



Introduction to molecular biology

A6M33BIN

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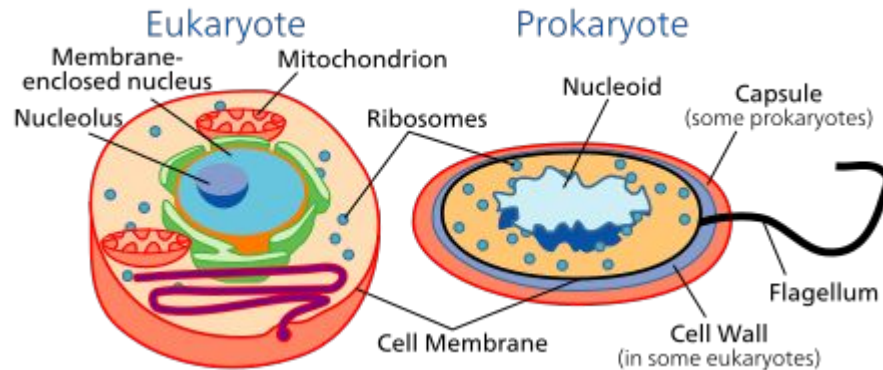
Inspired by Tomáš Martínek and Karel Jalovec

Overview

- Cell
 - Nucleic acids (DNA, RNA)
 - Genetic information
 - Replication
 - Transcription
 - Translation
 - Proteins
 - Genome
 - Summary
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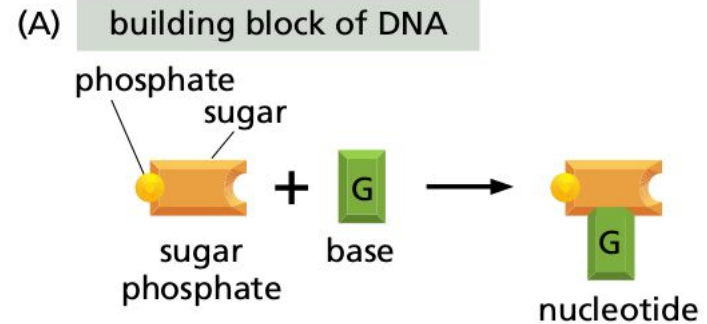
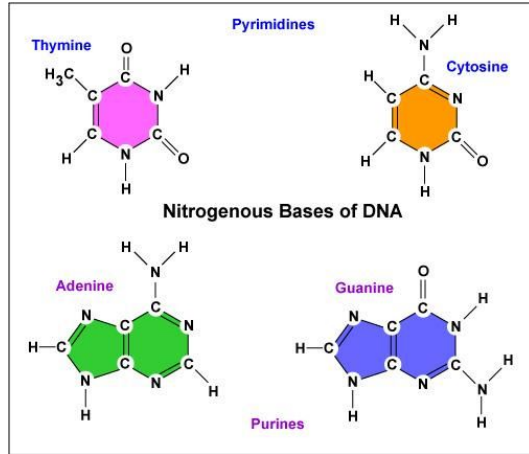
Cell

- Is a basic functional, structural, and biological unit
- Smallest unit of life
- Can replicate independently
- Types of cells
 - Prokaryotic: do not contain cell nucleus (bacteria)
 - Eukaryotic: contain cell nucleus (plants, animals, ...)



Nucleic acids - DNA (Deoxyribonucleic acid)

- “Blueprint” of an organism
- Composed of small molecules called nucleotides
- Nucleotide is a collection of three “building blocks”
- Four bases: adenine (A), cytosine (C), guanine (G) and thymine (T)



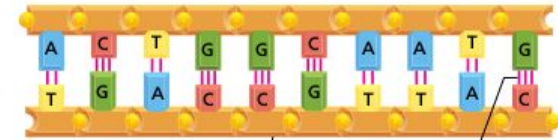
Polynucleotide chain and complementarity

- is a connection of nucleotides into the chain
- has an orientation (5' phosphate and 3' hydroxyl ends)
- bases are bonded to each others by hydrogen bonds
 - A and T (2 bonds)
 - C and G (3 bonds)
 - **Watson-Crick base pairing**
- other combinations are less probable

(B) DNA strand



(D) double-stranded DNA



sugar-phosphate backbone

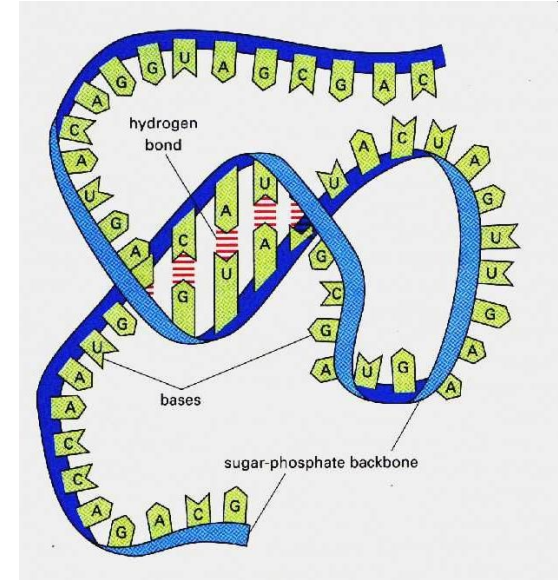
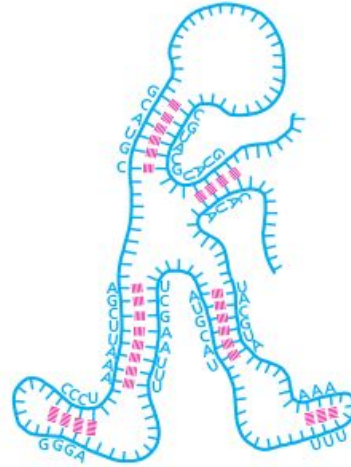
hydrogen-bonded base pairs

(E) DNA double helix



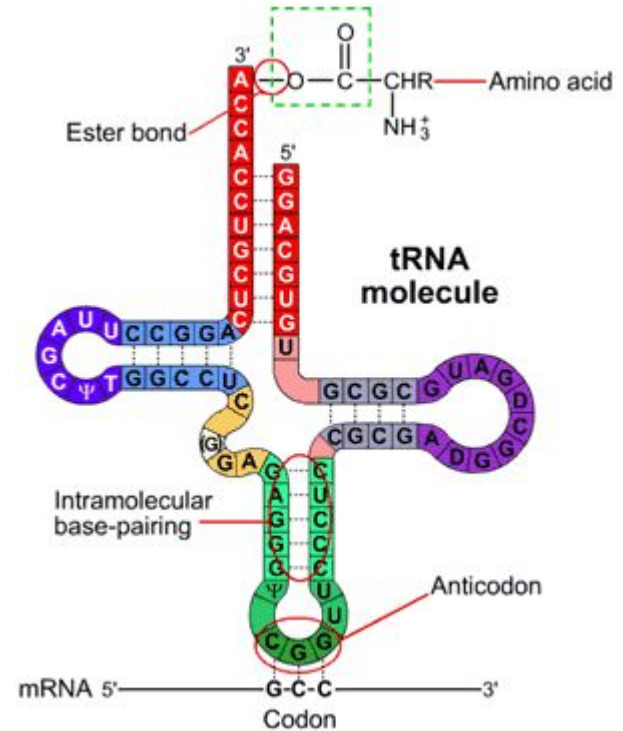
Nucleic acids - RNA (Ribonucleic acid)

- similar to structure of DNA
 - sugar + phosphate + base
 - **sugar is a ribose** (instead of deoxyribose)
- Bases
 - Adenine (A)
 - Guanine (G)
 - Cytosine (C)
 - **Uracil** (instead of Thymine T)
- RNA is single-stranded



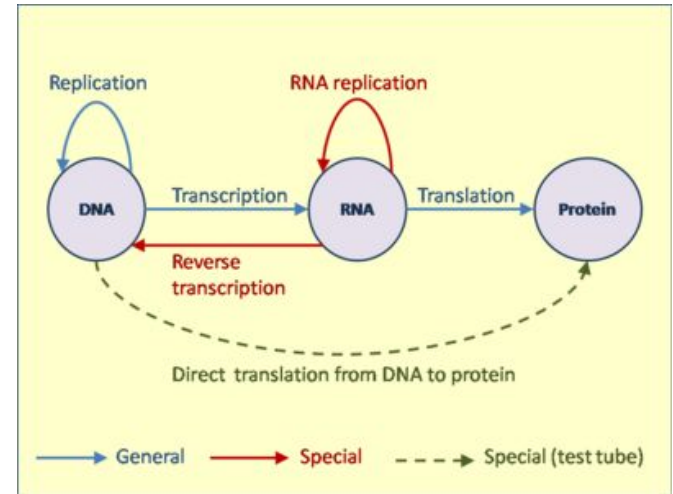
Types of RNA

- Messenger mRNA
 - Represents transcript of a gene from DNA that will be translated into protein (see transcription)
- Transfer tRNA
 - carries amino-acids to ribosomes (see translation)
- Ribosomal rRNA
 - includes major constituents of ribosomes (see translation)
- And many others ...
 - miRNA - gene expression regulation
 - siRNA - RNA interference
 - snRNA - splicing

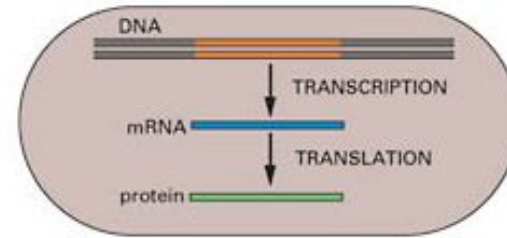
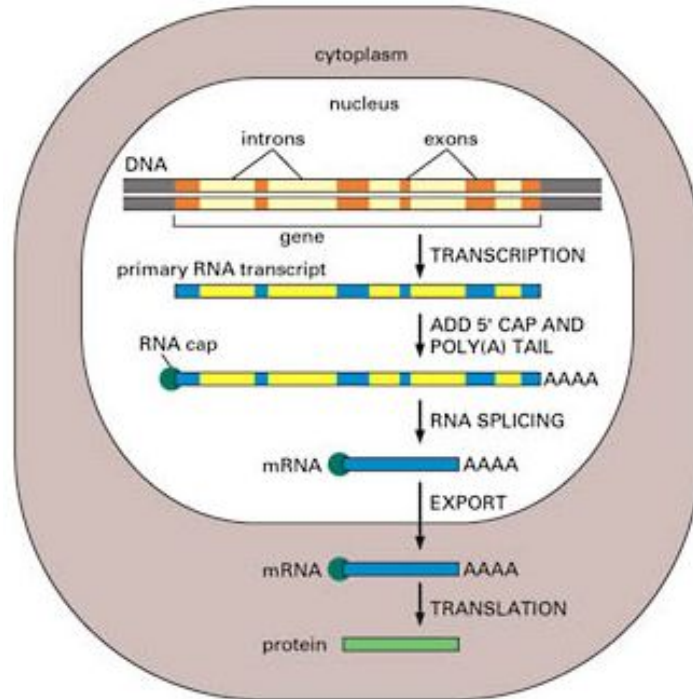


Central dogma of molecular biology

- Describes transfer of genetic information
- General transfers
 - DNA -> DNA (replication)
 - DNA -> RNA (transcription)
 - RNA -> Protein (translation)
- Special transfers
 - RNA -> DNA (Reverse transcription)
 - RNA -> RNA (replication)
 - DNA -> Protein (laboratory conditions)



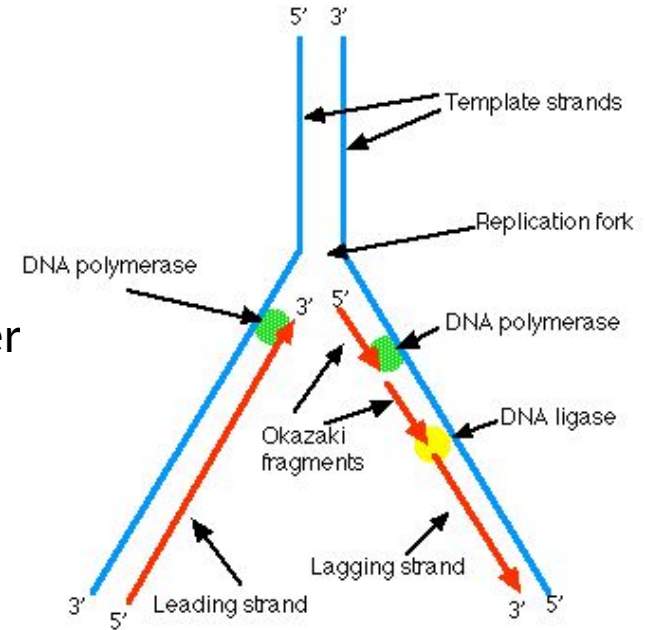
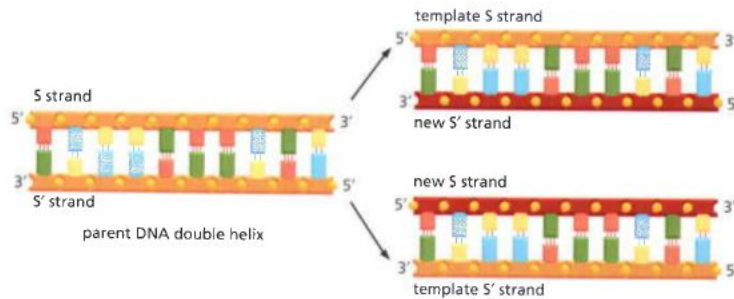
Eukaryotic vs. Prokaryotic protein synthesis



- exons are the coding parts
- introns are spliced out before translation

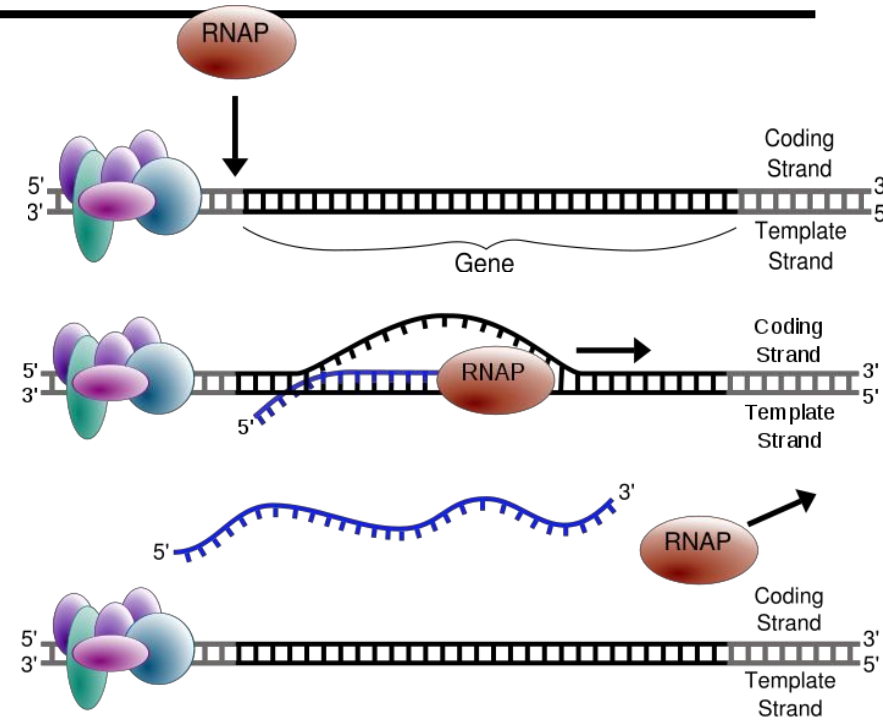
Replication

- is the process by which DNA makes a copy of itself during cell division (semi-conservative)
- DNA polymerase synthesizes the new strands by adding nucleotides in 5' -> 3' direction
- A correction activity (proofreading) of DNA polymerase in 3' -> 5' direction



Transcription

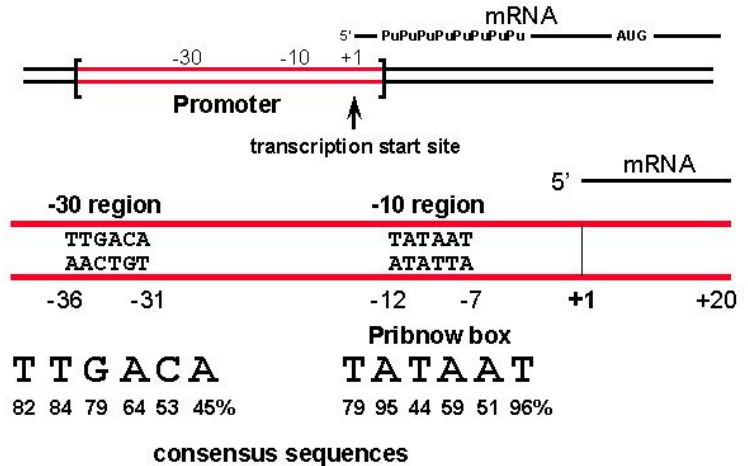
- is a process where DNA is copied into RNA by the enzyme RNA-polymerase (RNAP)
 - RNAP binds to a specific DNA region - promoter
 - Promoter is located near the transcription start sites of genes
 - New copies are created by a complementary rule
 - Resulting RNA is called mRNA (messenger RNA)
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Transcription - promoter

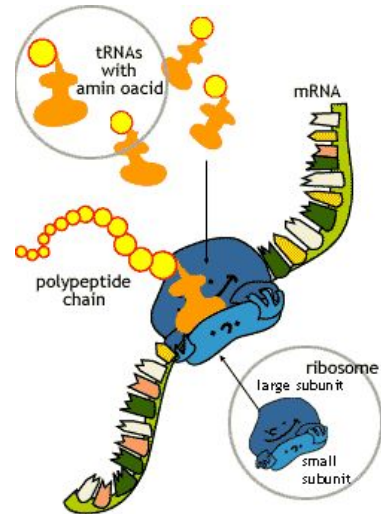
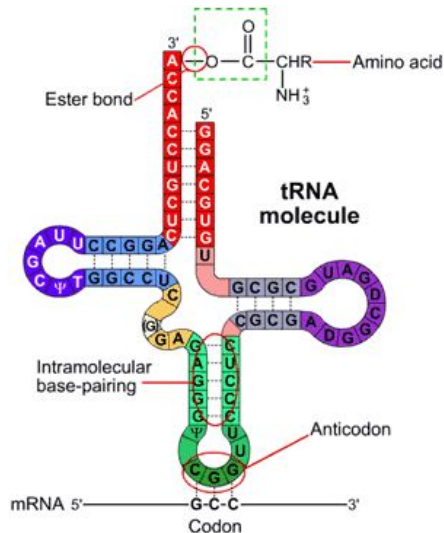
- Transcription starts with offset 0
- Pribnow Box starts with offset -10
- Gilber Box starts with offset -30

Promoter structure in prokaryotes



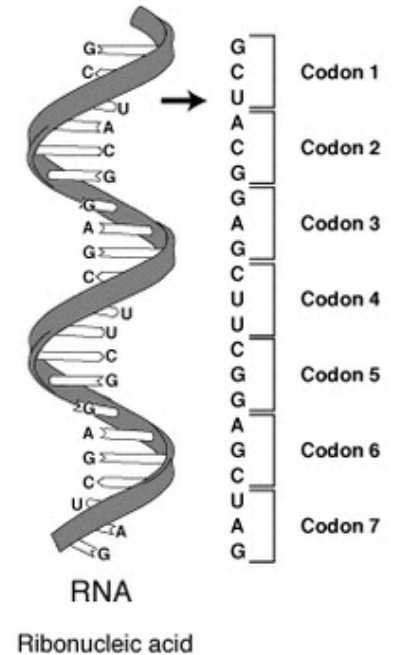
Translation

- mRNA is translated (“decoded”) to build a protein
- ribosomes are the machines that synthesize proteins from mRNA
- tRNA carries the amino acid specified by the codons



Translation - codons

- translation begins with the start codon and ends with the stop codon
- Codon is a triplet of nucleotides that corresponds to a single amino-acid
- Special codons
 - Start codon (AUG) - start of transcription
 - Stop codons (UAA, UAG, UGA) - termination of transcription



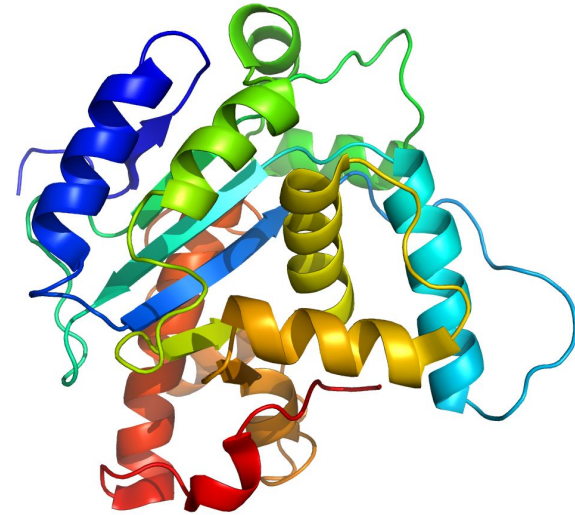
Genetic code

- is a set of rules that translate mRNA into the amino acids sequence of protein
- is degenerated (has redundancy)

| | | Second letter | | | | | |
|--------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|------------------|------------|
| | | U | C | A | G | | |
| First letter | U | UUU UUC | UCU UCC UCA UCG | UAU UAC | UGU UGC | U C | A G |
| | | UUA UUG | | UAA UAG | | | |
| | C | CUU CUC CUA CUG | CCU CCC CCA CCG | CAU CAC | CGU CGC CGA CGG | U C A G | A G |
| | | | | CAA CAG | | | |
| A | AUU AUC AUA | ACU ACC ACA ACG | AAU AAC | AGU AGC | U C A G | A G | |
| | AUG | | AAA AAG | | | | AGA AGG |
| G | GUU GUC GUA GUG | GCU GCC GCA GCG | GAU GAC | GGU GGC GGA GGG | U C A G | A G | |
| | | | GAA GAG | | | | |

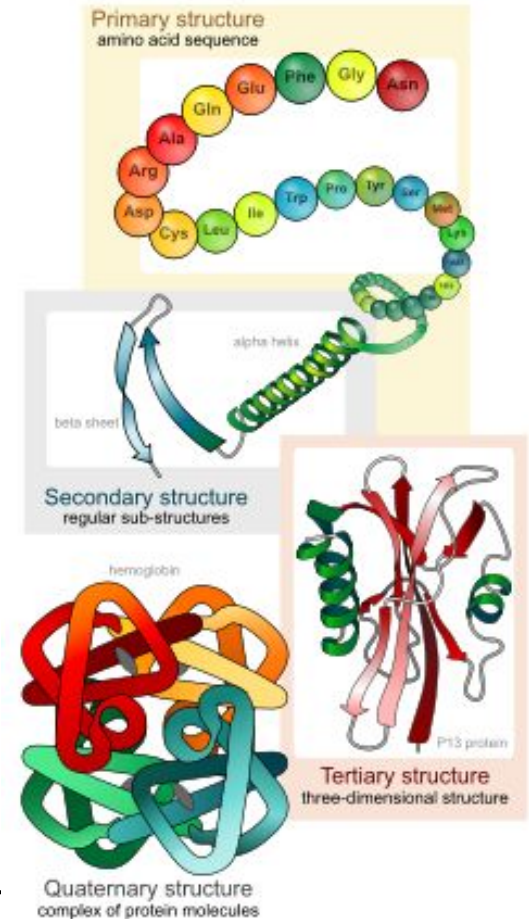
Proteins

- is a polymer composed of amino acids
- cells build their proteins from 20 different amino acids
- Functions
 - Enzyme - carry out almost all of chemical reactions that take place in cells
 - Messenger - transmit signals to coordinate biological processes between different cells, tissues, and organs
 - Transport/storage - bind and carry atoms and small molecules within cells and throughout the body
 - Structural component - provide structure and support for cells



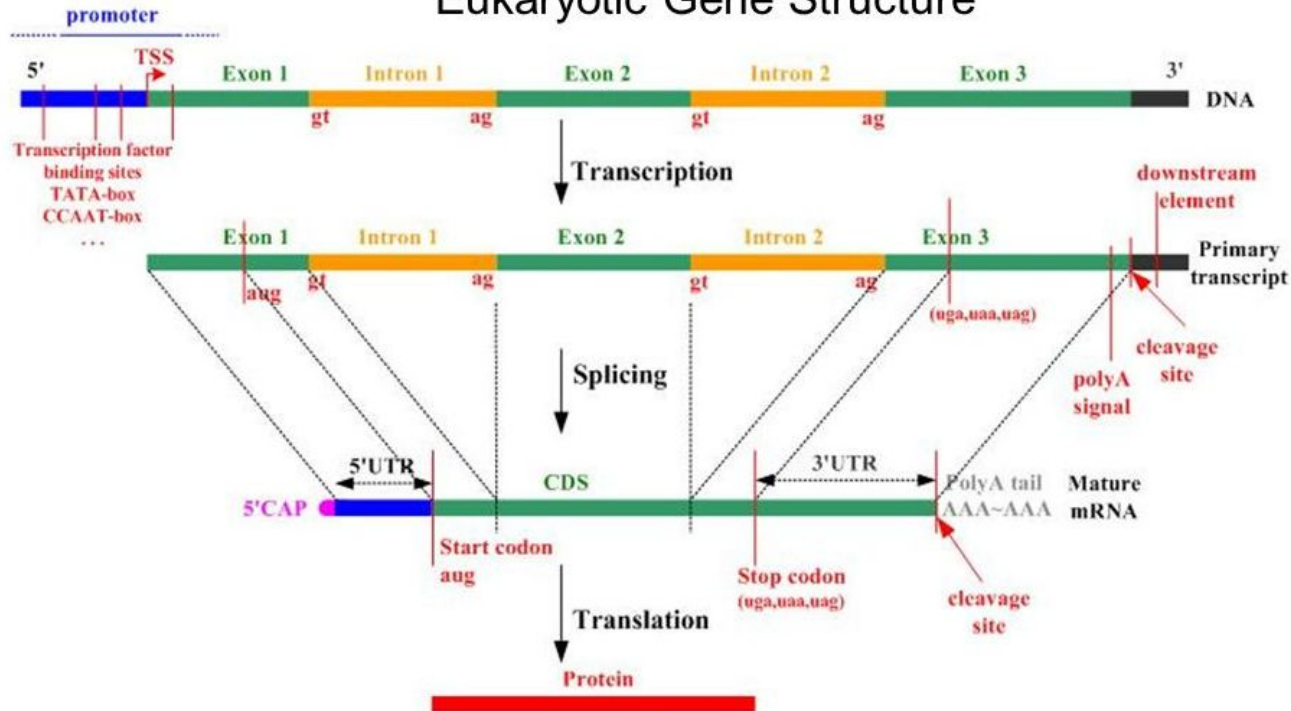
Protein structure

- Primary structure
 - amino acid linear sequence of the polypeptide chain
- Secondary structure
 - highly regular local sub-structures (alpha helix, beta strand or beta sheets)
- Tertiary structure
 - three-dimensional structure of a protein molecule (given by hydrophilic and hydrophobic properties of molecules)
- Quaternary structure
 - three-dimensional structure of a multi-subunit protein and how the subunits fit together

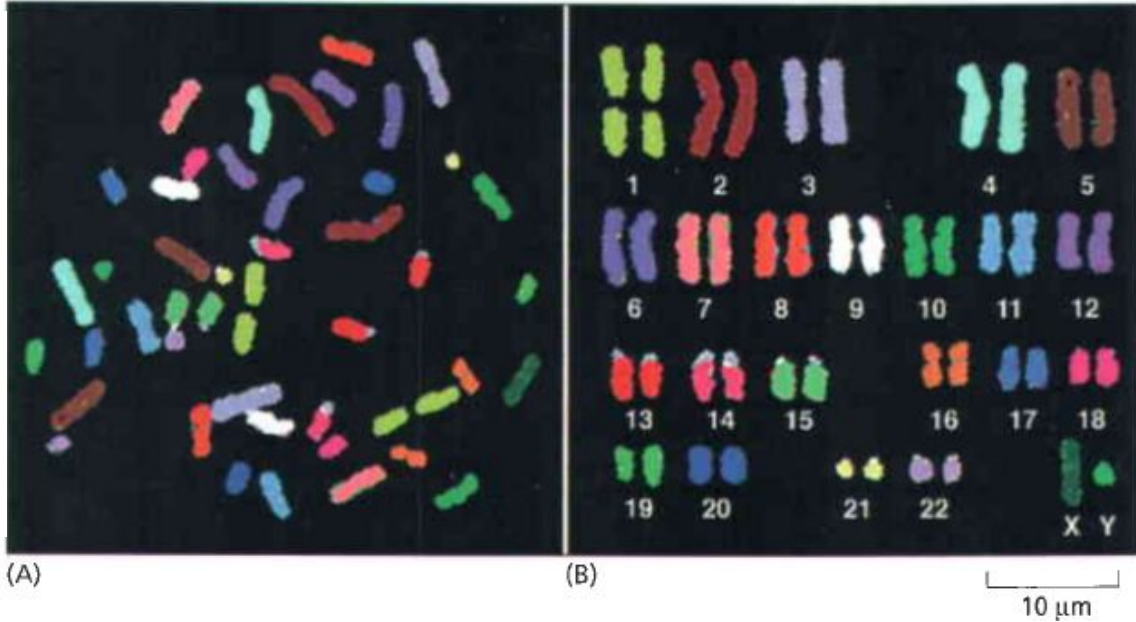
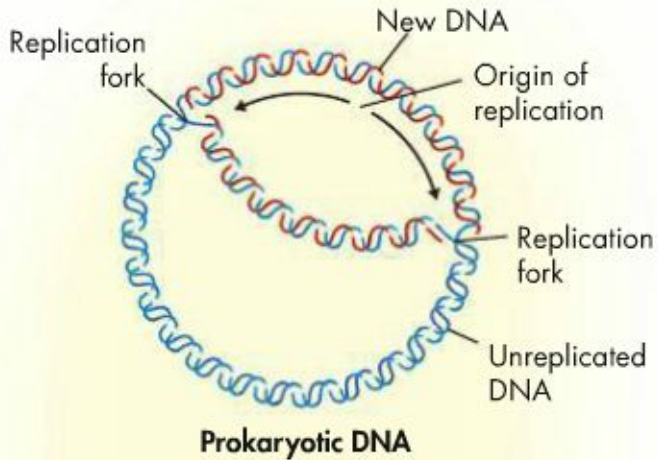


Eukaryotic gene structure

Eukaryotic Gene Structure

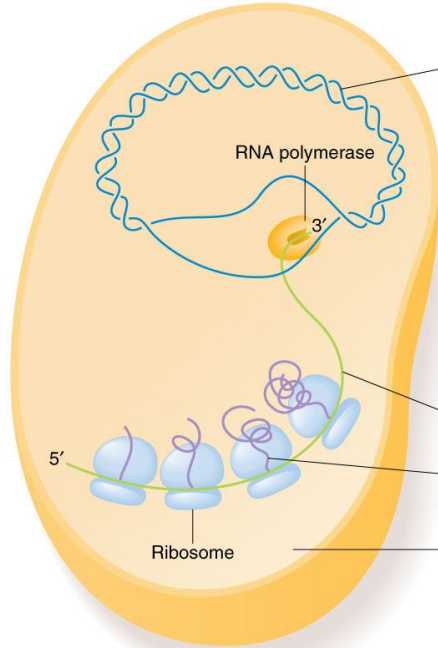


Genome structure

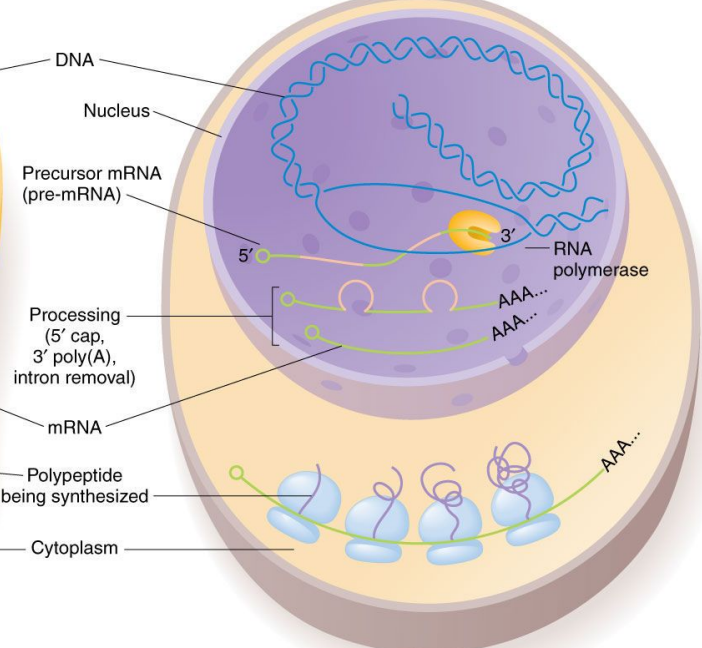


Summary

a) Bacterium



b) Eukaryote



Summary

