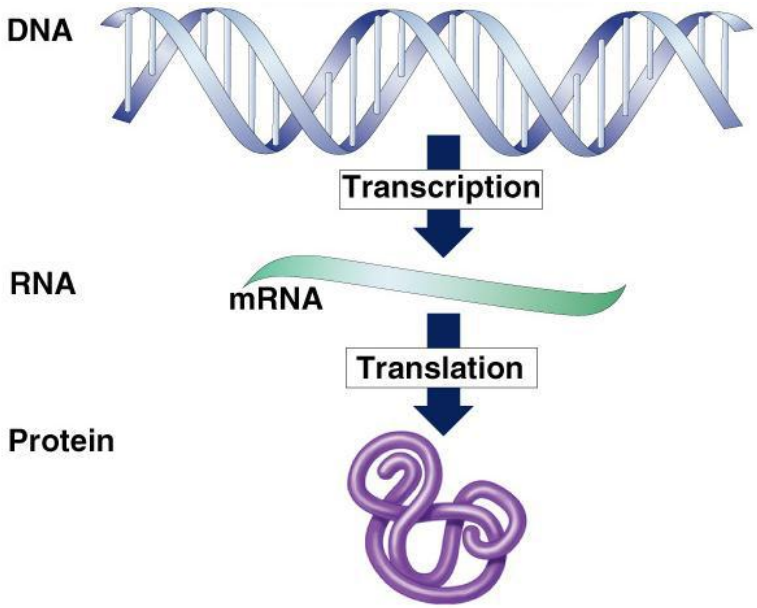
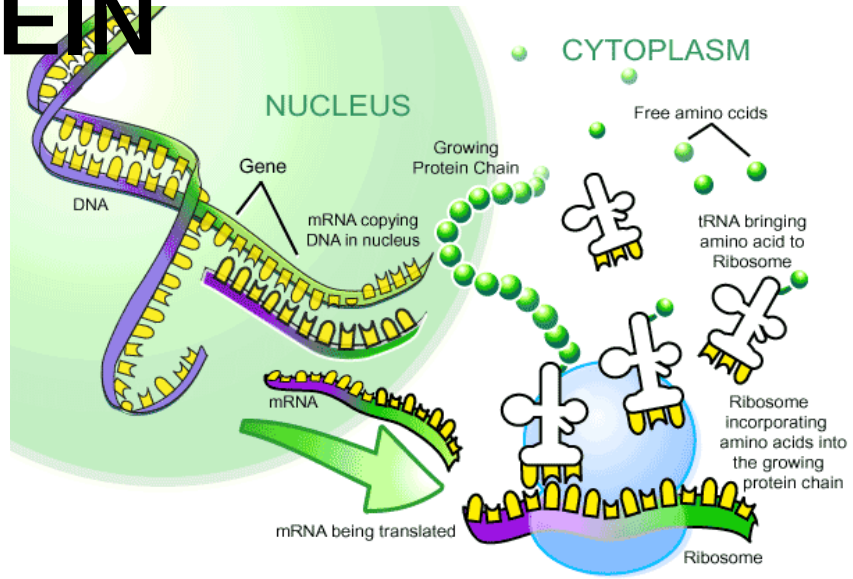


IB Biology

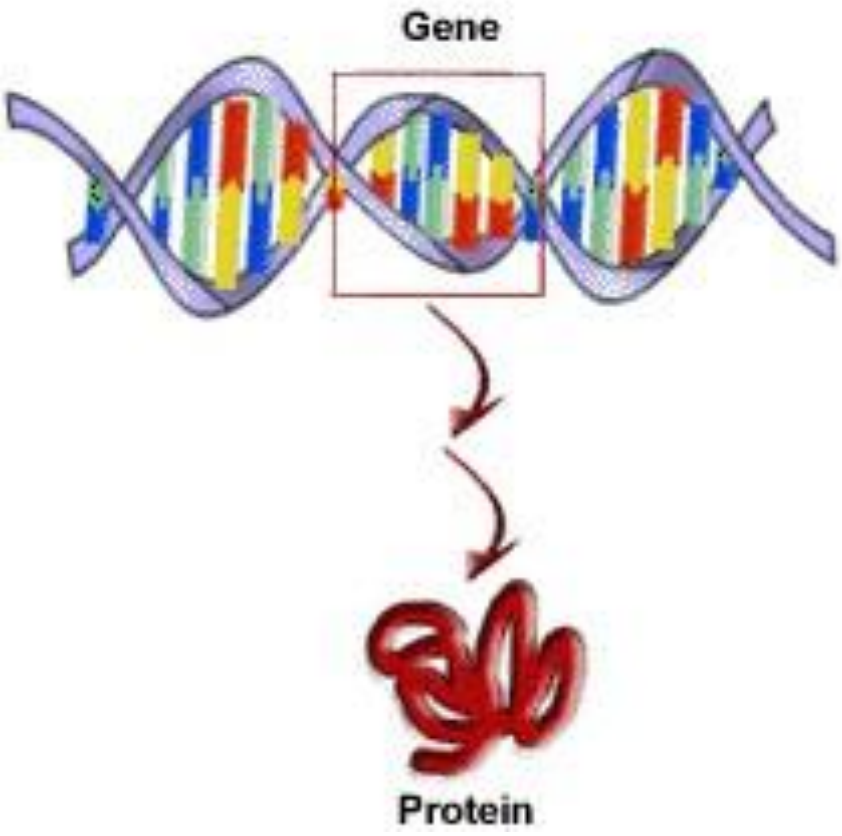
FROM GENE TO PROTEIN
HOW GENES WORK




GENOME PROJECT
WHEN I ASKED WHAT LITTLE GIRLS ARE MADE OF, I WAS HOPING HE WOULD SAY "SUGAR AND SPICE."

- DNA is like a book of instructions written with the alphabet A, T, G, and C.

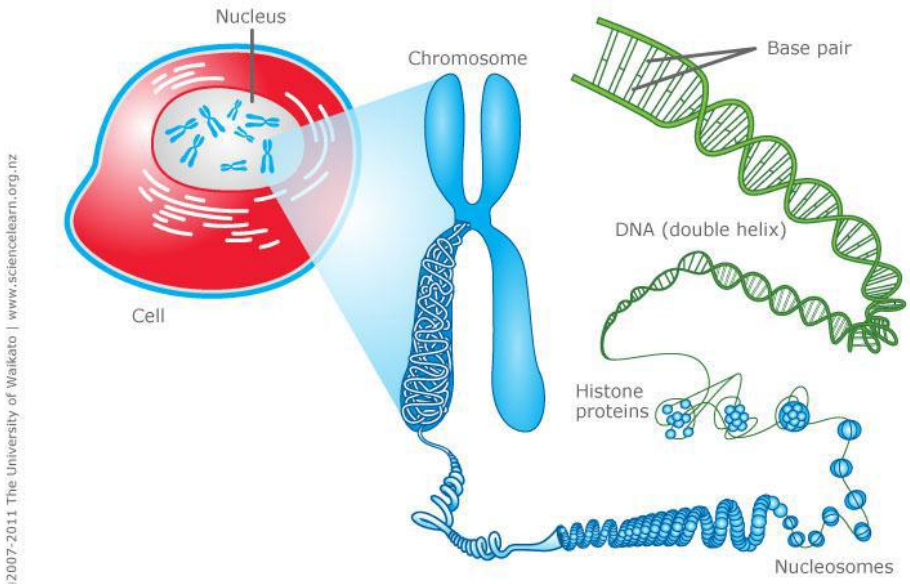
- Genes are specific sequences of bases that encode instructions on how to make proteins.



Genome

- The entire set of genetic information in an organism

- Human DNA is 3.2 billion base pairs long spread among 46 chromosomes

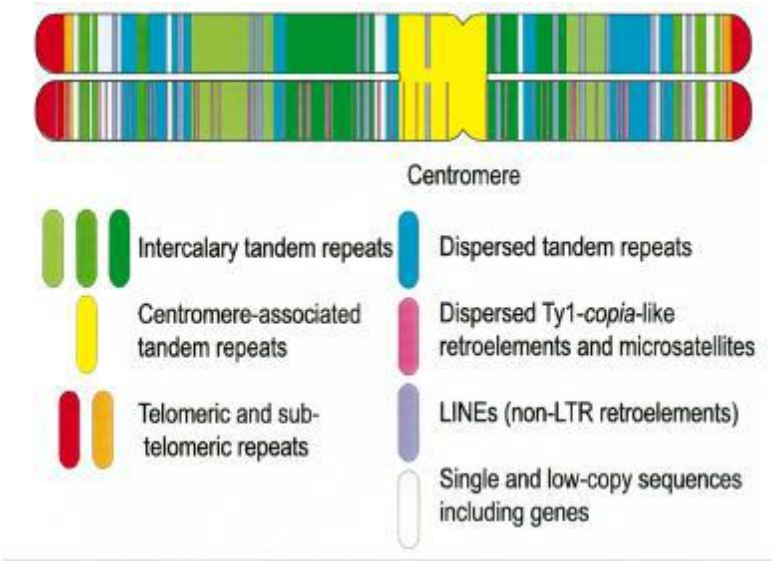


Genomes have DNA sequences that occur with different frequencies

- Some DNA sequences only occur ONCE in the entire genome
  - Most genes are UNIQUE, single copy DNA sequences
  - Remember, a gene is a section of DNA that codes for a protein
  - Only about 2% of the human genome is genes
  - Human DNA contains about 20,000 – 25,000 protein-coding genes

Genomes have DNA sequences that occur with different frequencies

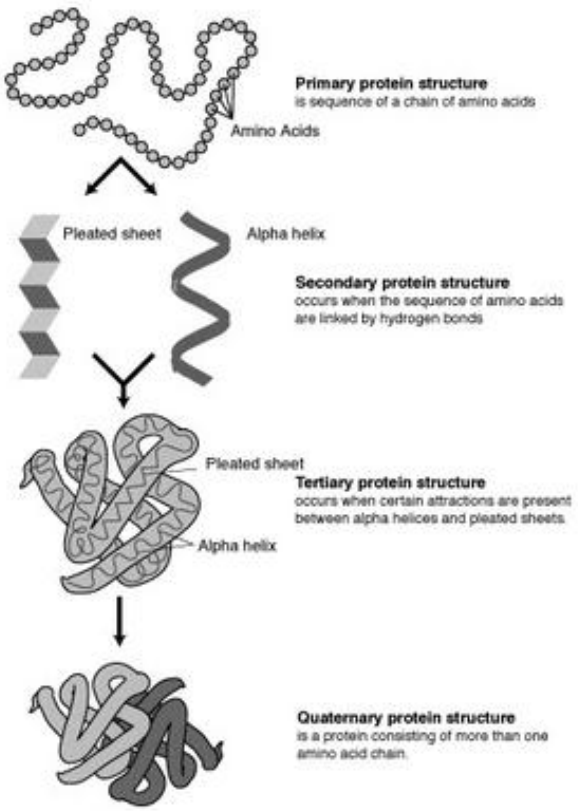
- Other DNA sequence are repeated over and over in the genome
- These are called HIGHLY REPETATIVE sequences



- 98% of the DNA consists of non-protein coding regions, which may:
  - Provide chromosomal structural integrity
  - Regulate where, when, and in what quantity proteins are made.
  - Provide the code for making RNA
  - Be left over DNA from viral infections
  - Be “junk” DNA (DNA that is there, but doing nothing that we know of)

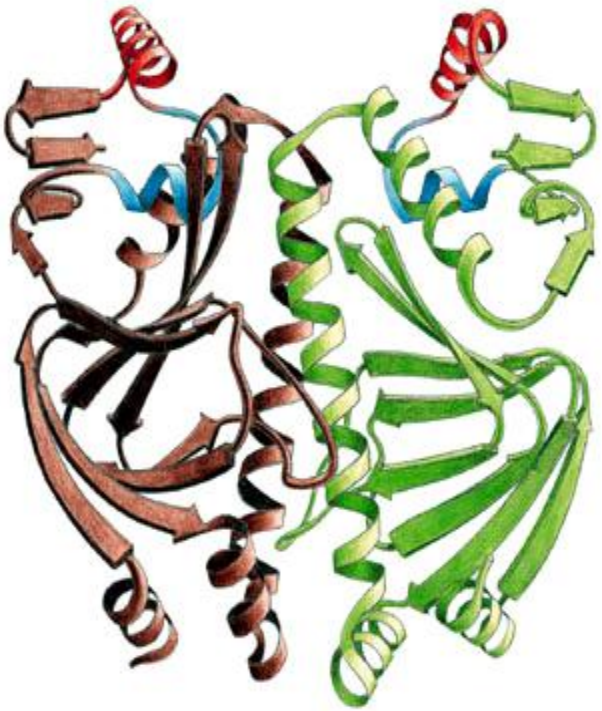
•Although genes get a lot of attention, it's the **proteins** that perform most life functions and even make up the majority of cellular structures.

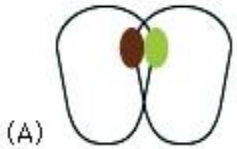
•Proteins are large, complex molecules made up of smaller subunits called amino acids.



Functions of proteins include:

- Enzymes
- Transport
- Structure
- Storage
- Hormones
- Receptors
- Defense

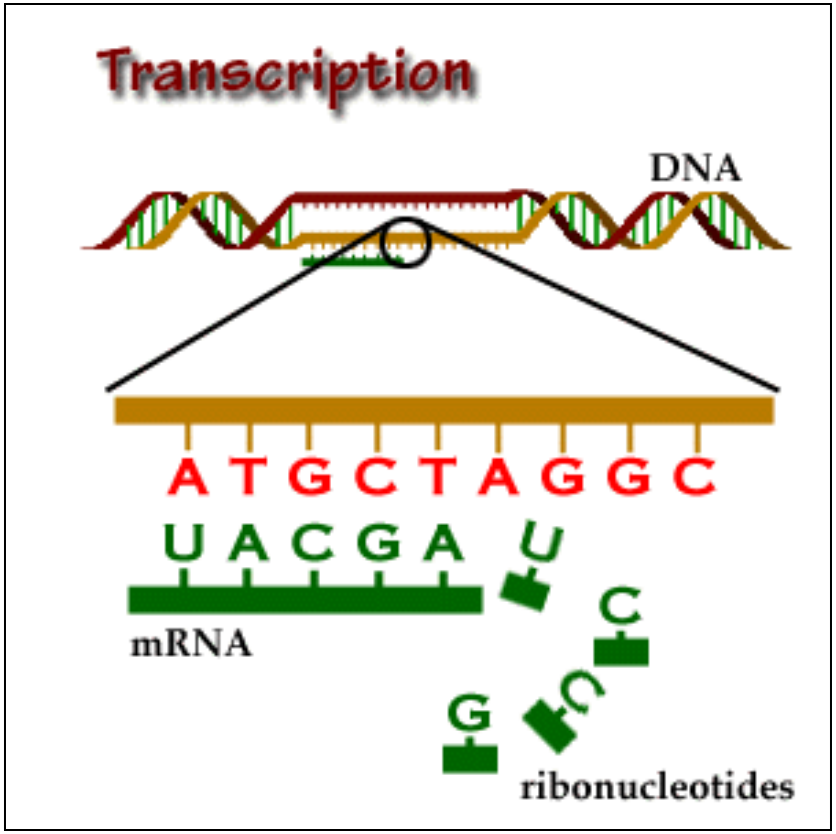




dimer of the CAP protein

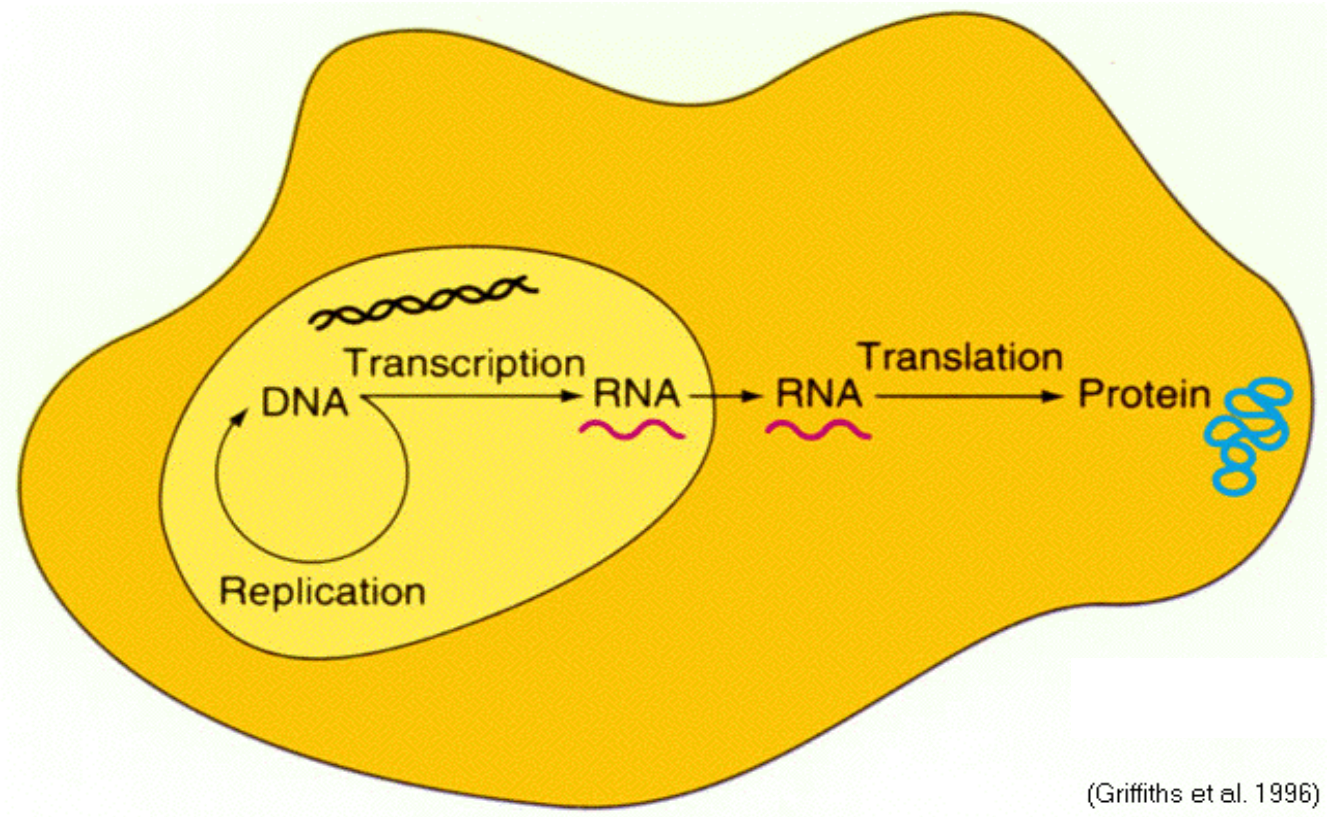
The path from gene to protein has three steps:

- In transcription, molecules of RNA are produced from the DNA:
  - Prokaryotes (cytoplasm)
  - Eukaryotes (in the nucleus, mitochondria, chloroplasts

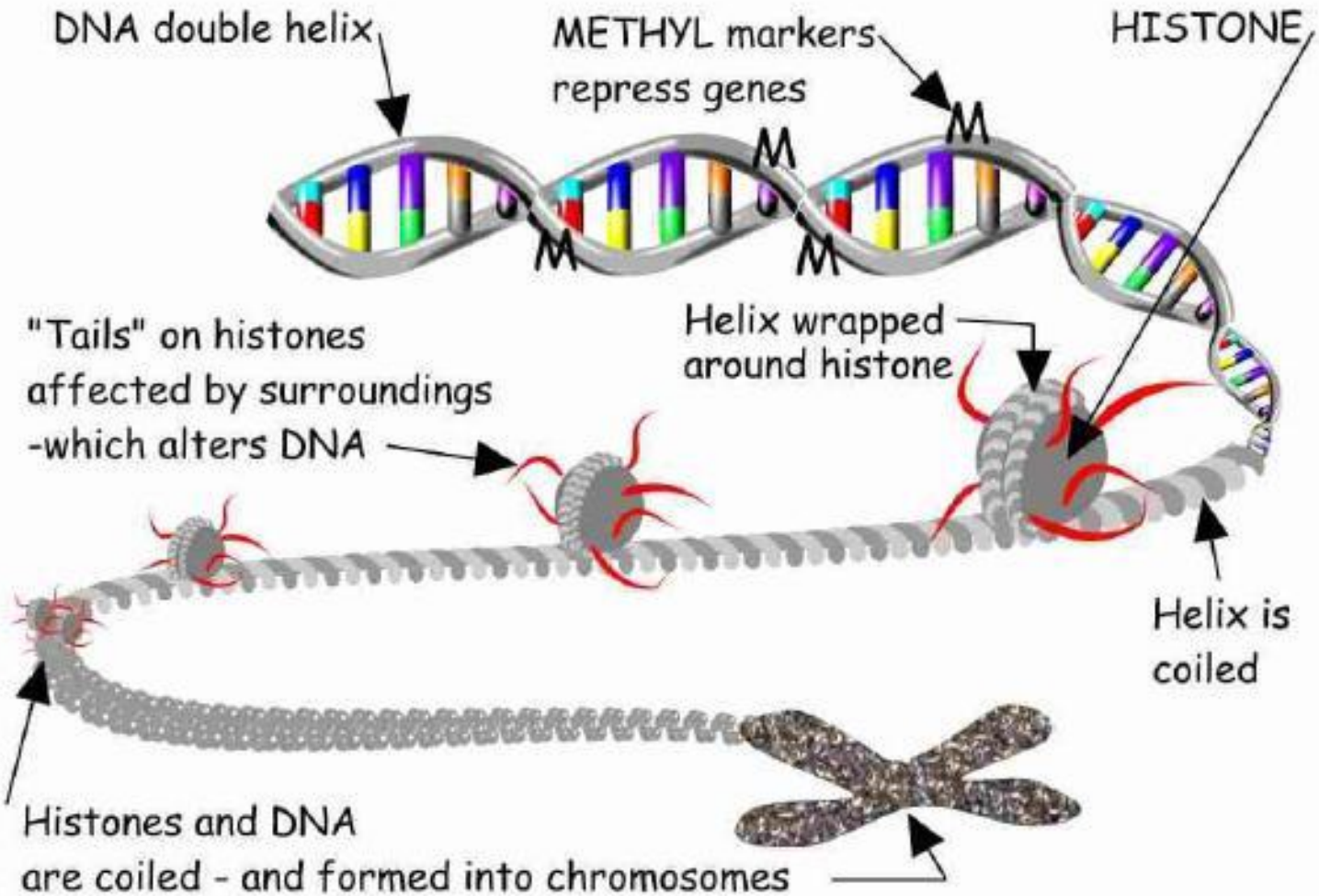


The path from gene to protein has three steps:

- During RNA processing, the RNA is modified before leaving the nucleus and non-protein coding regions of the RNA strand are removed

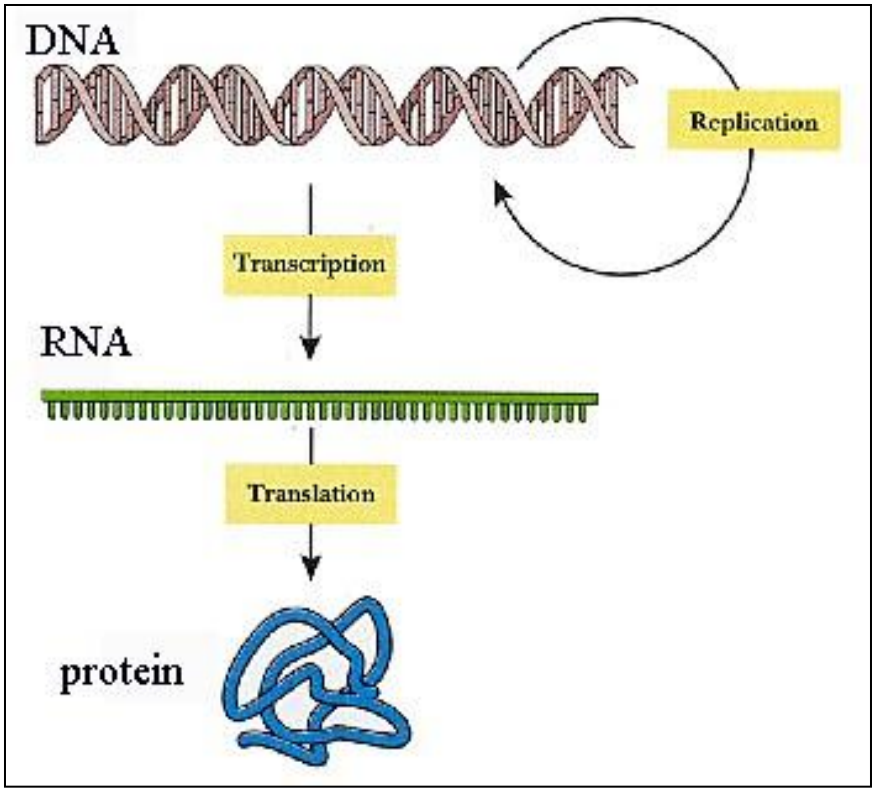


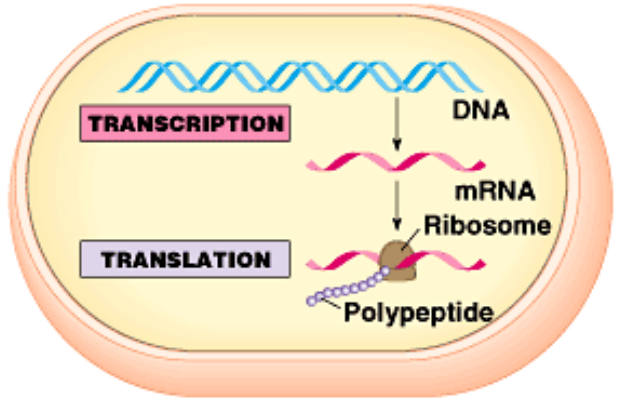
HISTONES AND METHYL MARKERS CONTROL DNA TRANSCRIPTION



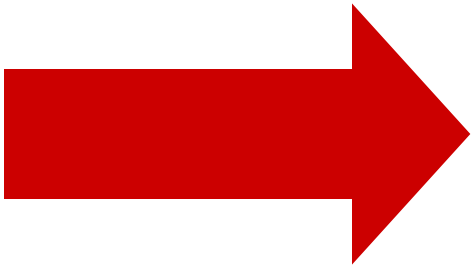
The path from gene to protein has three steps:

- In translation, RNA molecules are used as a code for protein assembly at the ribosome.

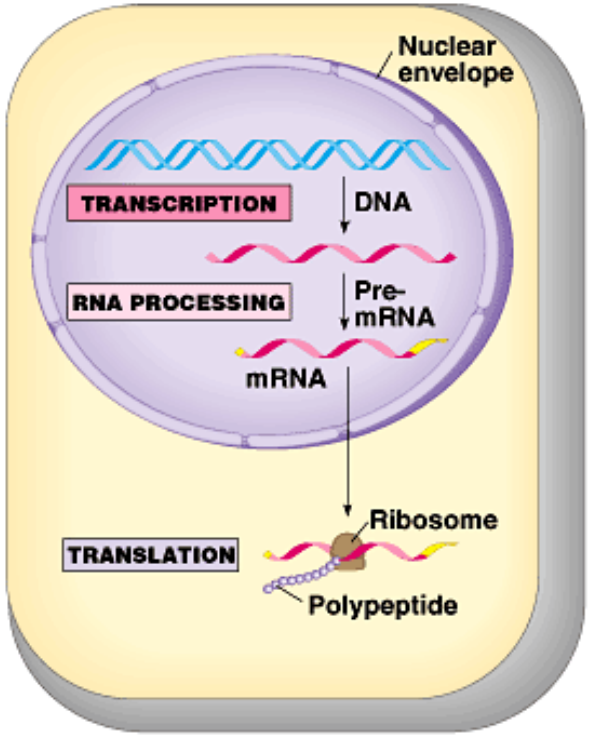




(a) Prokaryotic cell



TODAY WE WILL FOCUS ON TRANSCRIPTION



(b) Eukaryotic cell

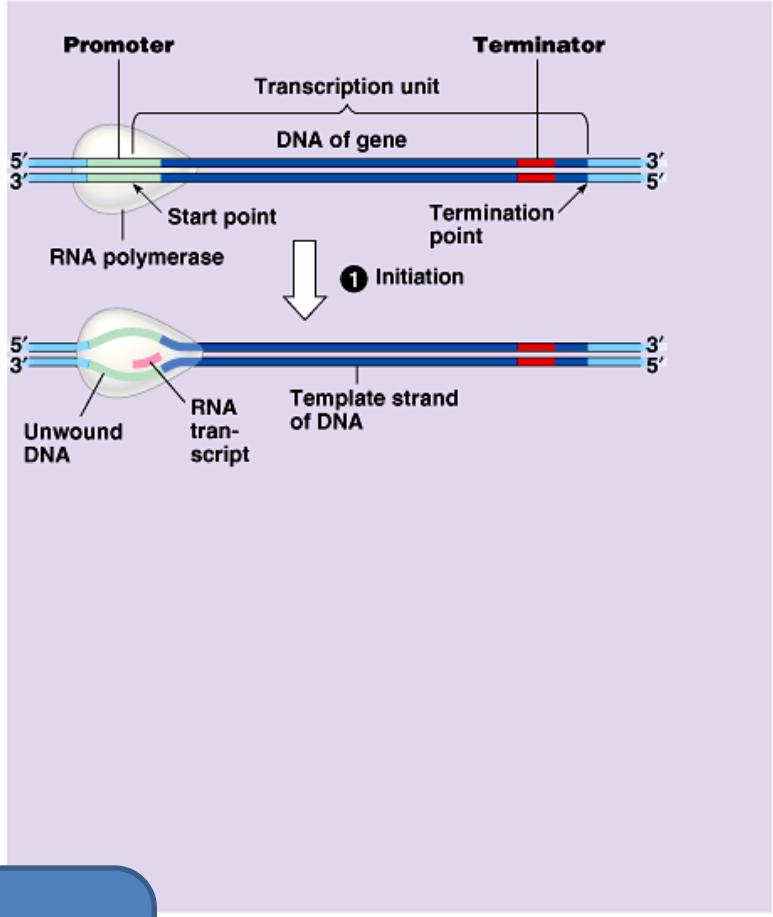
- Overview animation
- Detailed animation
- Another animation

Steps in Transcription

- Initiation
- Elongation
- Termination

Initiation

- RNA polymerase attaches to the DNA at a sequence called the PROMOTER

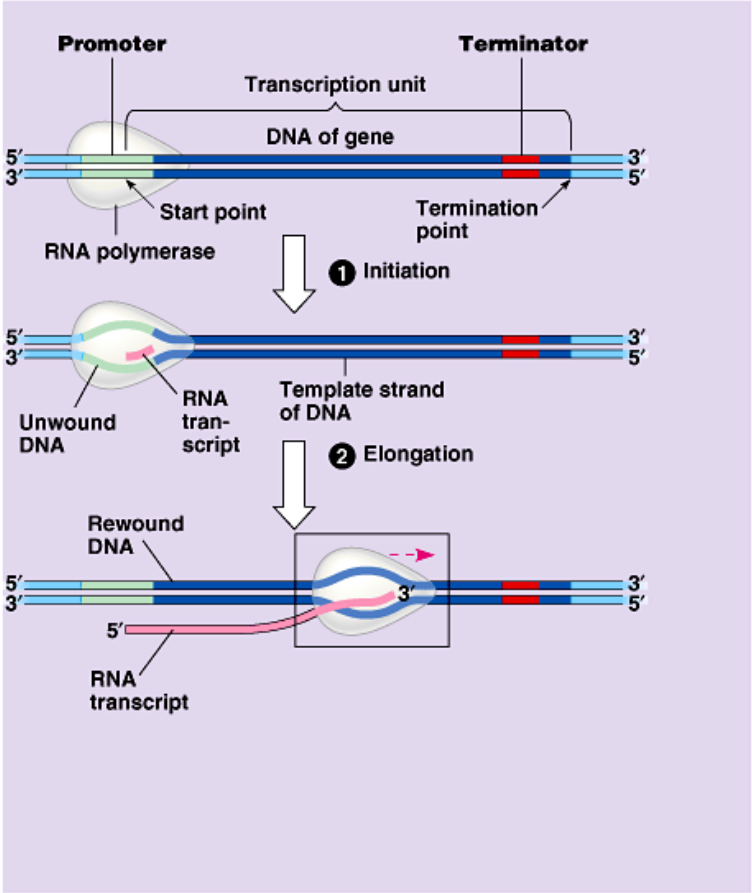


n Education, Inc., publishing as Benjamin Cummings.

A specific sequence of the DNA nucleotides usually “TATAAAA”

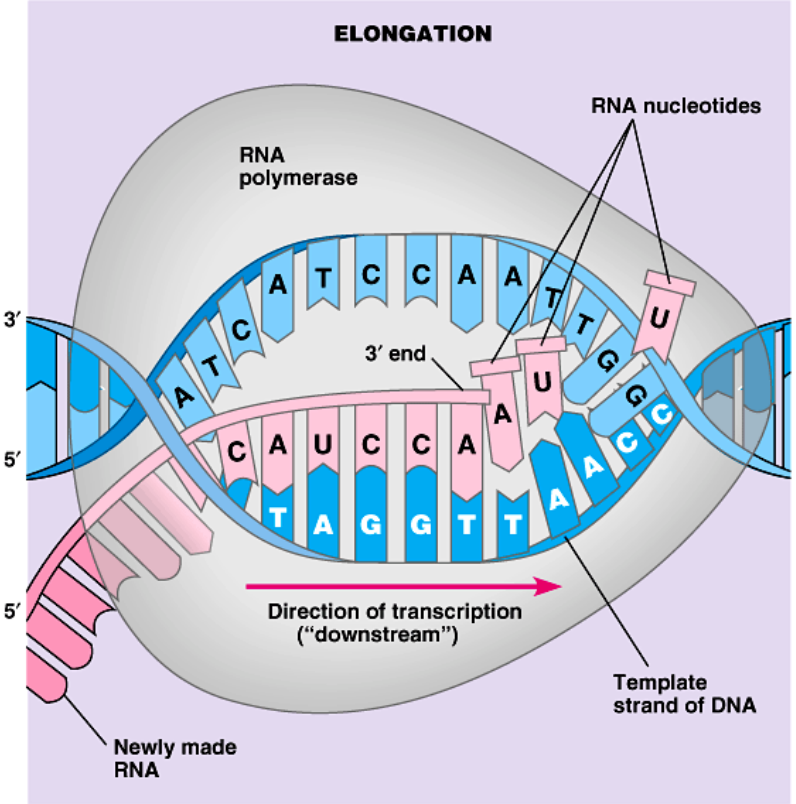
Elongation

- RNA polymerase synthesizes a new RNA
  - Adds in a 5’ to 3’ direction
  - Creates RNA anti-parallel to the template DNA strand
  - Based on complementary base pairing
  - Tri-phosphates, as with DNA replication



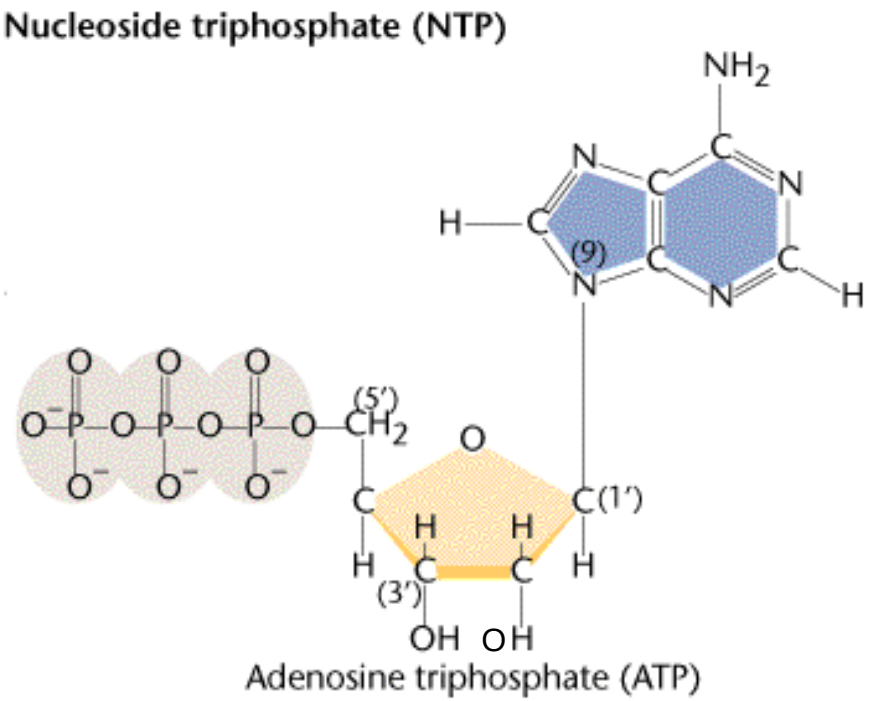
Elongation

- Only <u>one region</u> of <u>one DNA strand</u> is used as a template
  - The transcribed strand is called the "anti-sense" strand.
  - The non-transcribed strand is the "sense" strand because it has the same sequence (except T) as the new RNA strand.



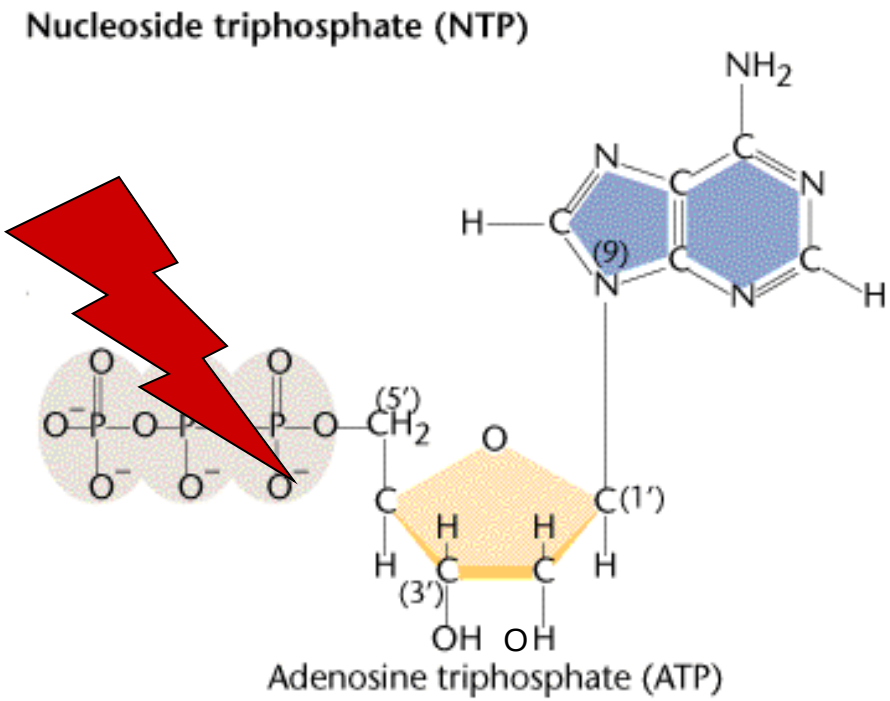
Elongation

- RNA polymerase adds nucleoside triphosphates (ATP, CTP, GTP and UTP) that pair with the exposed bases on one strand of the open DNA segment.



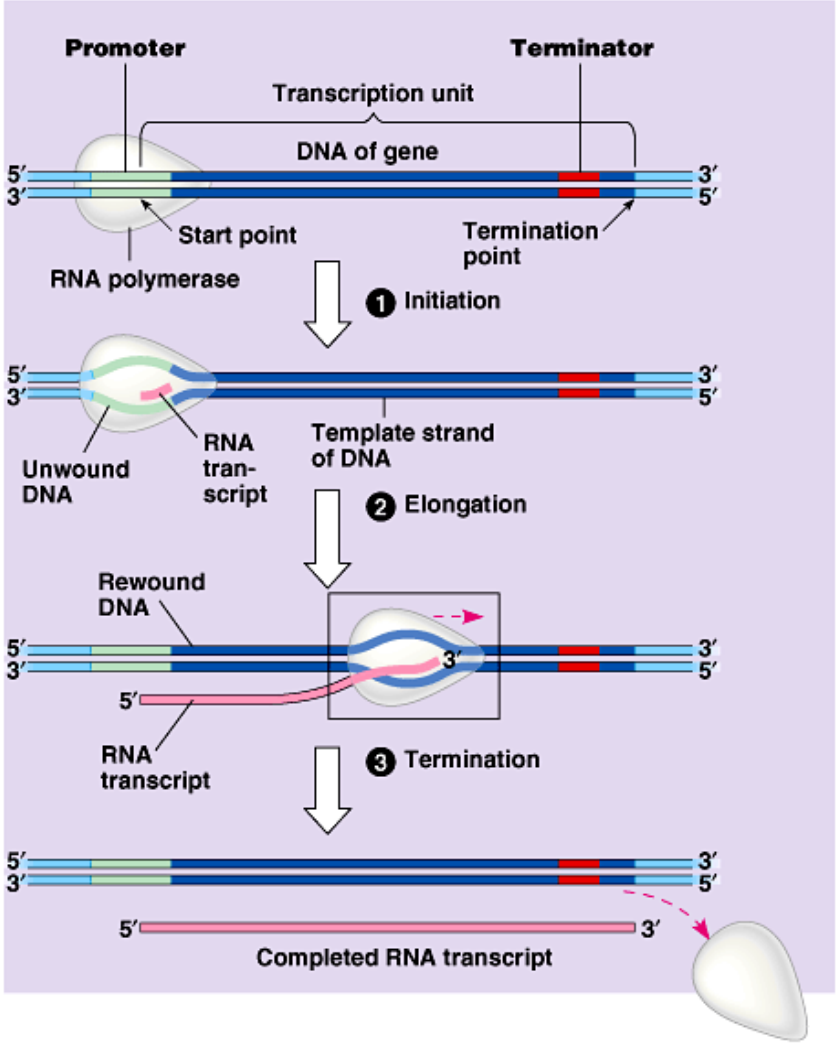
Elongation

- The energy necessary for the synthesis is provided by the breaking of the bond between the first and second phosphate in the triphosphates



Termination

- Transcription of the DNA continues until the RNA polymerase reaches a transcription terminator signal on the DNA, which dislodges the growing RNA strand and releases the polymerase.



Termination

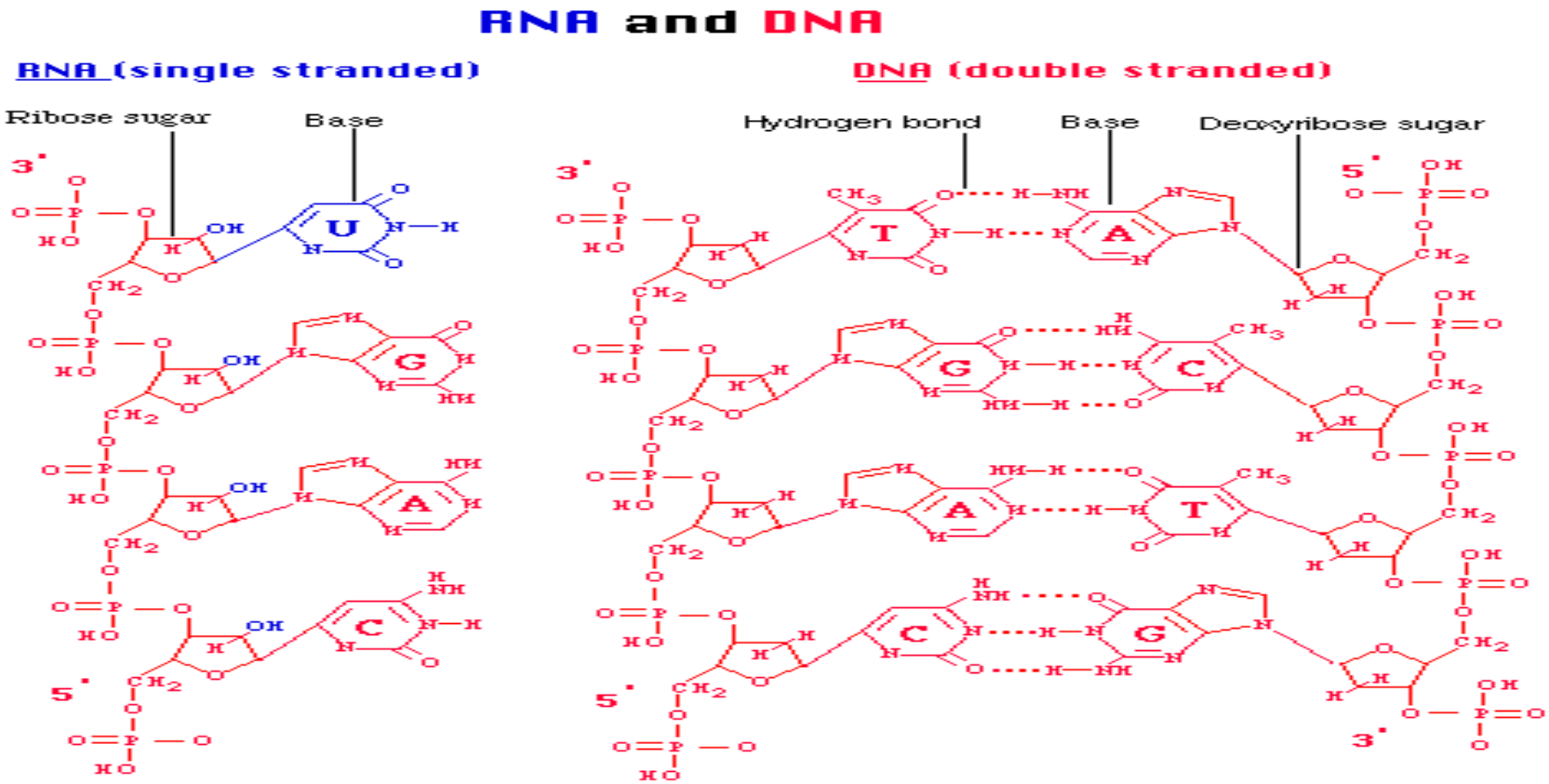
- Once the RNA for a particular region has been made, the double helix quickly reforms, displacing the growing single strand of RNA.

- Many RNA molecules can be transcribed from the same gene simultaneously.

- Transcription Animation

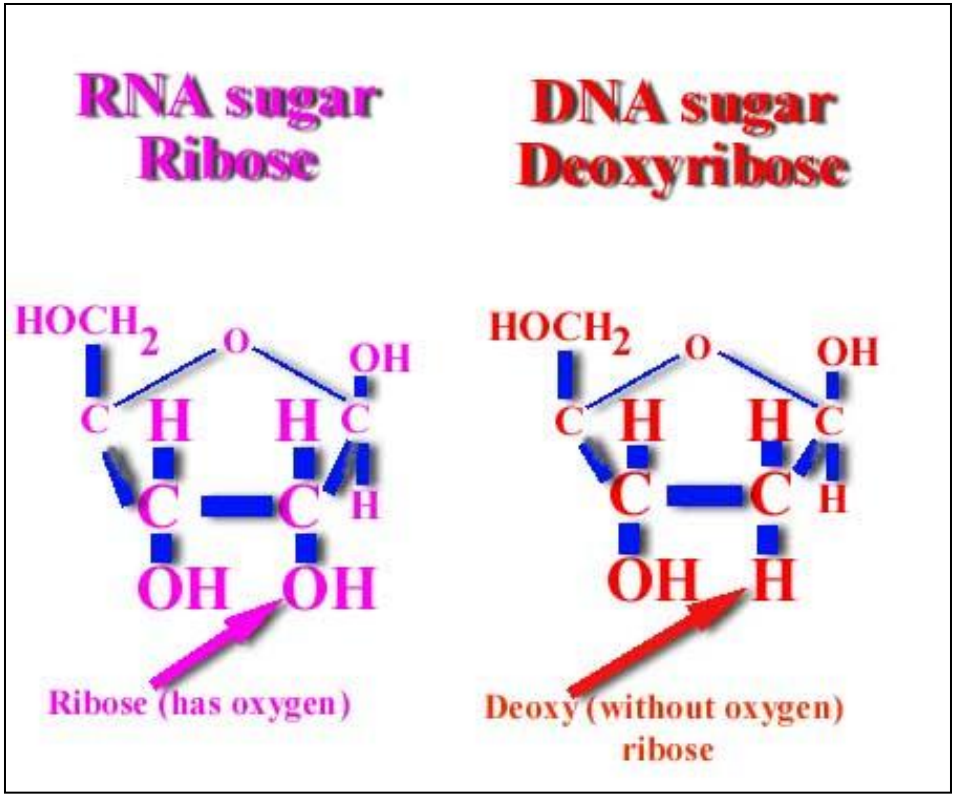
RNA differs from DNA in some ways:

- RNA is single stranded, DNA is double stranded
  - Although, RNA can base pair with itself



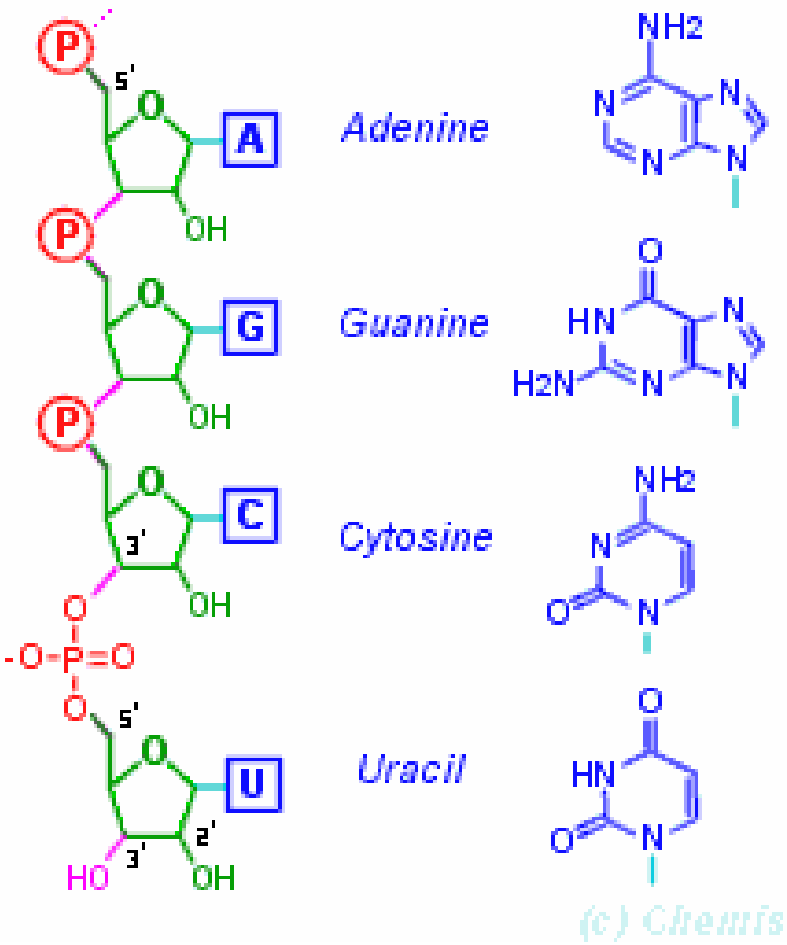
RNA differs from DNA in some ways:

- RNA has ribose sugar, not deoxyribose sugar



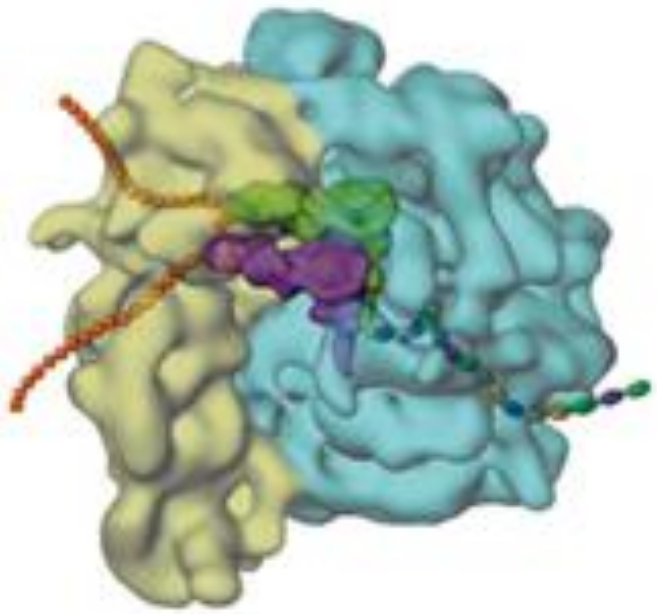
RNA differs from DNA in some ways:

- RNA bases are A, G, C and U (uracil), no T
  - Uracil is a pyrimidine and forms two hydrogen bonds with adenine



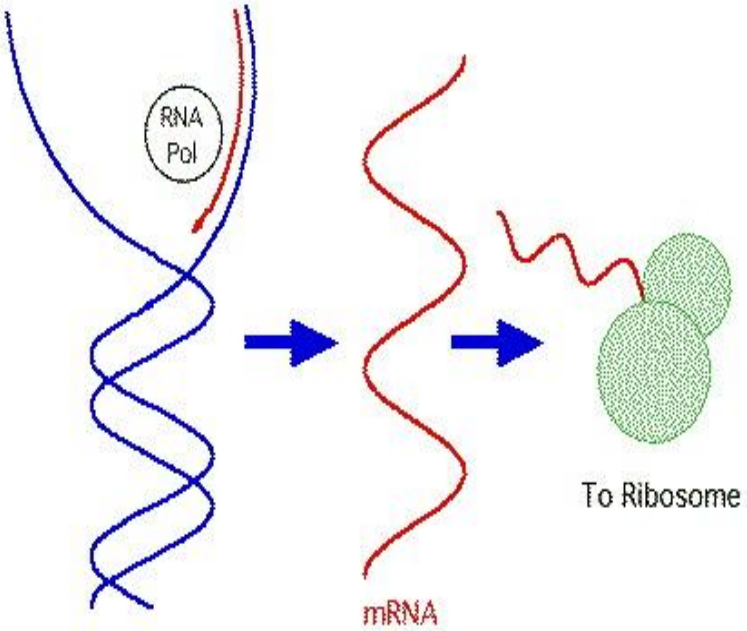
Classes of RNA

- Ribosomal RNA (rRNA)
  - The configuration is unknown but they are very large and contain thousands of nucleotides.
  - Inside the nucleolus, combines with special proteins to make ribosomes

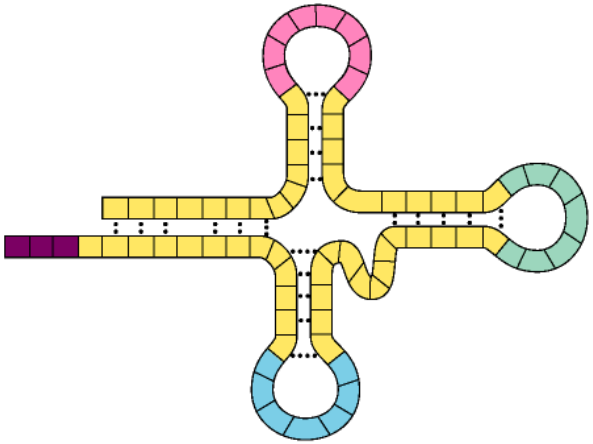


Classes of RNA

- Messenger RNA (mRNA)
  - Moves into cytoplasm where is becomes associated with ribosomes and starts protein synthesis.
  - Usually 75-300 nucleotides in length
  - Not folded

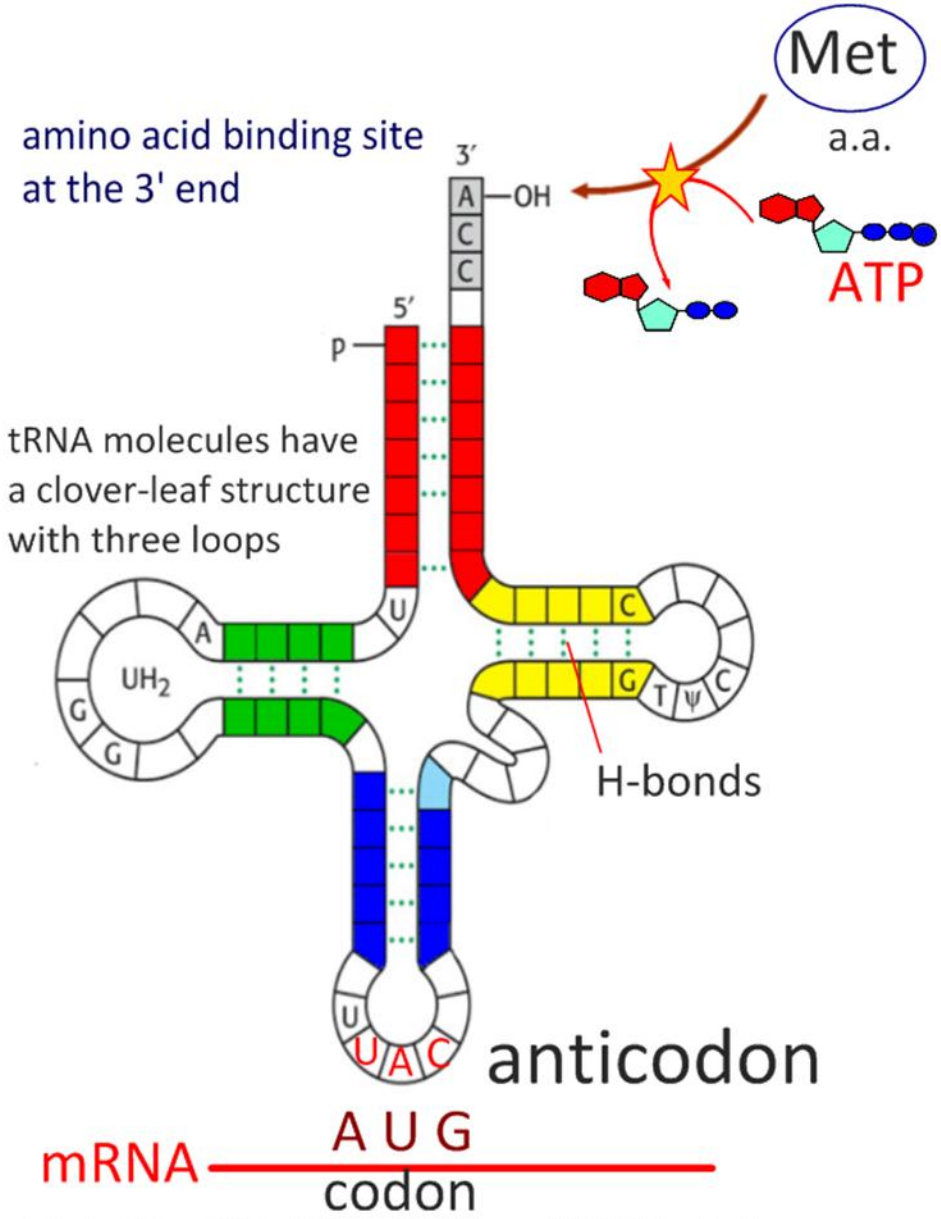


Classes of RNA



- Transfer RNA (tRNA)
  - 75-90 nucleotides in length
  - All cells have at least 20 different kinds (for carrying the 20 different amino acids).
  - The single strand folds back and base pairs with itself creating an “L” shaped double helix type of 3-D structure (Flattened out it looks like a ‘t’).
  - They bring amino acids to the ribosome.

tRNA is activated by a tRNA activating enzyme



http://molbioandbiotech.files.wordpress.com/2007/09/trna1.gif

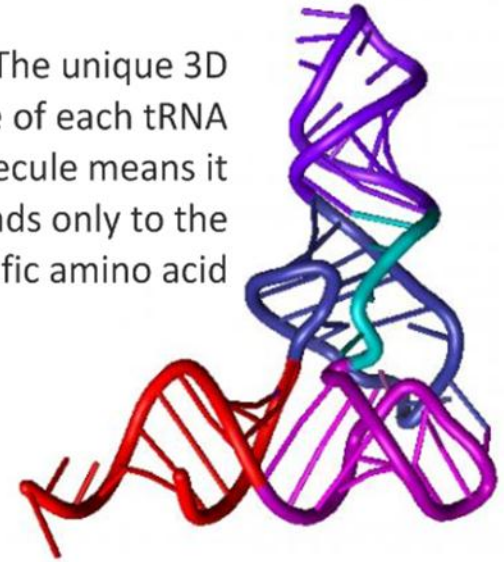
tRNA delivers amino acids to the growing polypeptide chain in translation.

It picks up new amino acids when activated by a specific tRNA activating enzyme.

This uses ATP.

There are 20 of these enzymes, corresponding to the 20 amino acids, for which the tRNA molecule has the complementary anticodon.

The unique 3D structure of each tRNA molecule means it binds only to the specific amino acid



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