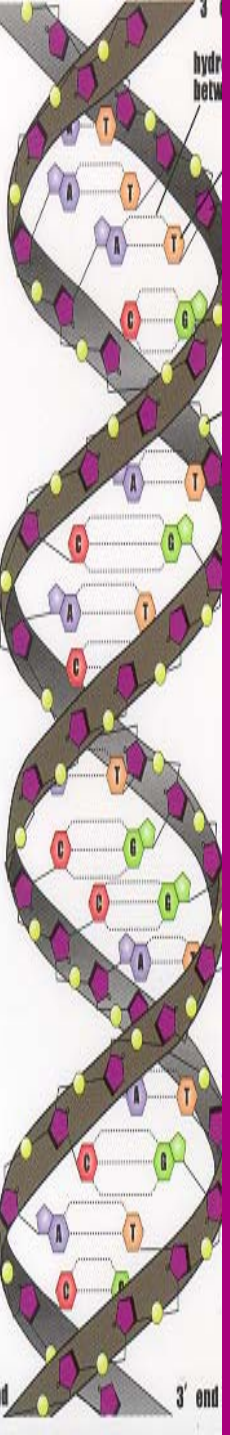
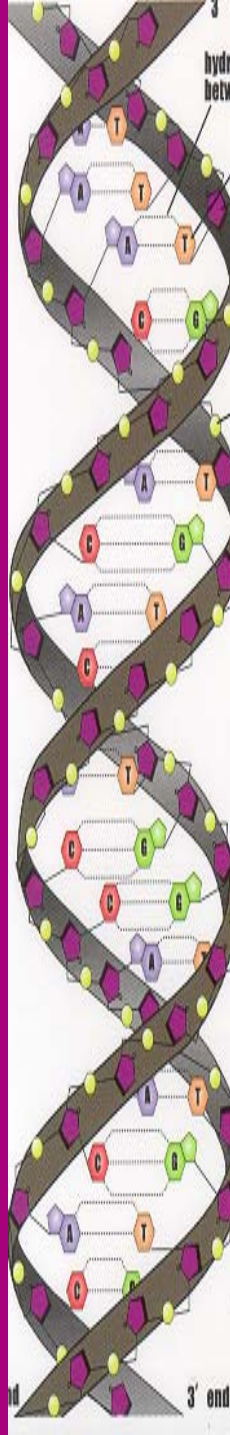


Protein Synthesis

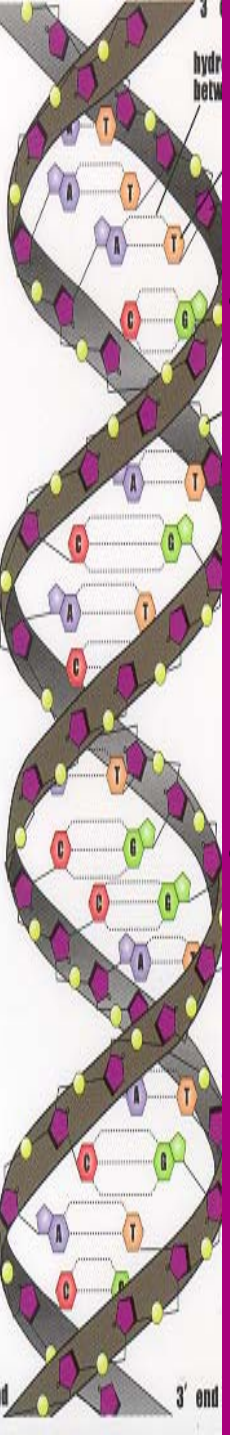
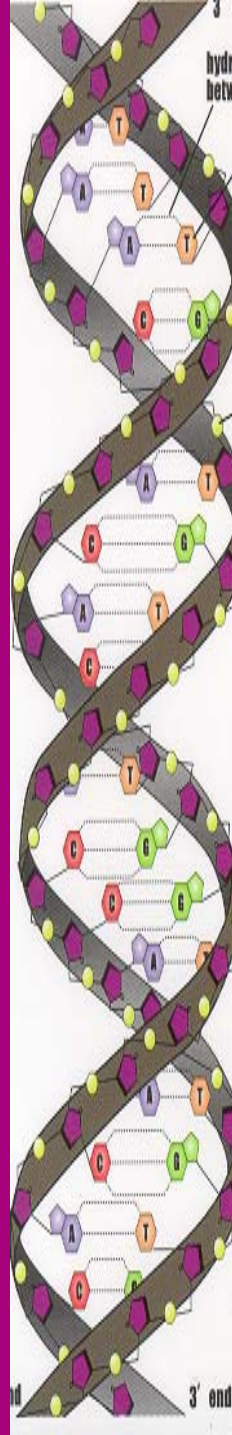
DNA to RNA to Protein



From Genes to Proteins

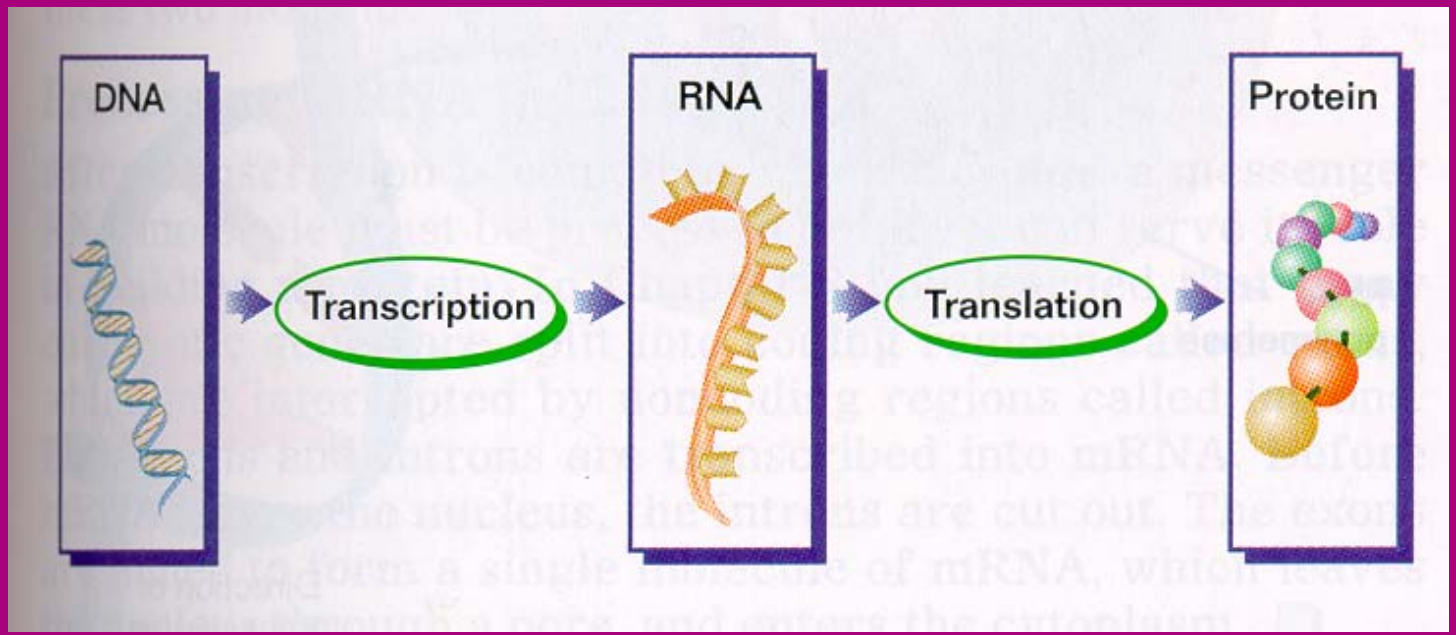
- Processing the information contained in DNA into proteins involves a sequence of events known as gene expression and results in protein synthesis.

- Proteins are not built directly from genes; hereditary information is transferred from DNA to a working set of directions - RNA

From Genes to Proteins

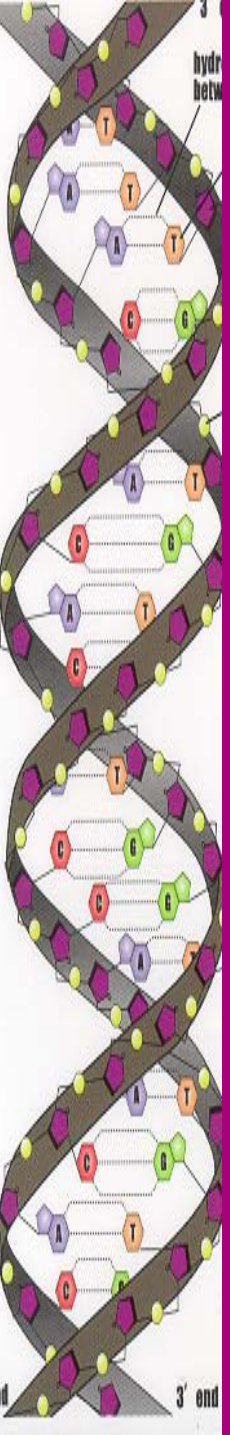
- Gene expression occurs in two steps:
  - transcription
  - translation



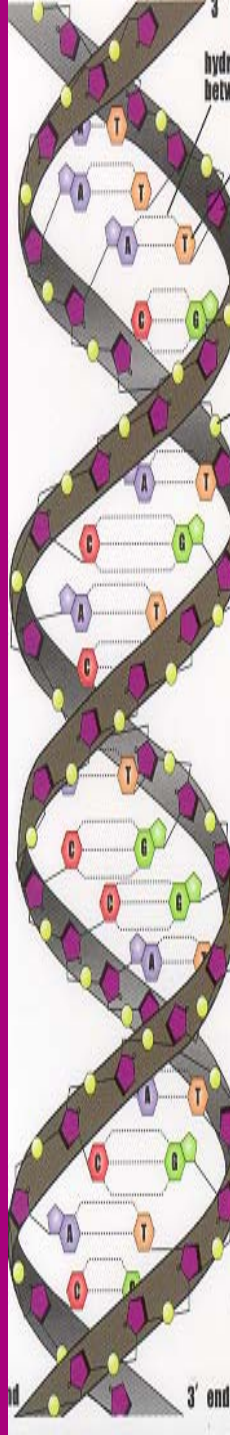
RNA

- In eukaryotes, the genes directing protein production are in the nucleus and the enzymes and amino acid building blocks for proteins are found at the **ribosomes** in the cytoplasm.
- Before proteins are made from these genes, an **RNA** molecule must be made
- RNA, **r**ibo**n**ucleic **a**cid, is responsible for taking the genetic information from the DNA in the nucleus to the site of protein synthesis.

Structure of RNA

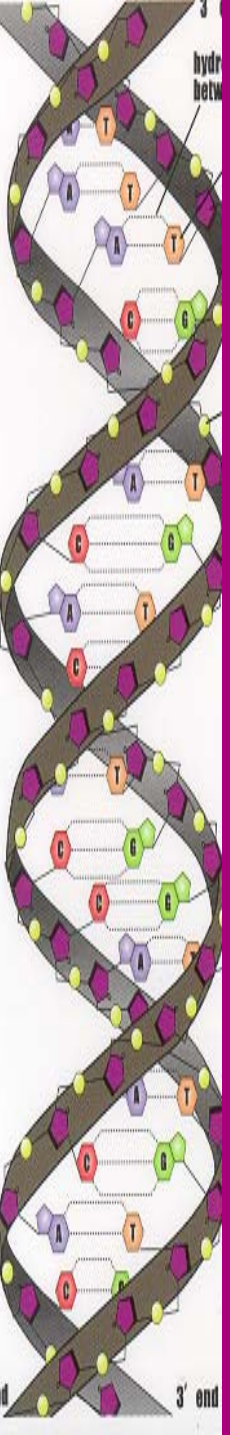
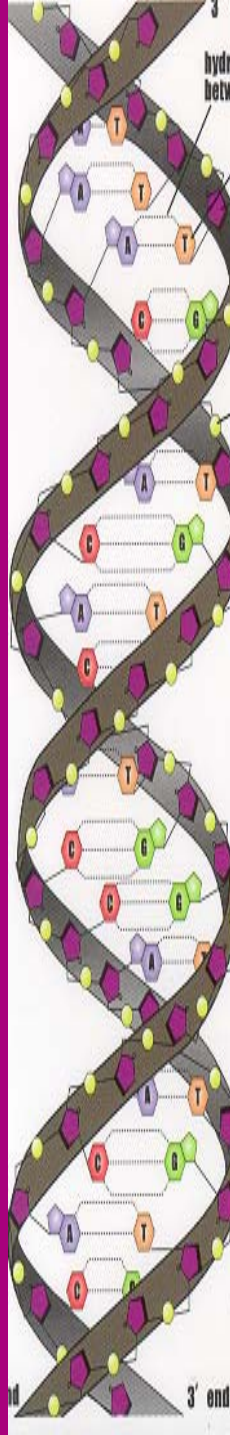


- RNA differs from DNA in three main ways:
  - RNA is single stranded
  - RNA contains ribose not deoxyribose
  - RNA contains uracil (U) not thymine (bonds with adenine)



Types of RNA

- Three types of RNA are essential for gene expression:
  - **mRNA** - carries information from DNA to ribosomes (working copy of DNA)
  - **tRNA** - carries amino acids to ribosomes
  - **rRNA** - plays a structural role in ribosomes

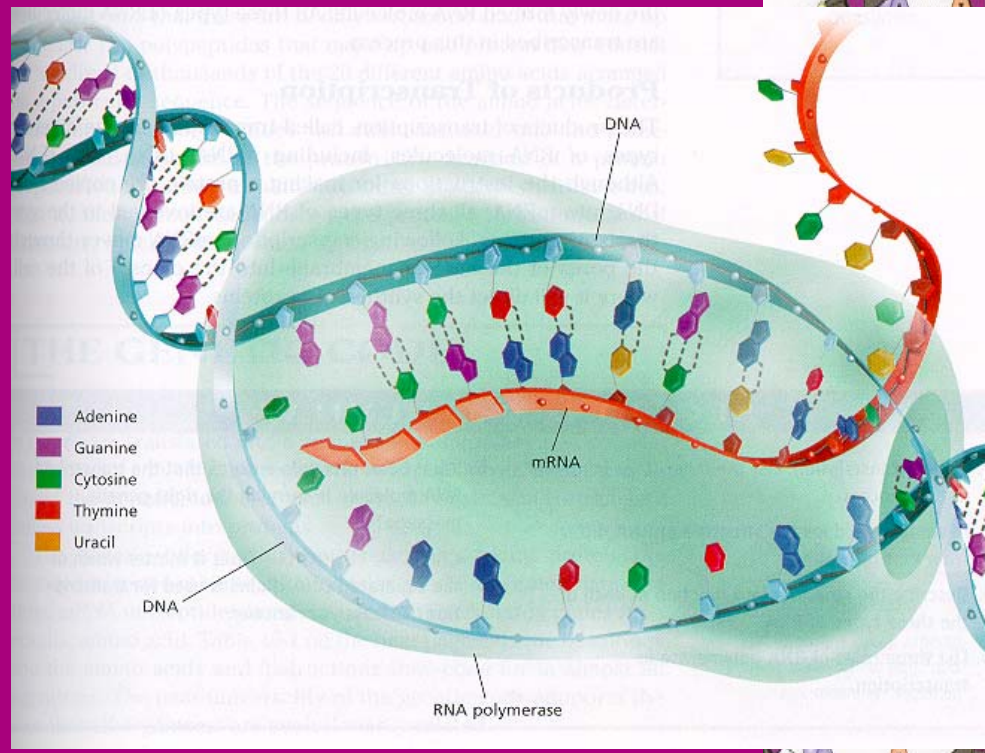



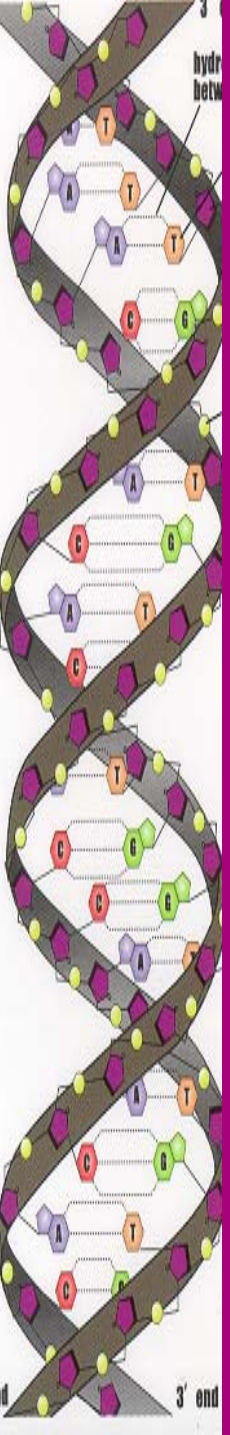
Transcription

Overview:

- Cell assembles a molecule of RNA using DNA as a template.
- In eukaryotic organisms this takes place in the nucleus

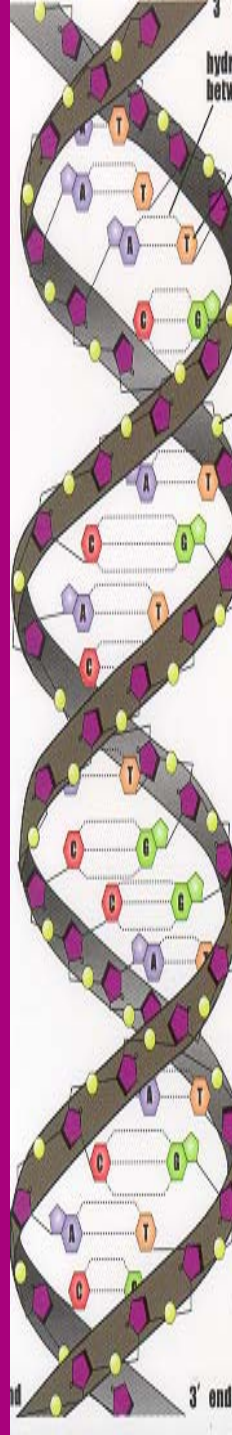
- **Steps**:
  - Transcription begins when **RNA polymerase** binds to a region of DNA called a **promoter** - a start signal on the DNA



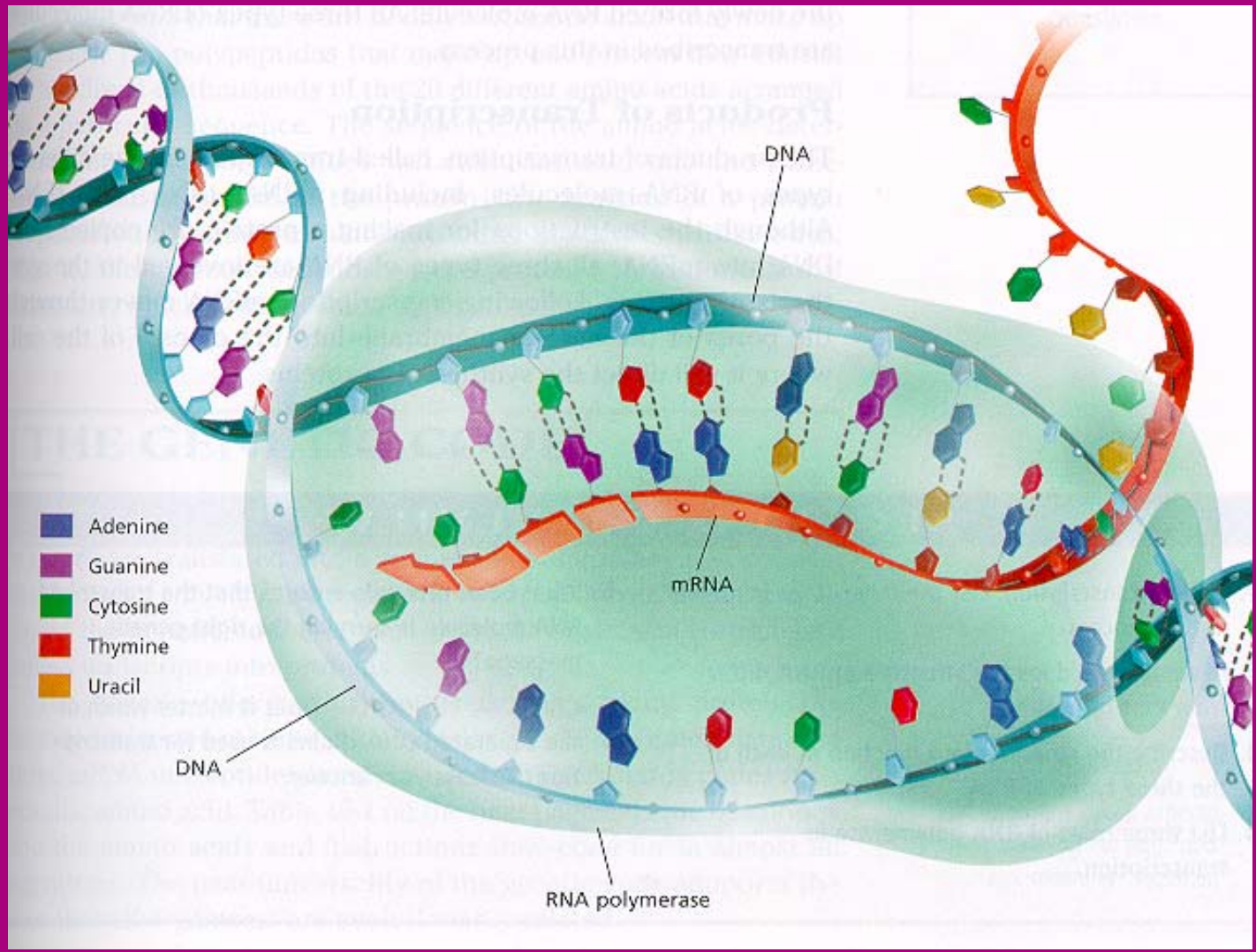


Steps of Transcription

- DNA unwinds and unzips - exposing nitrogen bases; one strand serves as template
- RNA polymerase moves down strand, reads each nucleotide and pairs it with a complementary RNA base
- single stranded RNA grows @ 60 nucleotides/sec
- RNA polymerase continues until it reaches a stop signal - **terminator**
- DNA rezips after polymerase passes by

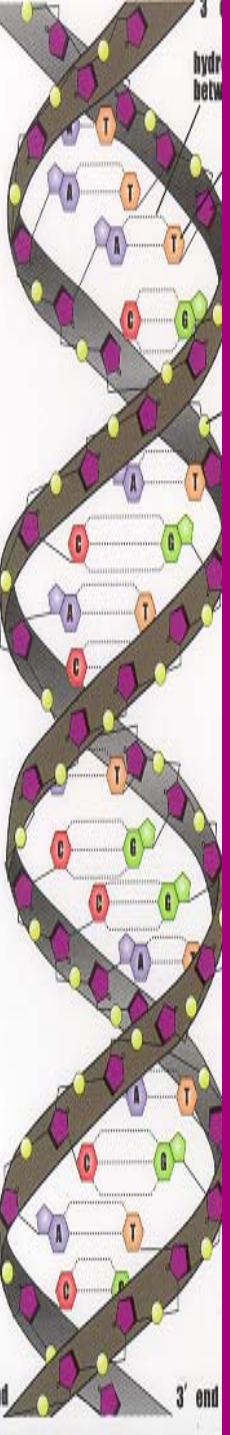


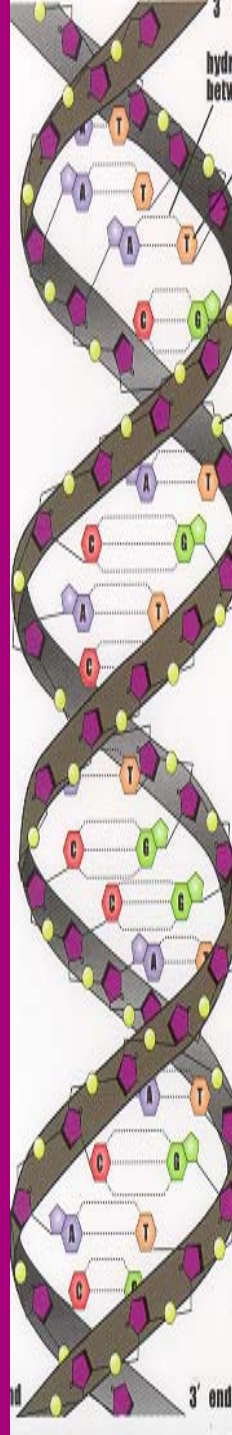
Transcription

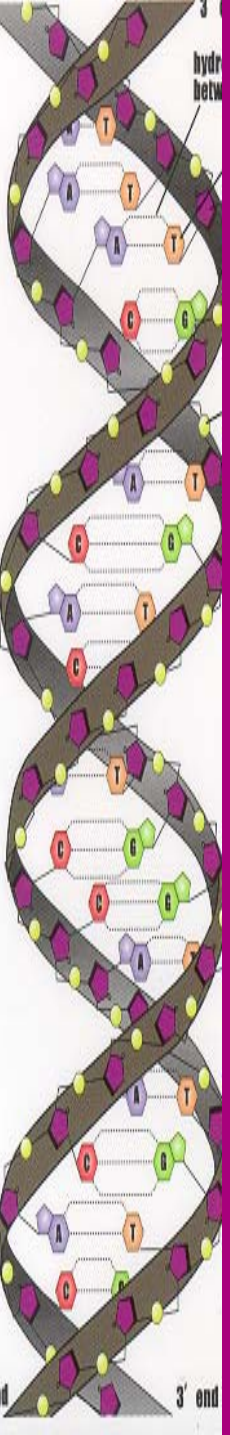


Protein Synthesis

- Proteins are made up of one or more polypeptides, each of which consists of a specific sequence of amino acids linked together by peptide bonds.
- There are 20 types of amino acids that make up proteins.
- The sequence of these amino acids (originally determined in the DNA code) determines the structure and function of the proteins.

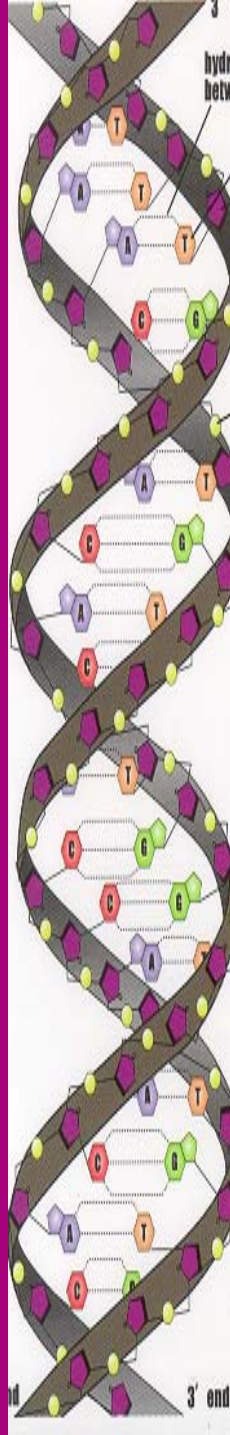






Genetic code

- All organisms have a genetic code made of three-nucleotide sequences called **codons.** The codon is located on the mRNA.
- Each of the 64 mRNA codons corresponds to a specific amino acid, a start or a stop signal
- The genetic code is nearly universal. Sequences code for the same amino acids in different organisms



Genetic code

	U	C	A	G	
U	Phe	Ser	Tyr	Cys	U
	Phe	Ser	Tyr	Cys	C
	Leu	Ser	stop	stop	A
	Leu	Ser	stop	Trp	G
C	Leu	Pro	His	Arg	U
	Leu	Pro	His	Arg	C
	Leu	Pro	Gln	Arg	A
	Leu	Pro	Gln	Arg	G
A	Ile	Thr	Asn	Ser	U
	Ile	Thr	Asn	Ser	C
	Ile	Thr	Lys	Arg	A
	Met	Thr	Lys	Arg	G
G	Val	Ala	Asp	Gly	U
	Val	Ala	Asp	Gly	C
	Val	Ala	Glu	Gly	A
	Val	Ala	Glu	Gly	G

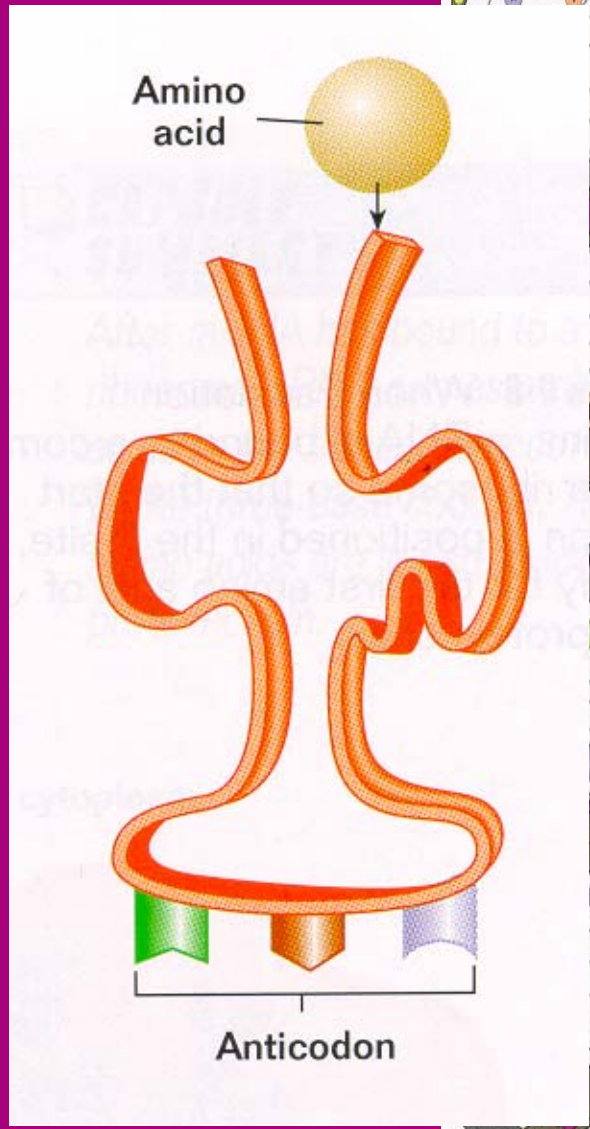
Translation

- **Overview:**
  - Cell produces a protein
  - Occurs at the ribosome in the cytoplasm where the cell keeps its supply of tRNA

- **Tools of translation** (in addition to mRNA)
  - tRNA
  - Ribosomes (rRNA)

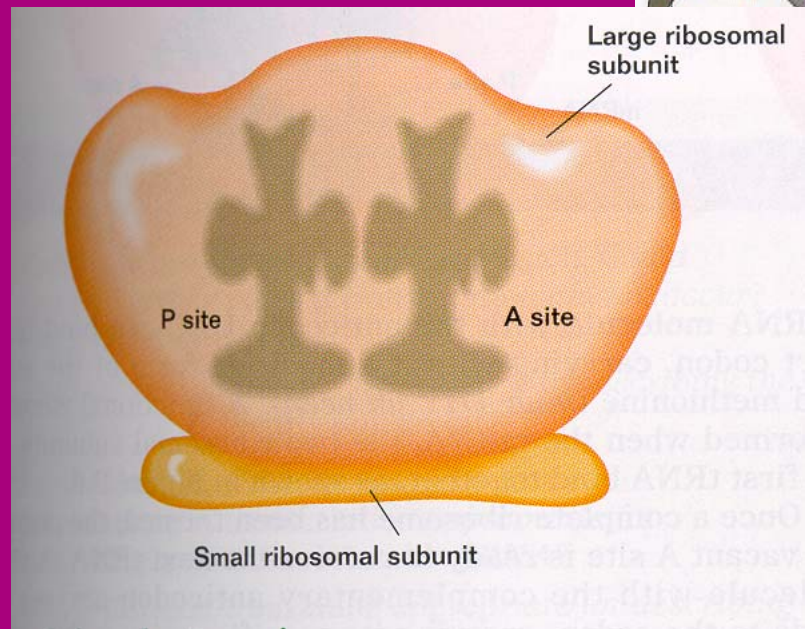
tRNA

- tRNA is a single stranded RNA molecule that is folded into a cloverleaf
- One of the loops has a three nucleotide sequence called an **anticodon** which complements the mRNA codon
- Opposite the anticodon is a site for attachment of a.a. which corresponds to a particular codon



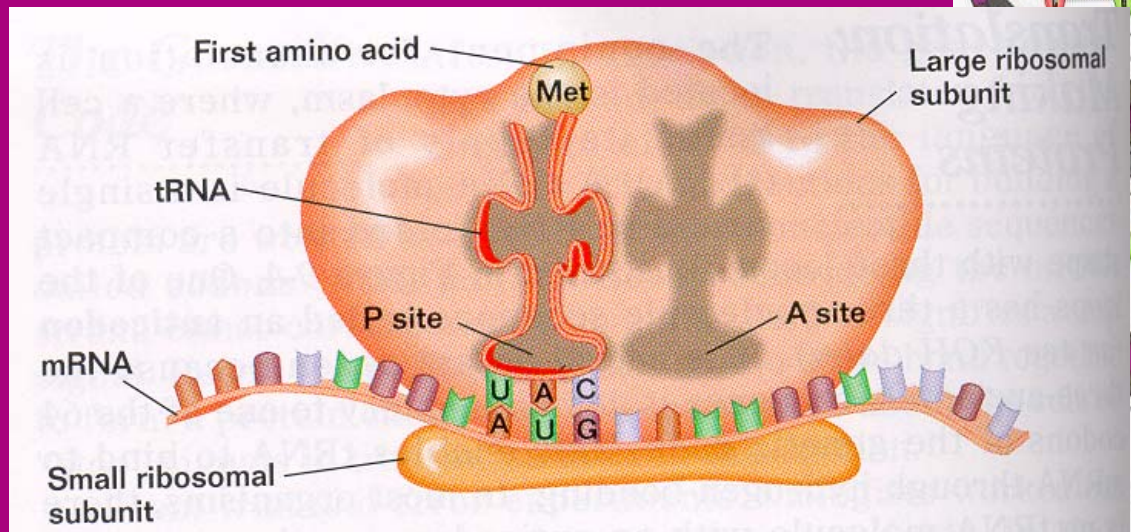
Ribosomes

- Ribosome are composed of rRNA and proteins.
- Ribosomes have three binding sites:
  - one site to hold mRNA with open codon
  - A site - holds tRNA molecule carrying a.a.
  - P site - also holds t RNA and attaches a.a. to growing protein chain



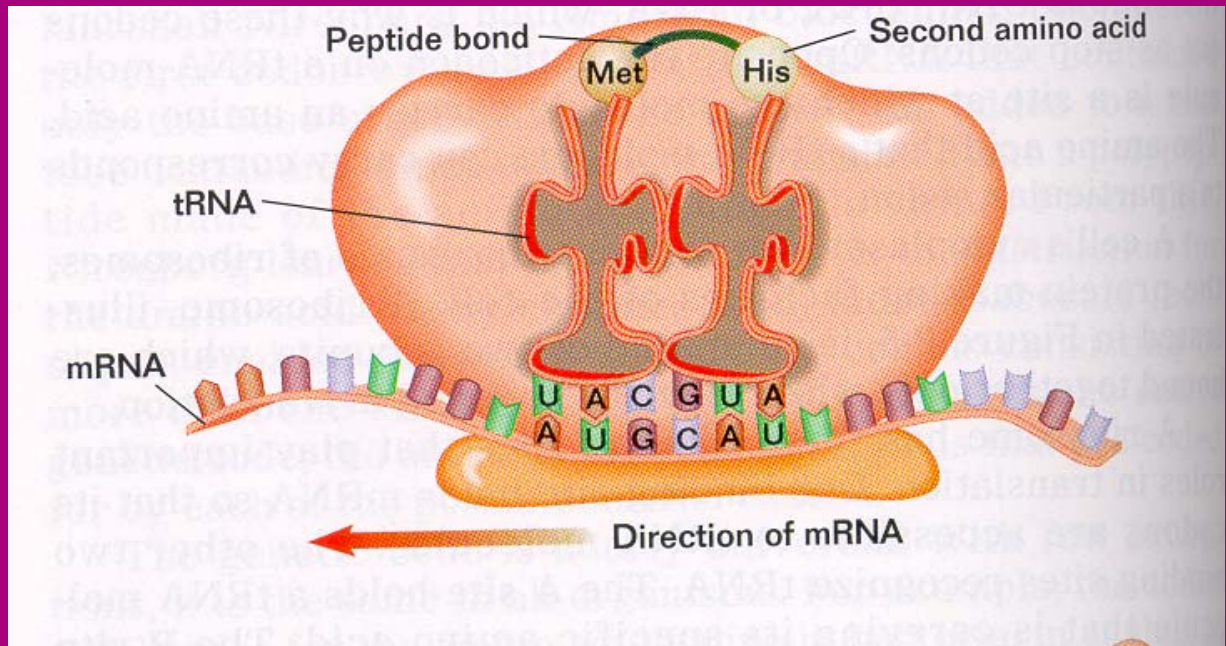
Translation:

- Begins when mRNA binds to the smaller ribosomal subunit.
- Large subunit attaches (ribosome is complete).
- A start codon on mRNA (usually AUG) signals beginning of protein chain
- tRNA molecule with anticodon UAC and methionine attached will bind to start codon in P site



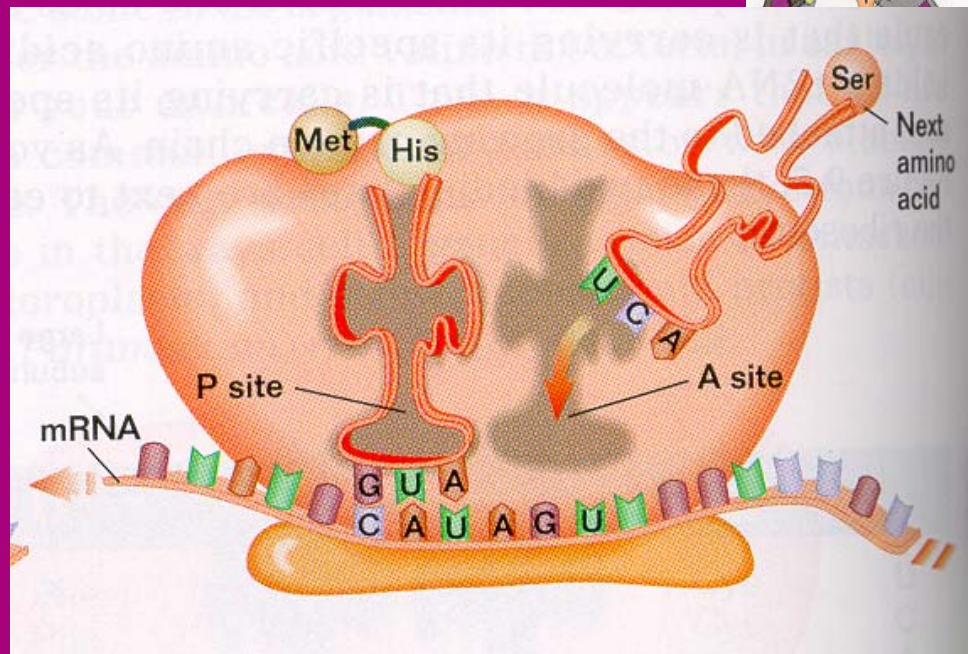
Translation continued…

- Codon in the vacant A site accepts the next tRNA
- Both P site and A site are now holding tRNAs with attached a.a.
- Peptide bond forms between the two a.a.



Translation continued…

- The tRNA in the P site detaches and moves away
- The tRNA in the A site moves into the P site
- The new codon in the A site attracts the complementary tRNA with a.a.



Translation continued…

- The sequence continues until a stop codon (for which there is no anticodon)is reached
- With nothing left to fit empty A site, ribosome complex falls apart
- Newly made protein is released into cell