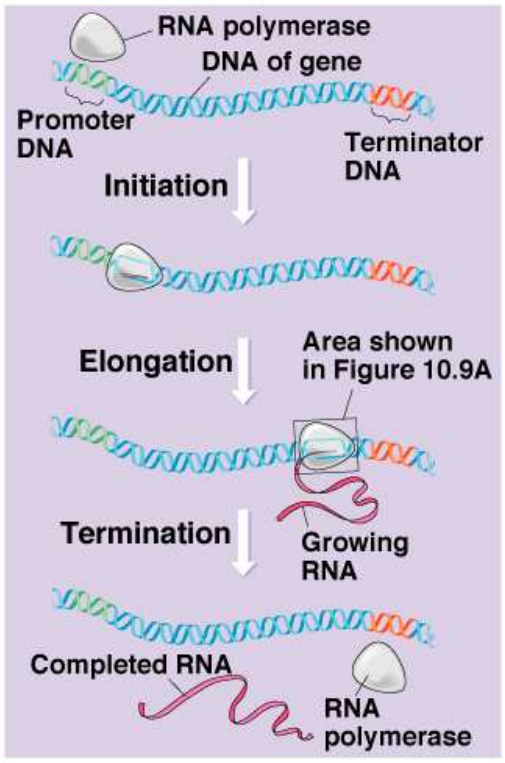
- DNA → RNA → polypeptides
- Transcription
- Translation
- One gene – one polypeptide



1. Transcription – Synthesis of RNA

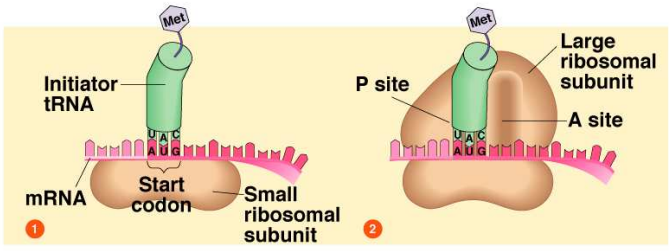
- Similar to DNA replication, except
  - RNA polymerase makes new RNA
    - Attaches to DNA at promoter
    - Ends at terminator
  - RNA synthesized on only one strand
    - RNA released from DNA
    - DNA strands reanneal



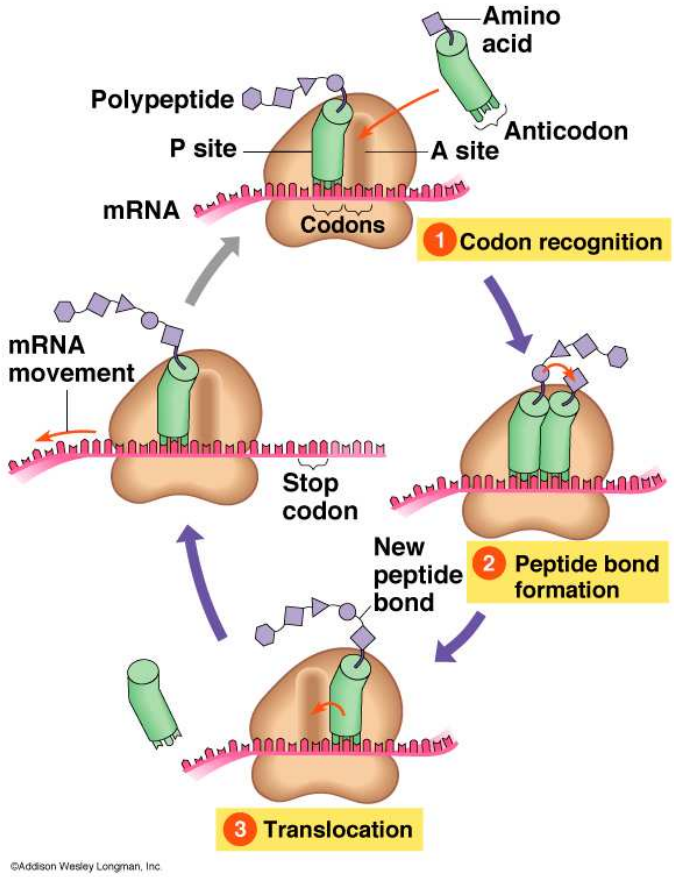


2. Translation – Synthesis of Proteins

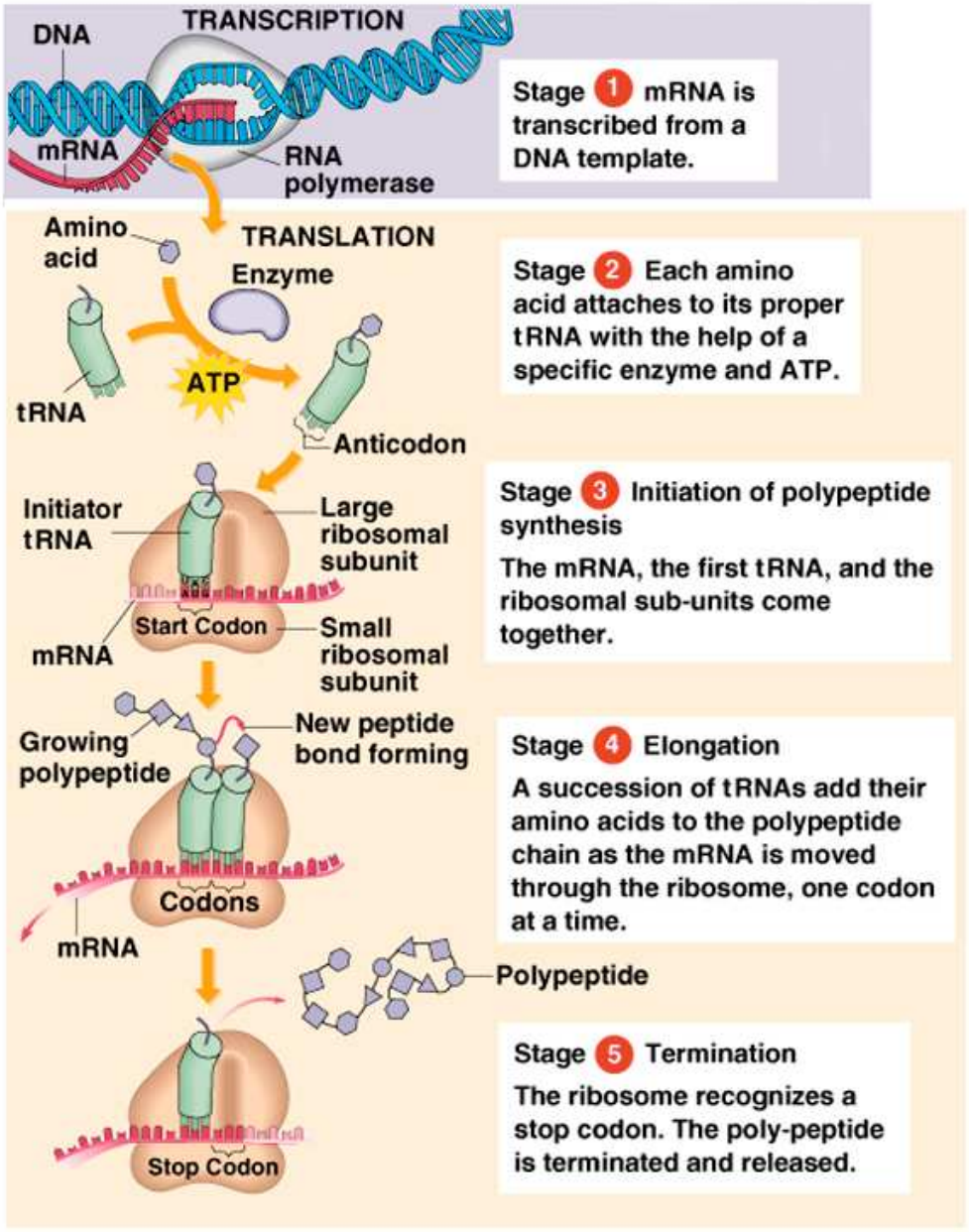
- Nucleotides → amino acids
- tRNA – two binding sites
  - specific amino acid
  - anticodon – for codon on mRNA
- Initiation
  - Ribosome binds mRNA at start codon
  - Complementary tRNA binds mRNA



- Elongation
  - Second tRNA binds second codon
  - Ribosome catalyzes peptide bond
    - First tRNA released
    - Second tRNA holds peptide
  - Ribosome shifts down one codon

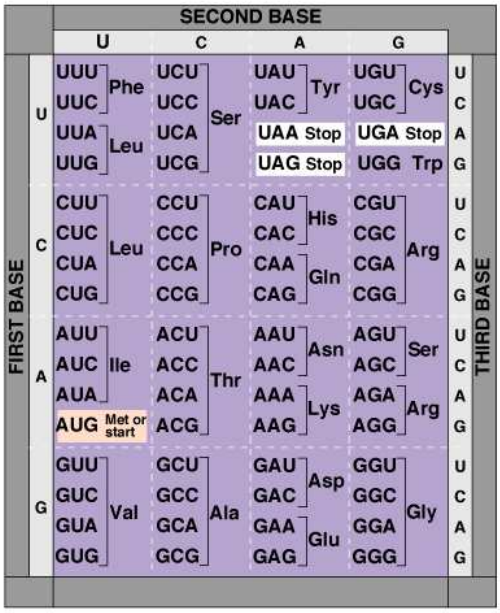


- Termination
  - No tRNA binds to stop codon
  - Amino acid chain released



3. Genetic Code

- 20 amino acids
- 4 nucleotide bases
  - Need 3 nucleotides for 1 amino acid
  - 1 codon starts translation
  - 3 codons stop translation
  - 61 codons bring amino acids
    - Some represented by a single codon
    - Some coded by multiple codons
      - Redundancy of genetic code



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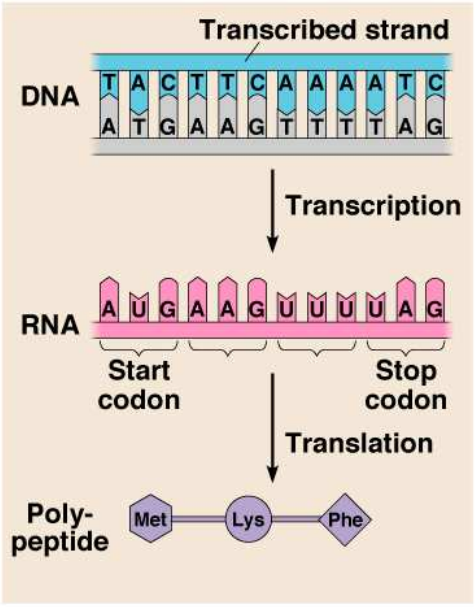


D. Mutations

- Changes in genetic material (DNA)
    - Sequence of nucleotides is changed
- Source of new alleles in populations
    - Heritable mutations
- Point Mutations (Base Substitutions)
    - Silent mutation
        - Redundancy in genetic code
    - Missense
    - Nonsense
        - Prevents formation of protein
- Deletion/Insertion
    - Frameshifts
        - Shifts codon reading frame

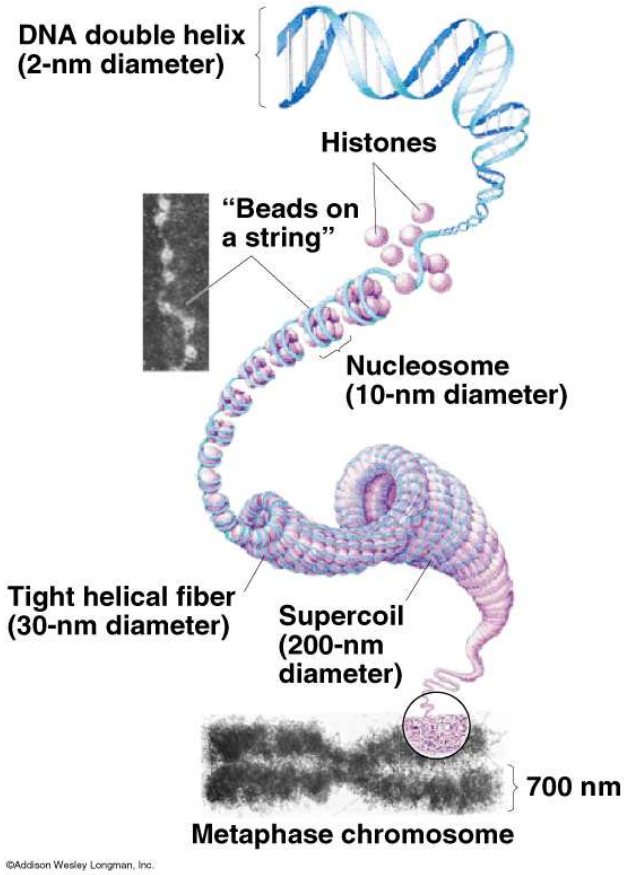
1. Mechanisms of Mutation

- Spontaneous
    - Mistakes in DNA replication.
    - Occur once in every 10^9 bases

- Mutagen
  - Chemical
    - Base (Nucleotide) analogs
    - Intercalating agents
  - Physical
    - X-rays, gamma rays
      - Ionize DNA
      - Break covalent bonds
    - UV radiation
      - Causes thymine dimers

E. DNA Packaging

- DNA double helix
- nucleosomes
- tight helical fiber
- supercoil
- metaphase condensing
  - e.g., X chromosome inactivation
    - Barr body



F. Differentiation

- Cells specialize for different functions
- Maintain complete genetic potential
    - No genes lost
    - Can produce complete individual
    - Specialized genes turned on
    - Unnecessary genes turned off