Chapter 10: Protein Synthesis

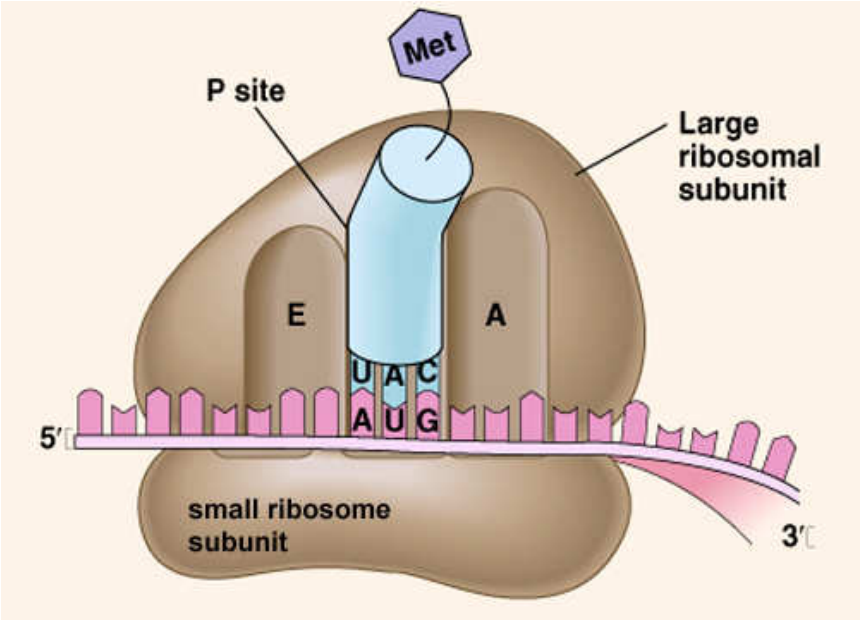
Biology

Let's Review

- What are proteins?
  - Chains of amino acids
  - Some are enzymes
  - Some are structural components of cells and tissues

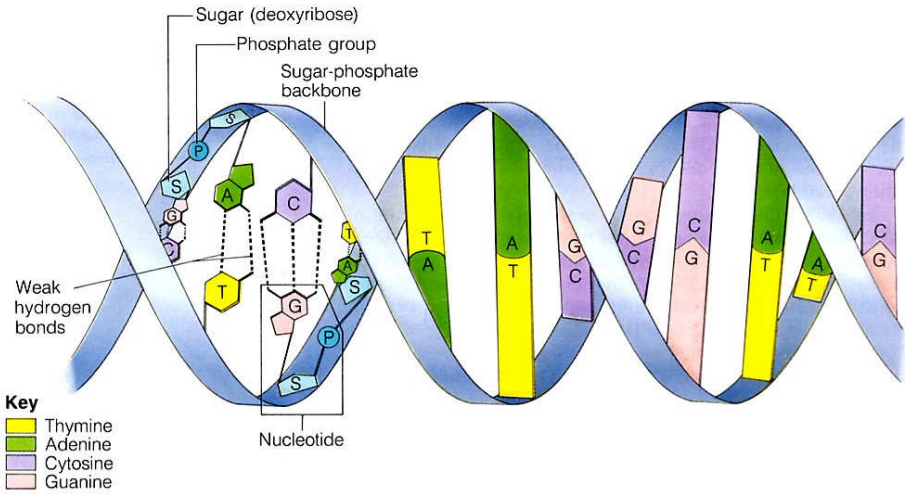
More Review

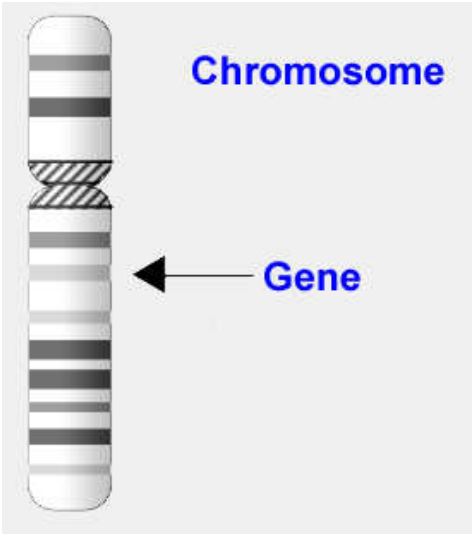
- What are ribosomes?
  - Cell structures built of protein and RNA
  - The site of protein synthesis



And More Review..

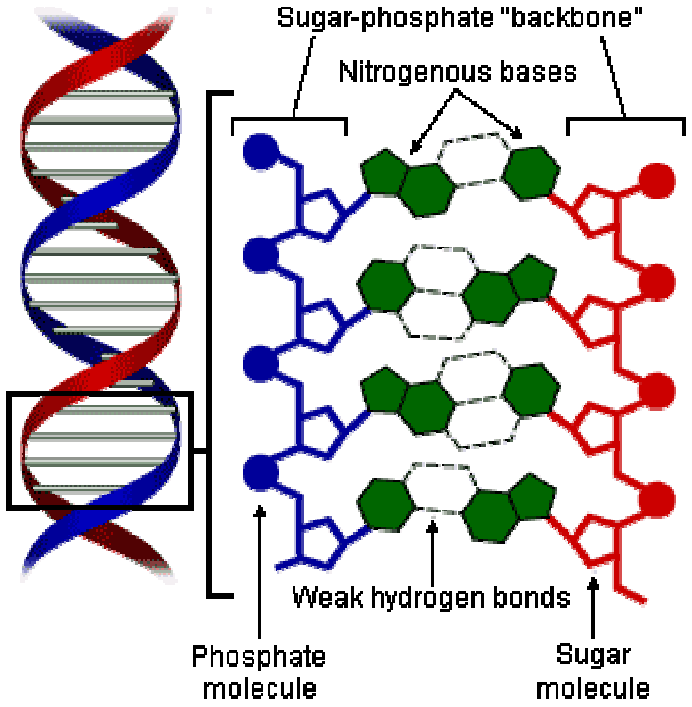
- What is the difference between DNA and genes?
  - DNA is a long molecule of nucleotides that contains many genes
  - Genes are short segments of DNA that code for a specific protein or RNA





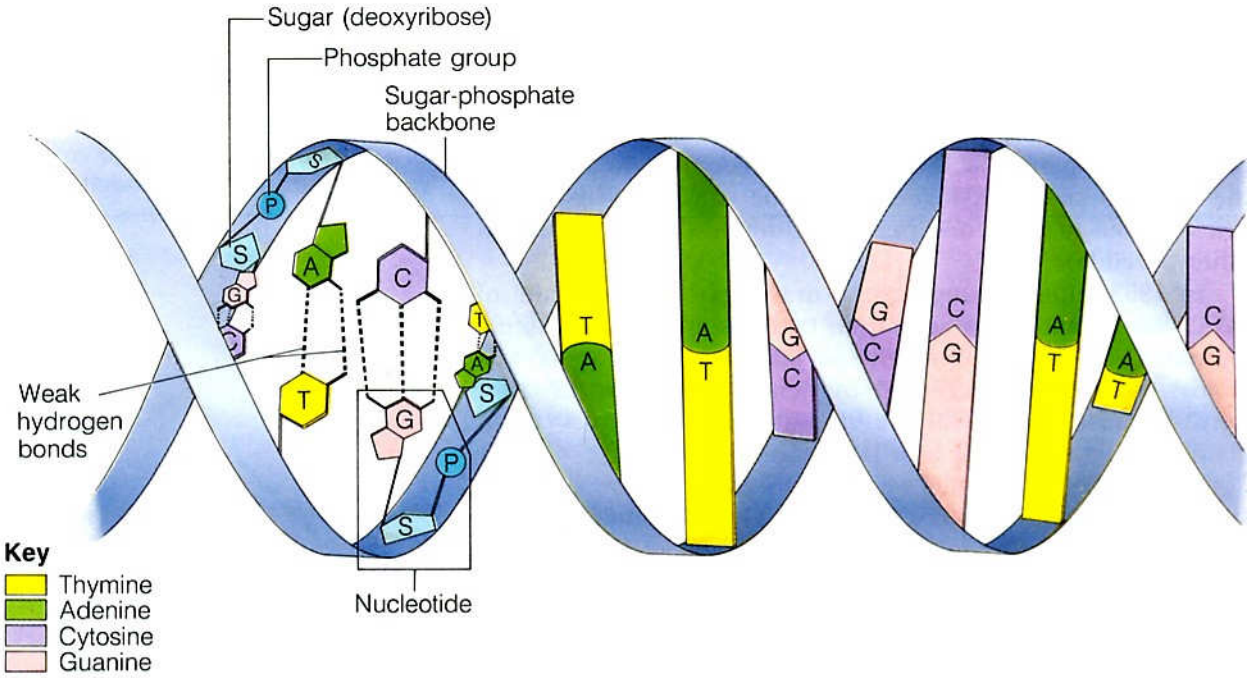
And more…

- What is the structure and function of DNA?
  - It is two strands of complementary nucleotides
  - Four bases – adenine, thymine, cytosine, guanine



And finally….

- What are the base-pairing rules?
  - Adenine pairs with thymine
  - Cytosine pairs with guanine



From Genes to Proteins

- Proteins are built according to instructions coded in DNA
- Proteins are not built directly from DNA
- RNA must be involved

Differences between RNA & DNA

- RNA is a ***single strand*** of nucleotides, DNA is double-stranded
- RNA contains the sugar ***ribose***, DNA contains deoxyribose
- RNA has adenine, cytosine, and guanine, but the fourth base is ***uracil***, DNA contains thymine as the fourth base

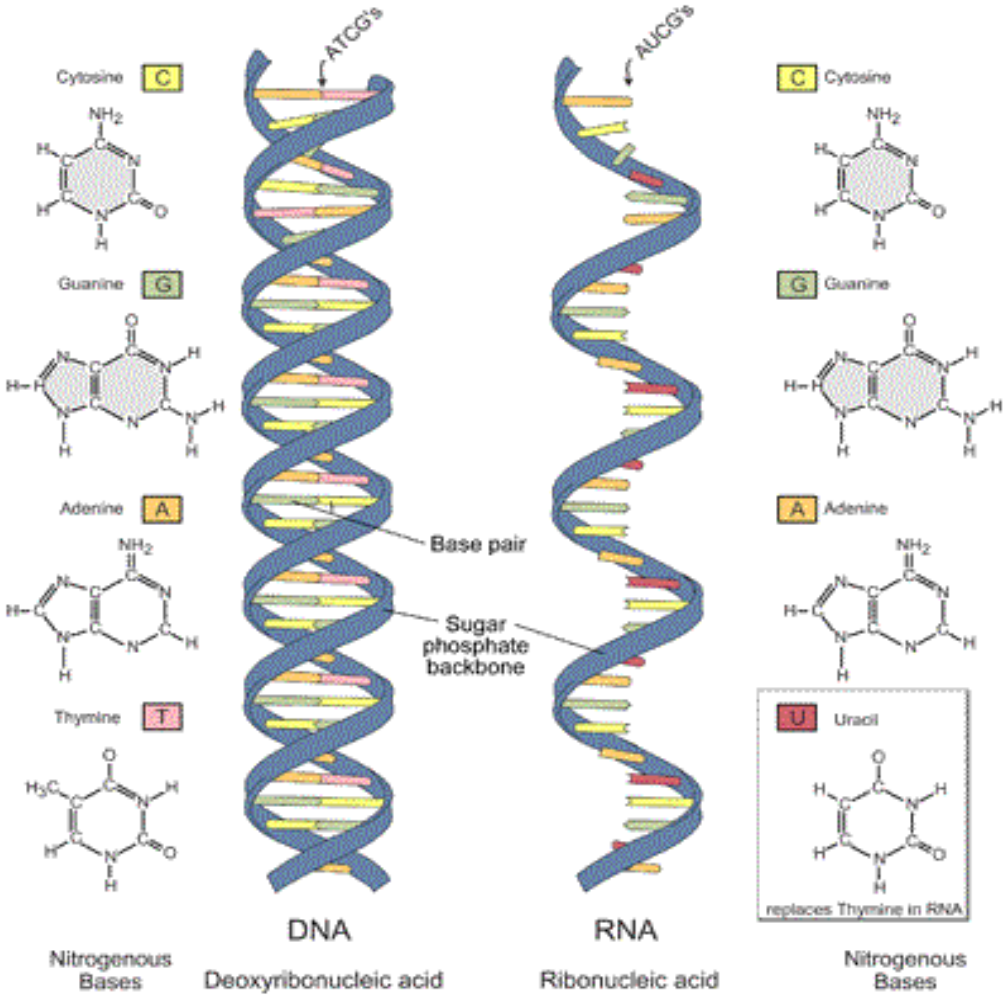
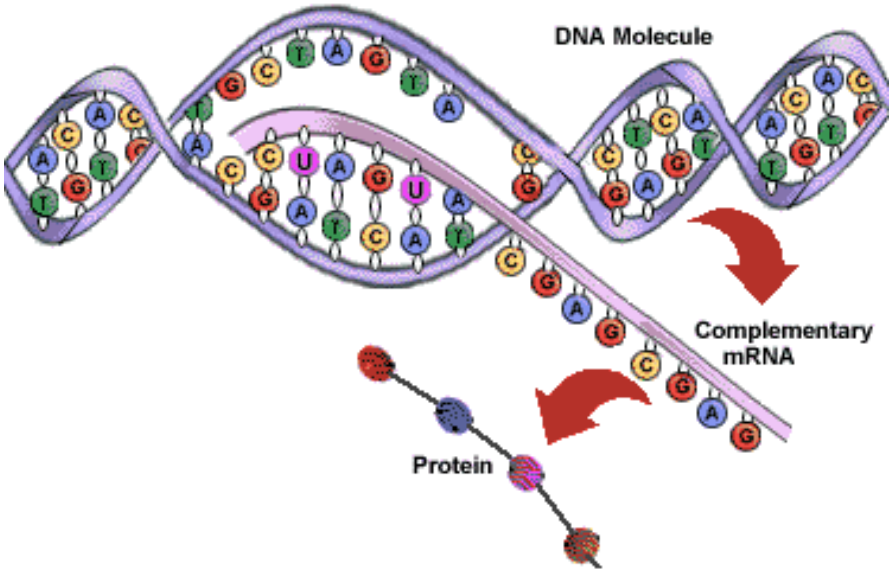


Image adapted from: National Human Genome Research Institute.

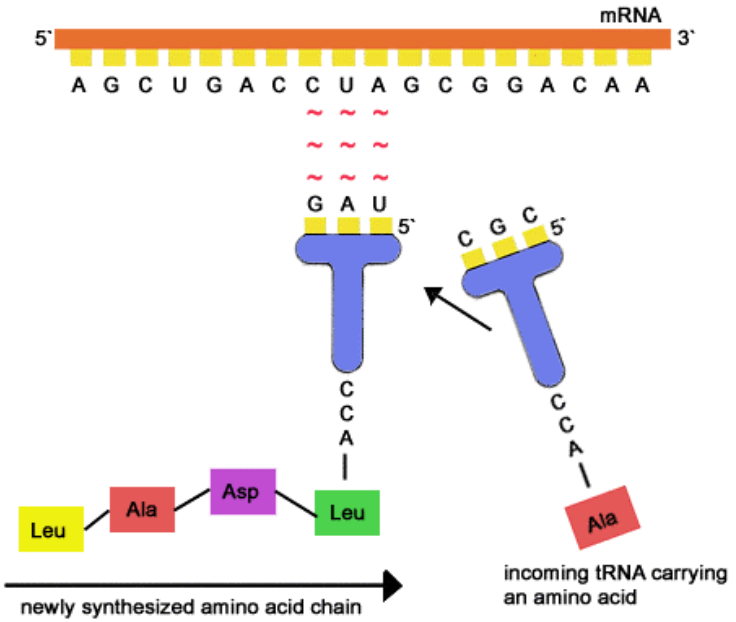
Transcription

- The process of transferring the instruction for the making of a protein from the gene to an RNA molecule



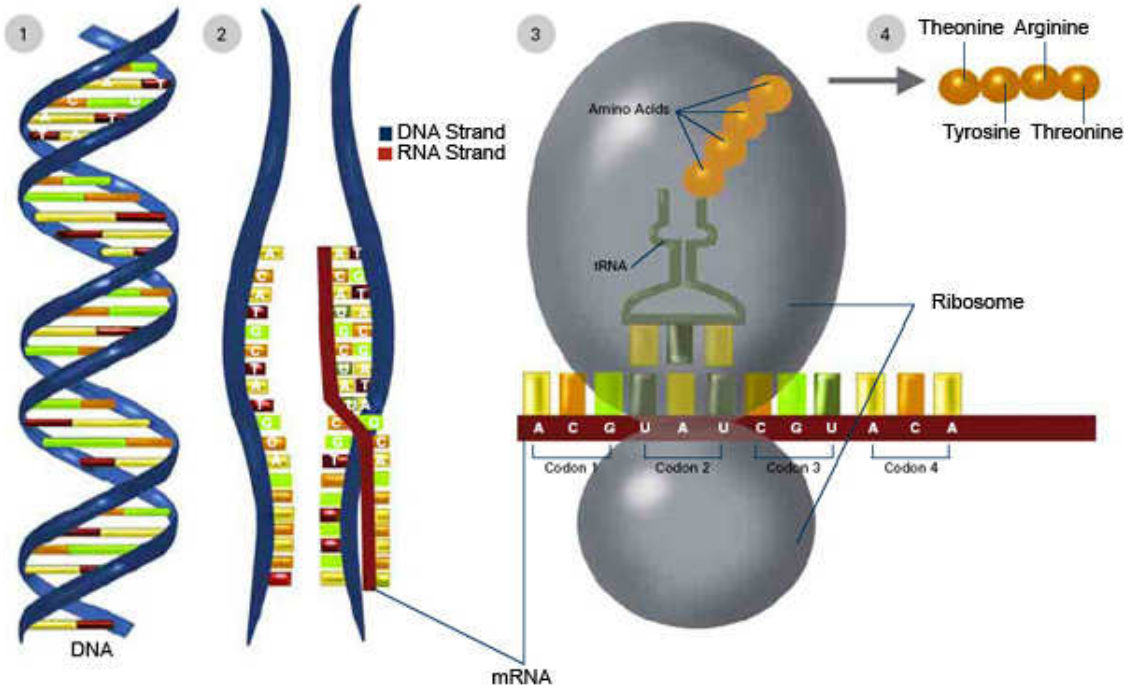
Translation

- The process of putting together the amino acids to make a protein by reading the instructions on the RNA molecule



Protein Synthesis

- The entire process of making proteins from the information that is encoded in DNA
- Also called ***gene expression***

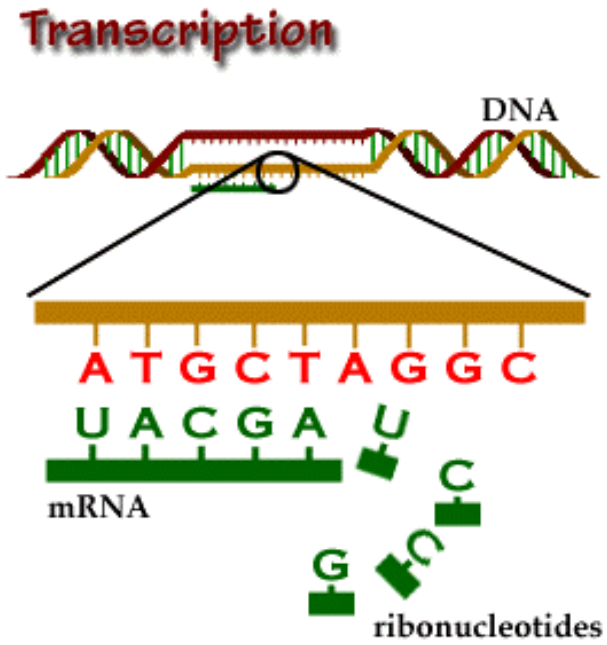


Transcription

- The first step – taking the information from a gene and transferring it to a molecule of RNA

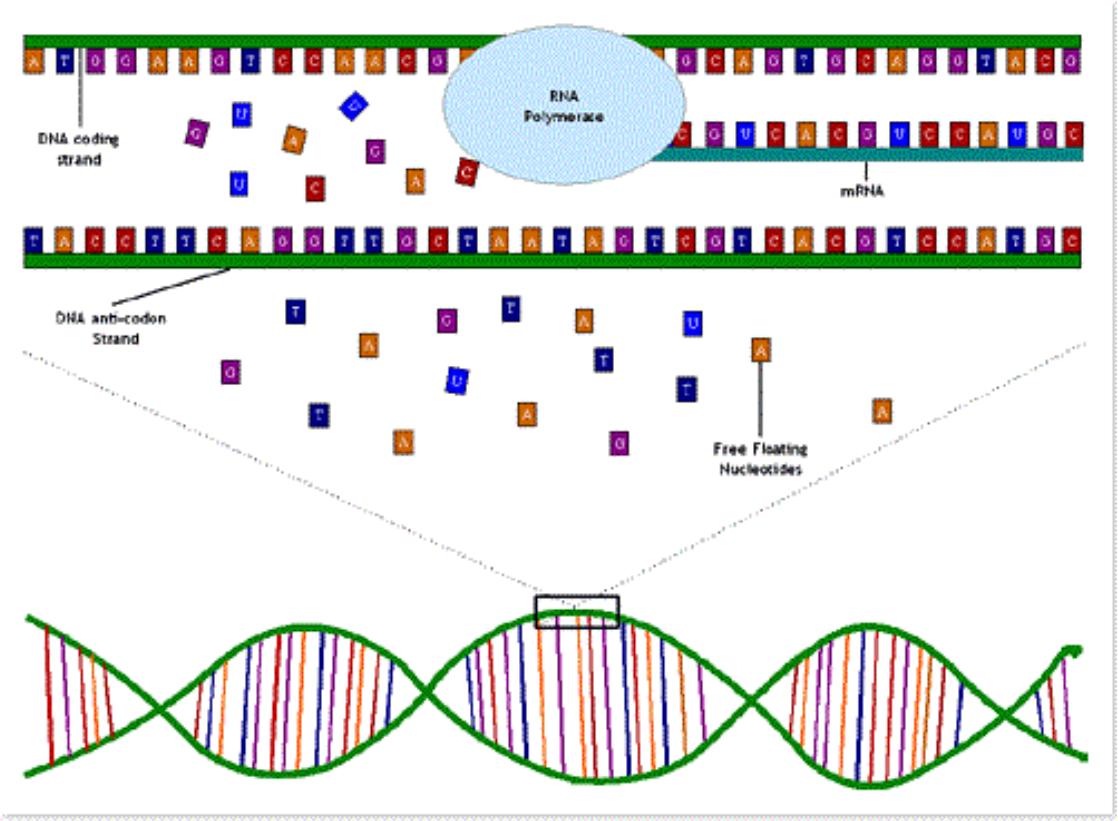
RNA polymerase

- An enzyme that adds and links the complementary RNA nucleotides together as it "reads" the DNA nucleotides



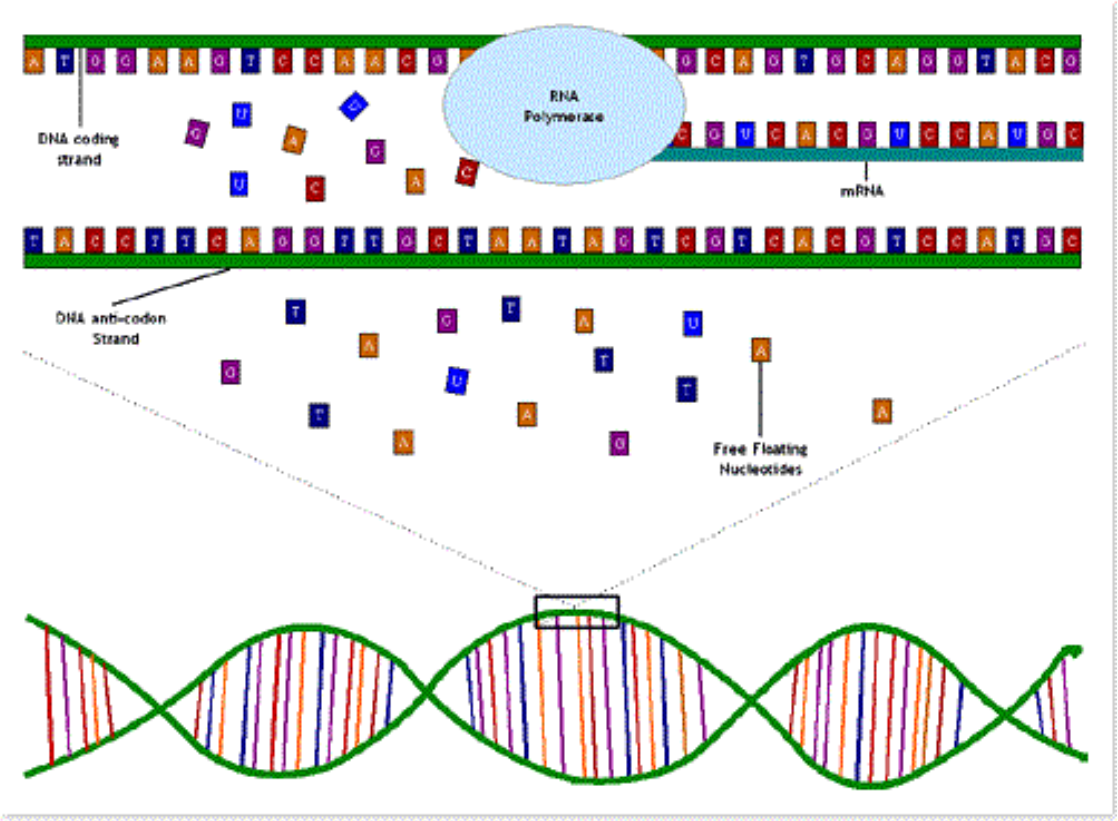
Transcription – Step 1

- RNA polymerase binds to the gene's promoter-the "start" sequence



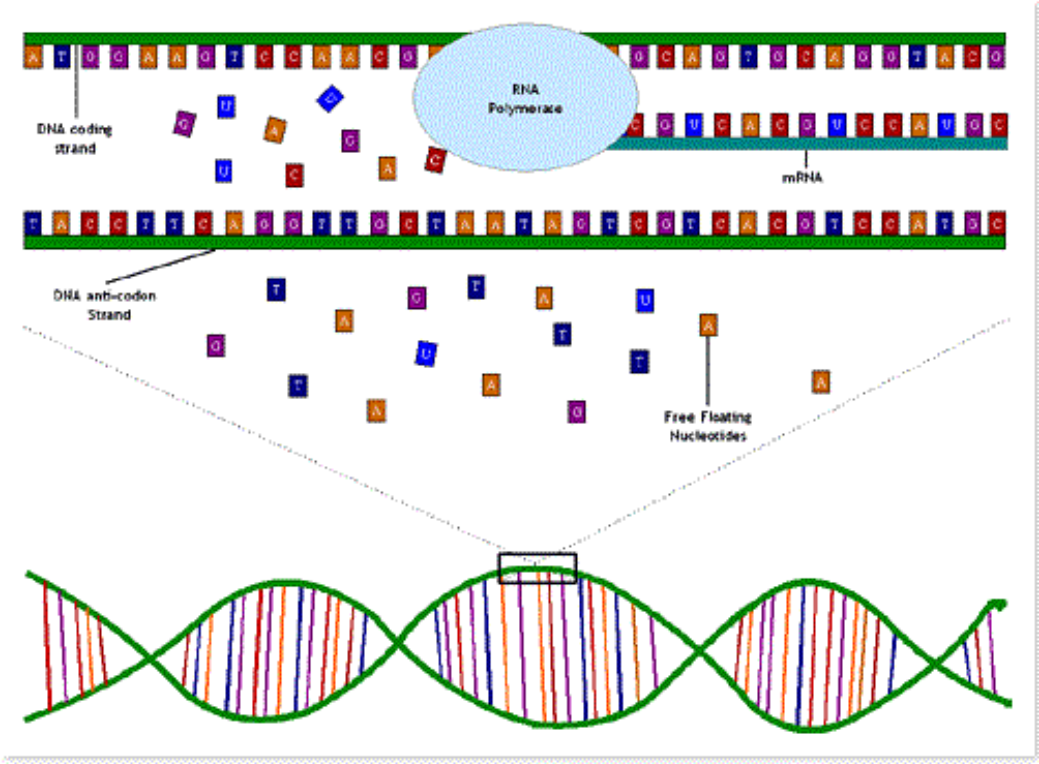
Transcription – Step 2

- RNA polymerase unwinds and separates the two DNA strands, exposing the nucleotides



Transcription – Step 3

- RNA polymerase adds and links RNA nucleotides as it "reads" the gene, following the base-pairing rules with cytosine paired to guanine and adenine paired to uracil



Stop signal

- Transcription proceeds until RNA polymerase reaches a “stop” sequence that marks the end of the gene

Formation of RNA strand

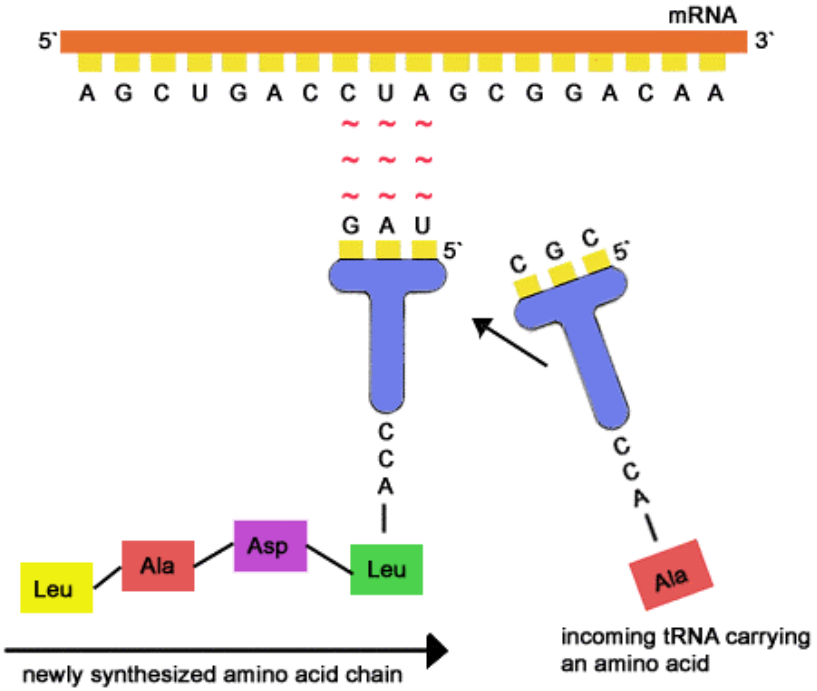
- RNA polymerase adds RNA nucleotides to the single strand of RNA and these link together with covalent bonds
- As the RNA polymerase travels down the strand, the DNA double strand closes up behind it
- Only one part of the DNA strand serves as a template

Transcription

- Takes place in the nucleus of eukaryotic cells
- Takes place in the cytoplasm of prokaryotic cells

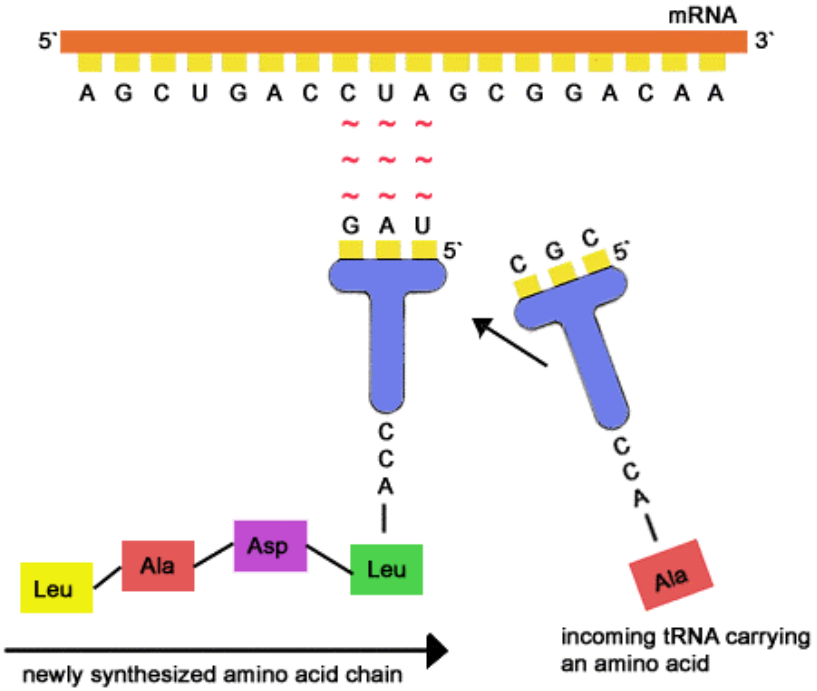
Messenger RNA

- This is the type of RNA that is made when the cell needs a particular protein
- This type of RNA carries the instructions for the protein to the site of translation



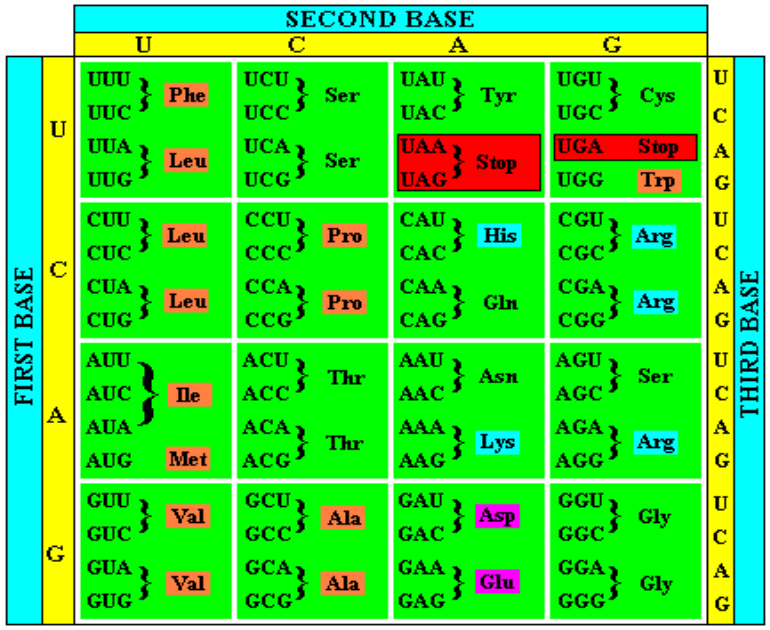
Translation

- The nucleotides are "translated" from the language of nucleotides to the language of proteins
- The RNA instructions are written in 3-nucleotide sequences called ***codons***



The genetic code

- The codons code for a specific amino acid
- The amino acids and the start and stop signals coded by each of the possible codons is arranged in a chart-the genetic code

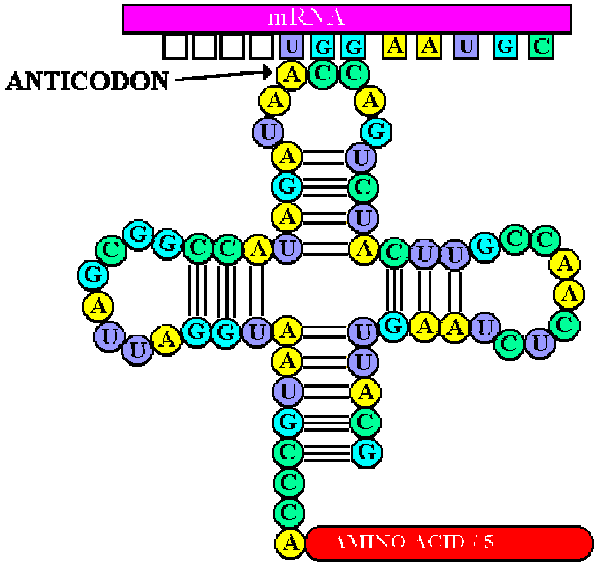


Translation

- Takes place in the cytoplasm
- Ribosomes and RNA molecules help create the protein

tRNA

- Transfer RNA are single strands of RNA that temporarily hold a specific amino acid on one end of their structure
- It is folded into a compact cloverleaf shape, and has an anticodon
- Anticodon – a 3-nucleotide sequence that is complementary to an mRNA codon

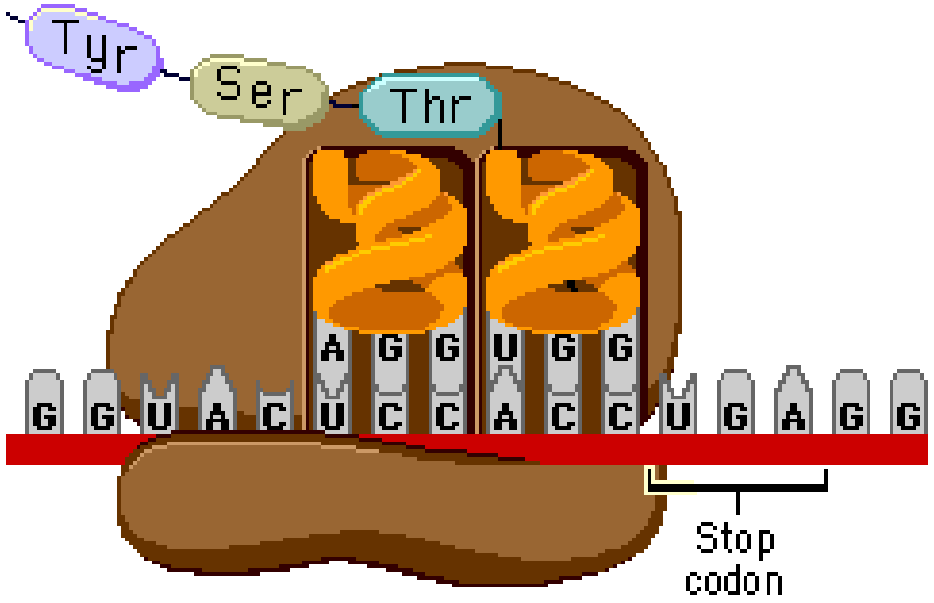


rRNA

- Ribosomal RNA are RNA molecules that make up part of the ribosome
- A cell's cytoplasm has thousands of ribosomes

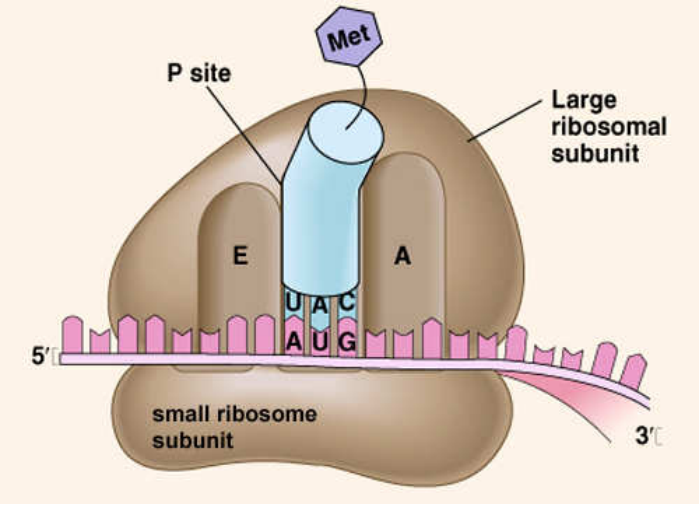
Ribosome

- Each temporarily holds one mRNA and two tRNA molecules



7 Steps of Translation –Step 1

- Step 1: mRNA, tRNA carrying methionine, and 2 ribosomal subunits bind together
  - The mRNA, the 2 ribosomal subunits, and the tRNA carrying methionine form a functional ribosome
  - The mRNA start codon "AUG" is oriented in the P site of the ribosome, so the tRNA can bind to the start codon



7 Steps of Translation

- Step 2: The tRNA carrying the amino acid specified by the codon in the A site arrives
  - The tRNA with the complementary anticodon binds to the codon in the A site

7 Steps of Translation

- Step 3: Enzymes help form a peptide bond between the two amino acids
  - The A and the P site are occupied by tRNA molecules with their specific amino acids
  - Peptide bonds will join the adjacent amino acids to form an amino acid chain

7 Steps of Translation

- Step 4: The tRNA in the P site will detach leaving behind the amino acid

7 Steps of Translation

- Step 5: The tRNA and associated mRNA in the A site shift over to the P site
  - This occurs in such a way that the entire ribosome shifts, so that the A site has a new codon of the mRNA unit
  - The tRNA with the complementary anticodon binds to the new codon in the A site

7 Steps of Translation

- Step 6: The tRNA in the P site detaches, leaving its amino acid

7 Steps of Translation

- Steps 2 – 6 are repeated until the "stop" codon is reached
  - The stop codon does not have a tRNA with a complementary anticodon, so protein synthesis stops
  - The stop codons are: UAG, UAA, or UGA
  - The new protein is released into the cell