DNA LESSON PLAN

I. DNA structure
 A. Levels of Chromatin packing
  1. Chromosomes
  2. DNA super coil
  3. Genes / Genetic Information
 B. Nitrogenous bases:
  1. Purines
   a. Adenine: Guanine
  2. Pyrimidines
   a. Cytosine, Thymine in DNA: (Uracil in RNA)
 B. Pentose Sugars: Furanose forms of D-Ribose
  1. β– D-2-Deoxyribofuranose in DNA
  2. β– D-2- Ribofuranose in RNA
 C. Nucleosides
  1. Glycosidic Bonds (Sugar to Nitrogenous Base)
   a. Anomeric bond between N-1 of pyrimidine or N-9 of purine to C1' of sugar
 D. Nucleotides
  1. Phosphoester bond
  2. Phosphate Backbone
  3. Nucleic Acids
 E. The double helix
  1. 3' and 5' ends
  2. Direction of transcription

II. Transcription

III. Types of RNA
 A. mRNA
 B. tRNA
 C. rRNA (see Table 1: teacher information).
 D. RNA polymerase
  1. Binding
  2. Initiation of polymerization
  3. Elongation
  4. Termination
 E. mRNA
  1. Introns and Exons
  2. Splicing
 F. Genetic Code: A triplet code read
  1. 3 bases per amino acid
  2. No overlap: No punctuation
  3. Degenerate: 64 combinations for 20 amino acids: 3 stop codons
  4. Code is Universal
 G. tRNA
  1. Interacts with Nucleic acids and amino acids
  2. 20 tRNA ; one for each amino acid

3. Acyl t RNA synthase catalyzes connection

H. rRNA

1. Subunits
2. Location on Rough ER

I. Translation process

1. Location
2. Mechanics

J. Packaging the proteins.

Introduction:

Students may well be aware of DNA as a result of its role in forensic science and topical issues such as cloning and genetically modified foods. They should also be aware that the sequence of bases within the DNA encodes all of the genetic information for a given organism. The issue for this lesson is how that information is used to synthesize the many proteins within our body. The lesson will explore the role of the various types of RNA as well as the mechanisms of transcription and translation. Initial question: How does our body make proteins?

Discussion:

Chromosomes are the structures that students associate with genetic information. Figure 1 shows how DNA super-coils to form these familiar structures. Students should remember the function of genes and their location on the DNA helix. Figure 2 is an overview of the transcription / translation process. The focus of this lesson is on the mechanisms that copy and translate the genetic information into proteins.

DNA structure should be reviewed briefly.

Figure 3 shows the structure of pyrimidines and purines: review the letter convention and the difference between uracil and thymine. Compare RNA with DNA via the difference in base pairs and their respective sugar.

Figure 4 shows the structure of furanose sugars in relation to the ribose sugar. Students should be shown how to number the prime positions in the ring and where the anomeric carbon is located. This will help in later discussion of DNA structure and direction of translation. Figure 5 shows the glycosidic bonds that form between the sugars and nitrogenous bases. The nucleosides are then linked via phosphoester bonds to phosphate groups: figure 5a shows the phosphate group and the ester linkages to the nucleosides: these are cyclic nucleotides. Nucleotides link to other nucleotides to form the phosphate sugar backbone: figure 5b and 5c. Figure 5c and figure 6 show the 5' and 3' ends of the helix, stress this orientation for RNA transcription.

Figure 6 ends the review of DNA structure as it positions all of the structures into the helix. Students should see the location of the bases and be reminded that their sequence codes genetic information.

Table 1 shows the different types of RNA. Mention that each type has a different function in this lesson. The data in table 1 is the teacher's background information.

Transcription begins when the promoter complex and RNA polymerase bind to the DNA.

Figures 7 and 7a show this sequence. Once bound to the helix, transcription follows the steps in figure 7b and 7c. Highlight the direction of transcription and its relation to the DNA's direction.

The information coded in the mRNA is not all useful. Unnecessary regions (introns) are excised in between the transcription/ translation steps. The remaining exons carry all the useful information. The role of introns is a good discussion point for the class. Figure 8 shows the splicing of the introns.

Table 2 shows the genetic code. The instructions for reading them should be shown and students should write the code for several representative amino acids. Show the Stop and start sequences. The "rules" for reading the code are provided as teacher information.

Transfer RNA (tRNA) (figure 9) provides the link between amino acids and the coded information on the mRNA strand. Note that there are 20 tRNA molecules (one for each amino acid). tRNA are connected to their respective acids by aminoacyl t RNA synthetase (figure 9a). Mention the use of ATP for this reaction from the metabolism lesson plan: this is one reason why the body needs energy.

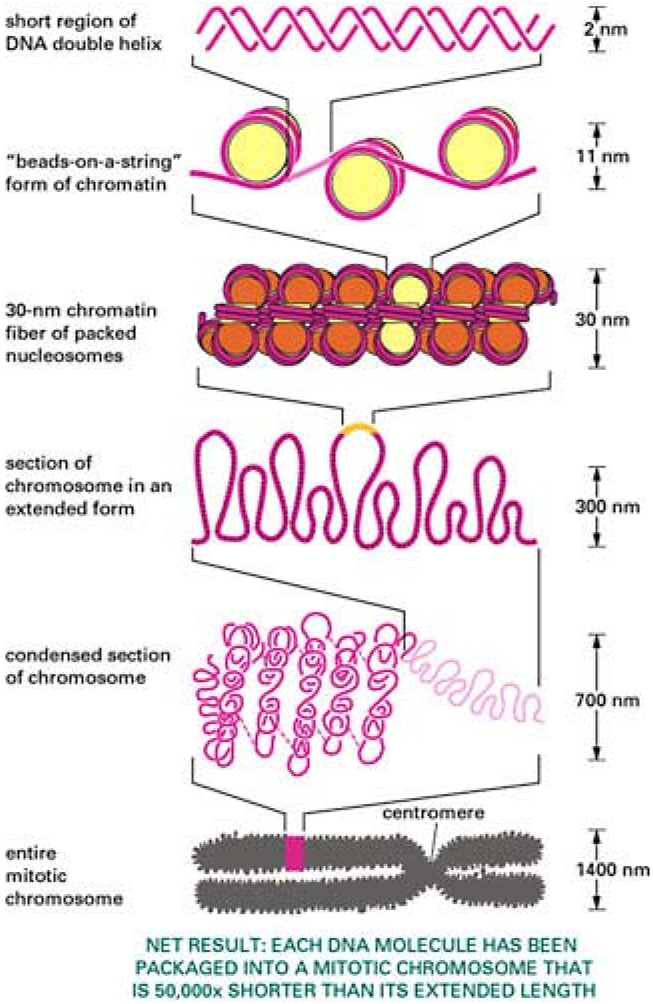
Note the attachments sites for the amino acids and the corresponding codons on the bottom of the molecule. Figure 9b is a good representation of the relation between tRNA codons, the mRNA and the genetic code. Once synthesis begins, the tRNA brings amino acids from within the cytosol to the mRNA where ribosomes facilitate the formation of peptide bonds between amino acids. (A good place to discuss the importance of a well balanced diet.)

Initiation of the synthesis begins when one of two ribosome units bind to the mRNA, followed by the attachment of the start codon (methione), followed by the second ribosome unit (Figure 10). Once all three units are in place, synthesis begins. (Figure 10a. shows the units clearly. It also shows the A, P, and E sites on the ribosome: the A site (Amino acyl binding site) is where subsequent tRNA will bind, the P site

(Peptidyl tRNA binding) site is the location of the growing peptide chain; the E site is the exit site for depleted tRNA.

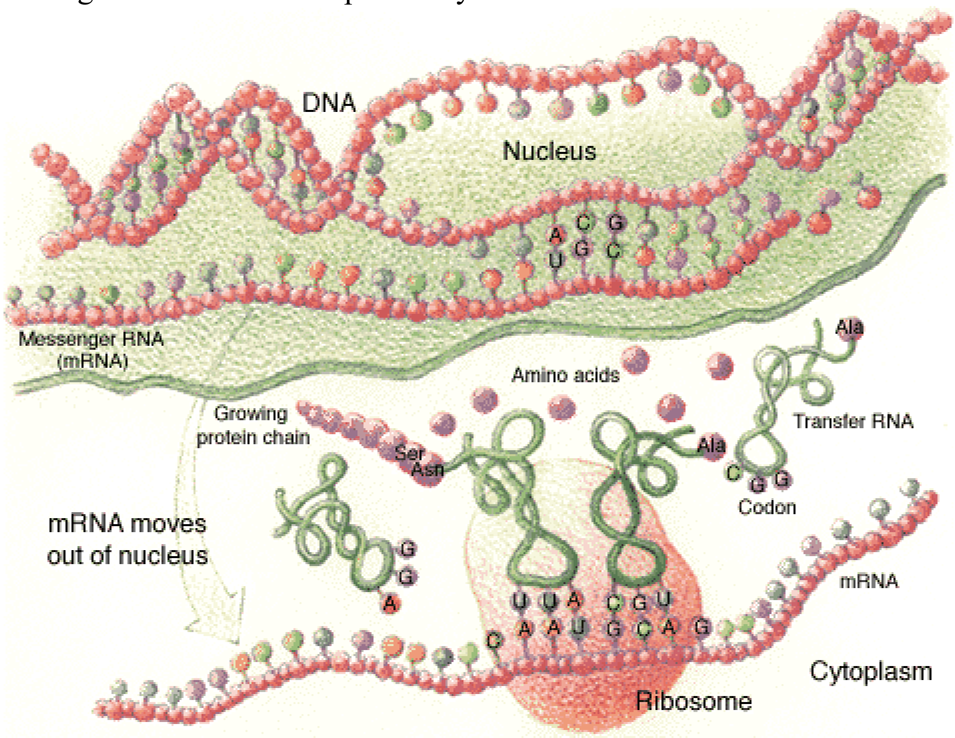
Elongation is the process of growing the peptide (Figure 10b). New tRNA bring in amino acids, a peptide bond is formed, the tRNA moves to the P site, the depleted tRNA moves to the E site, a new one arrives at the A site until the stop codon is reached. Once the stop codon is reached, a release factor binds to the ribosome, it releases from the mRNA and synthesis ends (Figure 10c).

Figure 1. Levels of Chromatin Packing



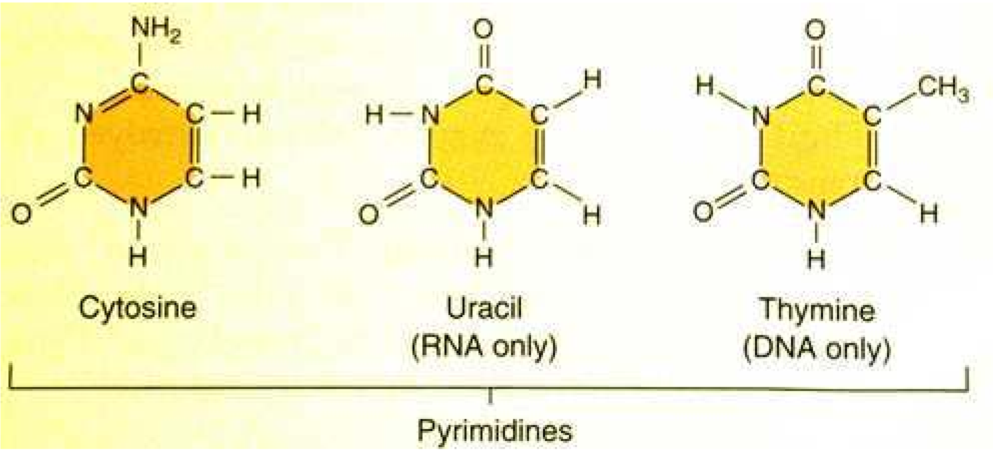
http://www.accessexcellence.org/RC/VL/GG/images/Fig_8.10.jpg

Figure 2: Overview of protein synthesis



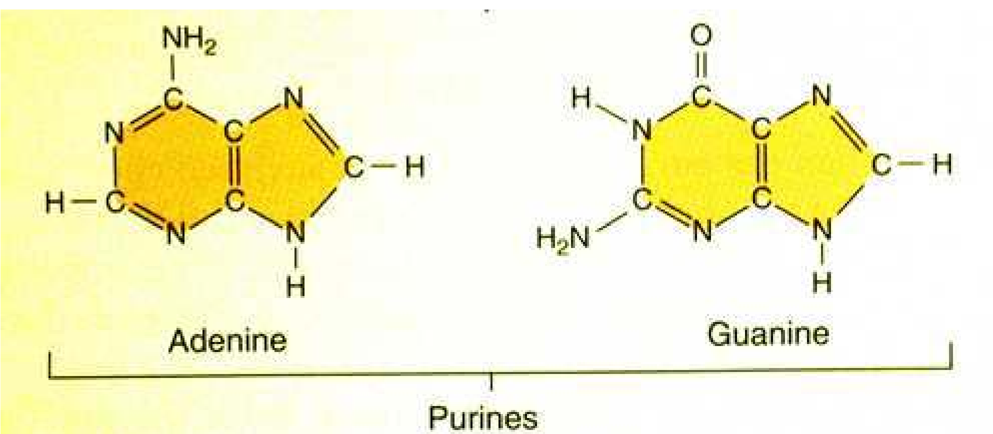
http://www.colorado.edu/physics/phys2900/homepages/Courtney.Schorr/images/genes.gif

Figure 3: Pyrimidines



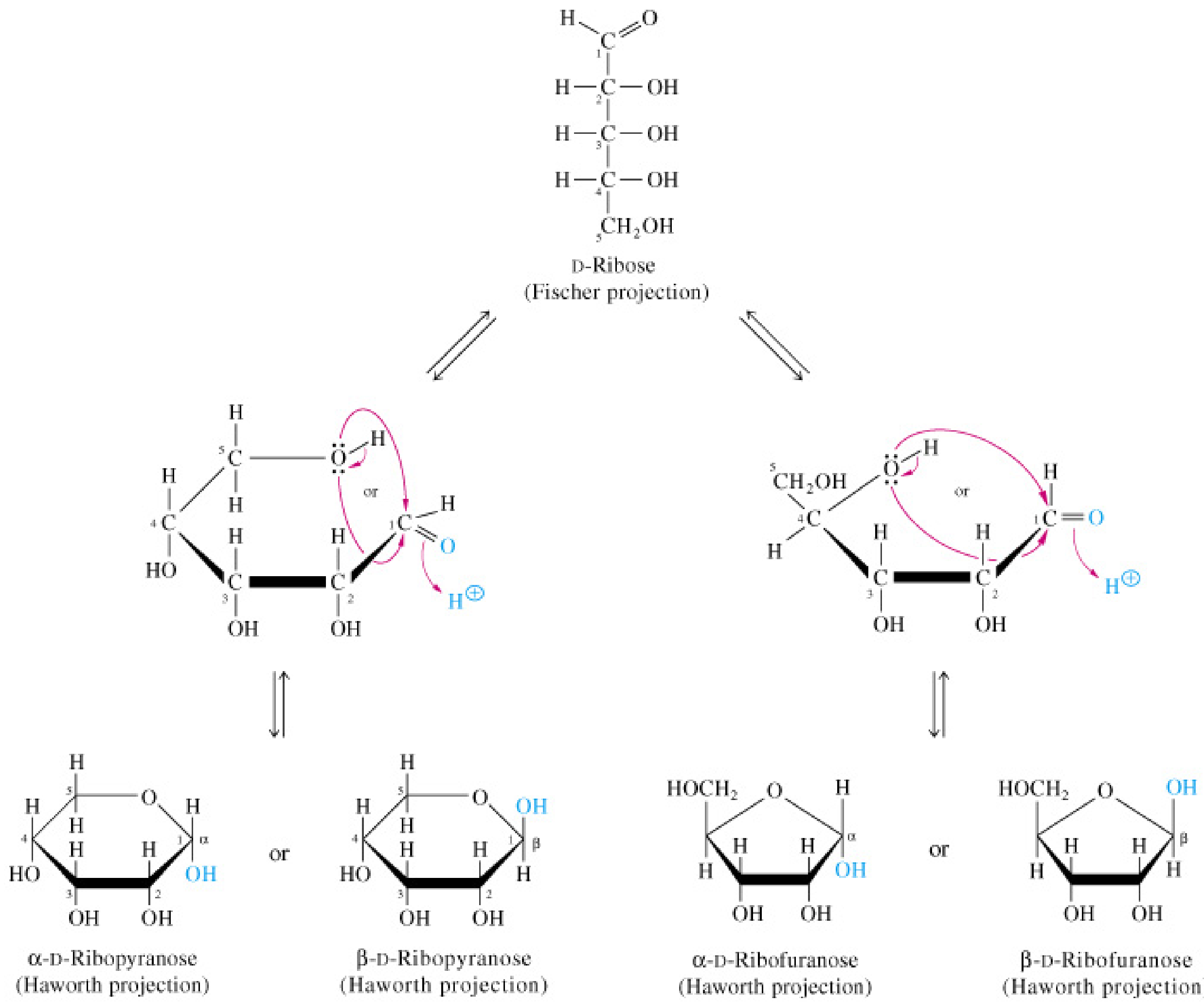
http://academic.brooklyn.cuny.edu/biology/bio4fv/page/molecular%20biology/DNA-components.html

Figure 3a. Purines



http://academic.brooklyn.cuny.edu/biology/bio4fv/page/molecular%20biology/DNA-components.html

Figure 4. Furanose sugars



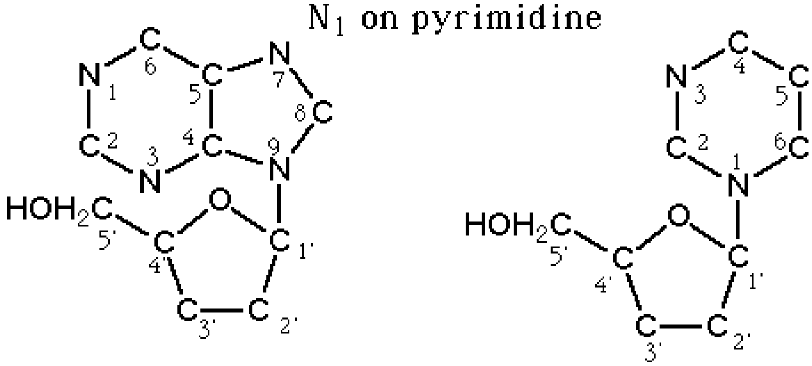
http://www.ksu.edu/bchem/courses/BIOCH521/f2001/c8images/FG08_09.JPG

Figure 5: Glycosidic Bonds

Dimers of sugar and bases

Nucleosides

connect to $C_{1'}$ on sugar
N_9 on purine
N_1 on pyrimidine

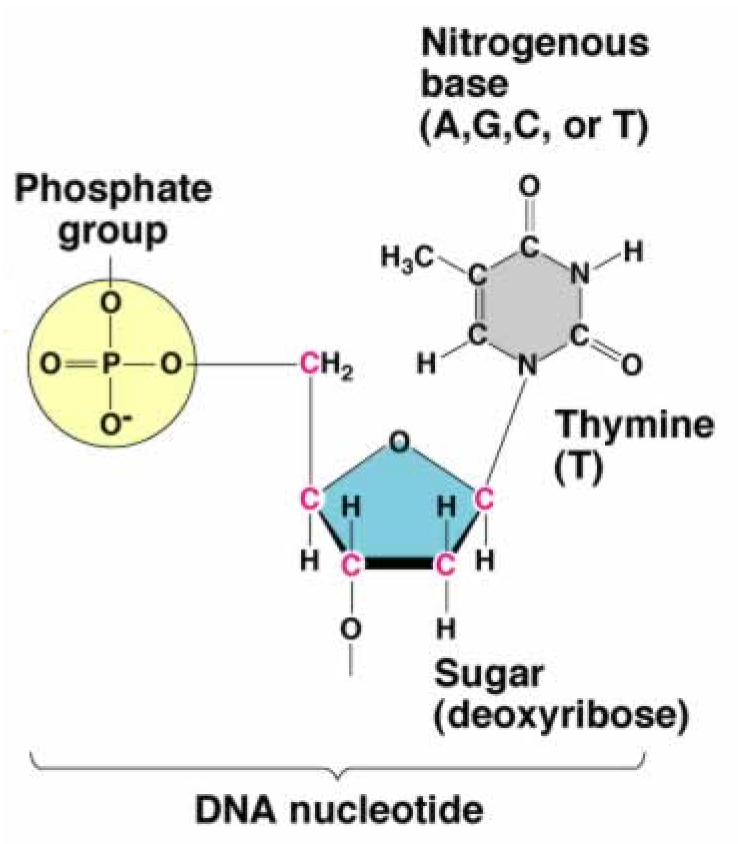


where $C_{2'}$ has OH for ribose
has H for deoxyribose

ribose	**deoxyribose**
adenosine	deoxyadenosine
guanosine	deoxyguanosine
uridine	deoxyuridine
cytidine	deoxycytidine
thymine riboside	thymidine

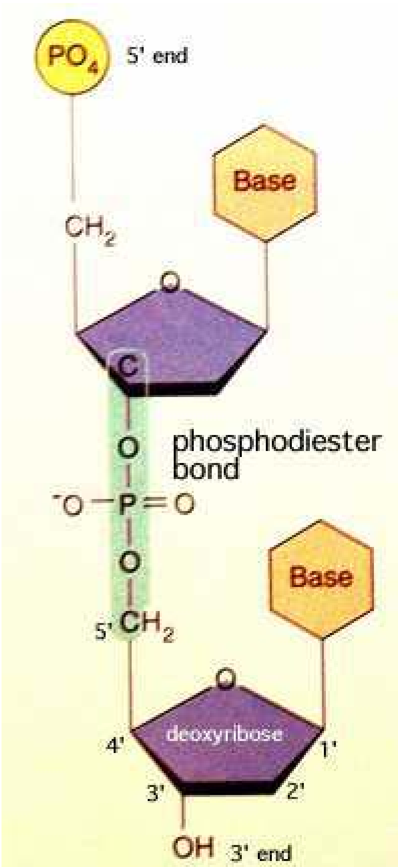
http://www.library.csi.cuny.edu/~davis/Bio100/Molecules/nucleoside.GIF

Figure 5a: A Nucleotide



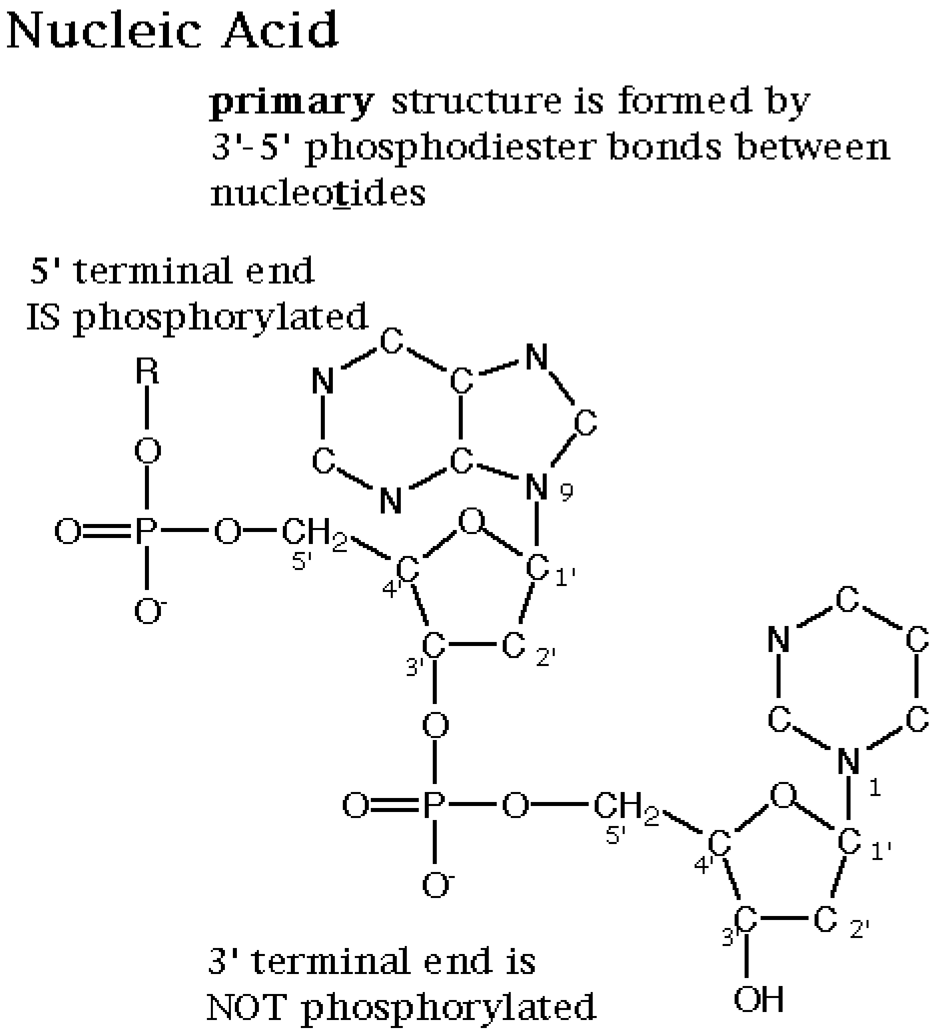
http://www.anselm.edu/homepage/jpitocch/genbio/nucleotidedna.JPG

Figure 5b. Phosphate sugar backbone



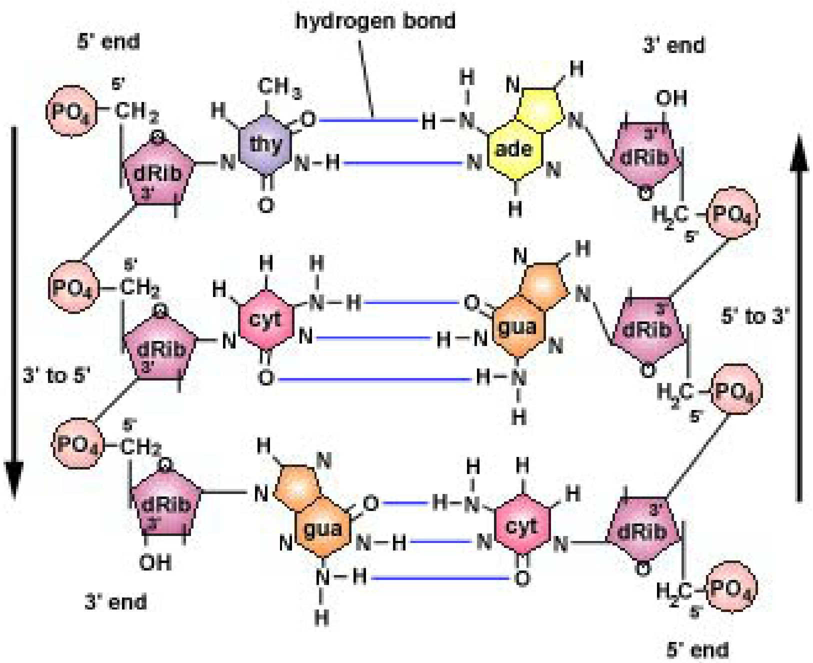
http://academic.brooklyn.cuny.edu/biology/bio4fv/page/molecular%20biology/DNA-components.html

Figure 5c. Nucleic Acid structure

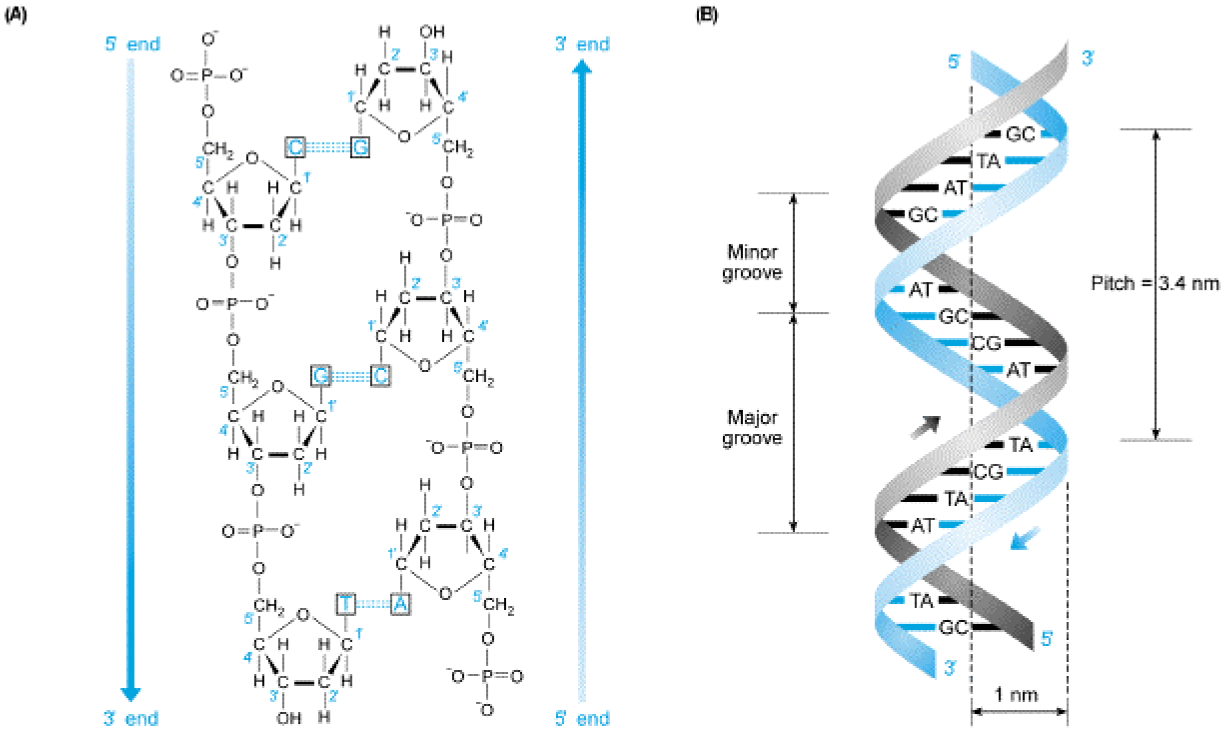


http://www.library.csi.cuny.edu/~davis/Bio100/Molecules/oligostruct.GIF

Figure 6: Hydrogen bonding of bases



http://www.cat.cc.md.us/courses/bio141/lecguide/unit1/prostruct/dnareppr/images/u4fg7.jpg figure 6a. The DNA helix: Direction and polarity



http://www.library.csi.cuny.edu/~davis/Bio100/Molecules/molecules.htm

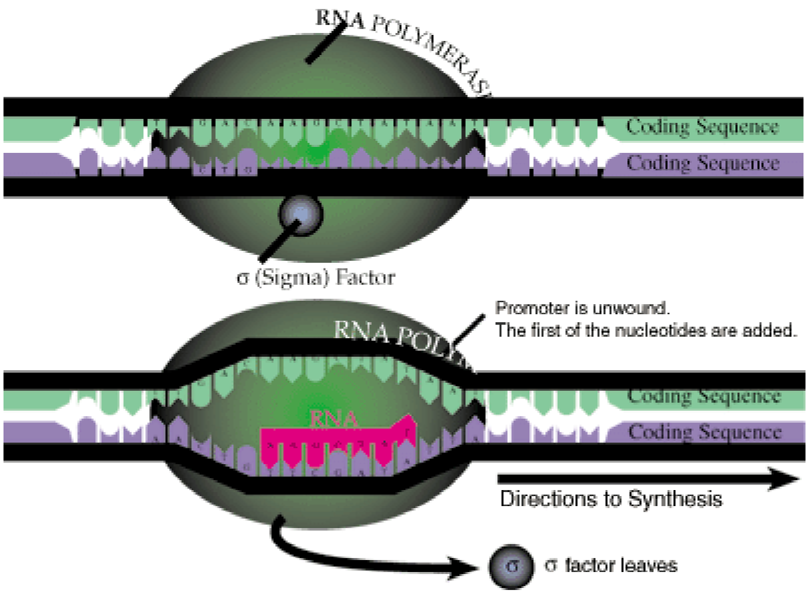
Table 1:Types of RNA

Types and Functions of RNA Molecules

Type of RNA	Function of RNA	% of All RNAs in Cell	# of Types of RNA per Cell	~ Length of RNA in bases
ribosomal - rRNA	mRNA translation	ca. 80	1 each	120-5000
transfer - tRNA	mRNA translation	ca.5	80-100	75-90
mesenger - mRNA	protein translation/regulatory	2-4	thousands	Avg. 0.2-12 kb
heterogeneous nuclear - hnRNA	intermediates of mRNAs	<0.1	thousands	0.5 - > 500 kb
small cytoplasmic - scRNA	signal recognition particle RNA processing	<1	tens	90-330
small nuclear - snRNA	mRNA processing, poly A addition, histone 3' processing	<1	~15 major	58-220
small nucleolar - snoRNA	rRNA processing & maturation methylation& pseudouridine form.	<1	100-200+	58-220
regulatory RNAs	regulation of RNA transcription, translation and stability	<0.01	?	60-20,000
guide RNAs	RNA editing	?	hundreds to thousands	50 - 90
telomerase RNA	template for telomere replication	?	~1	450
small, transregulatory RNAs	RNA degradation and translational regulation	?	?	~20

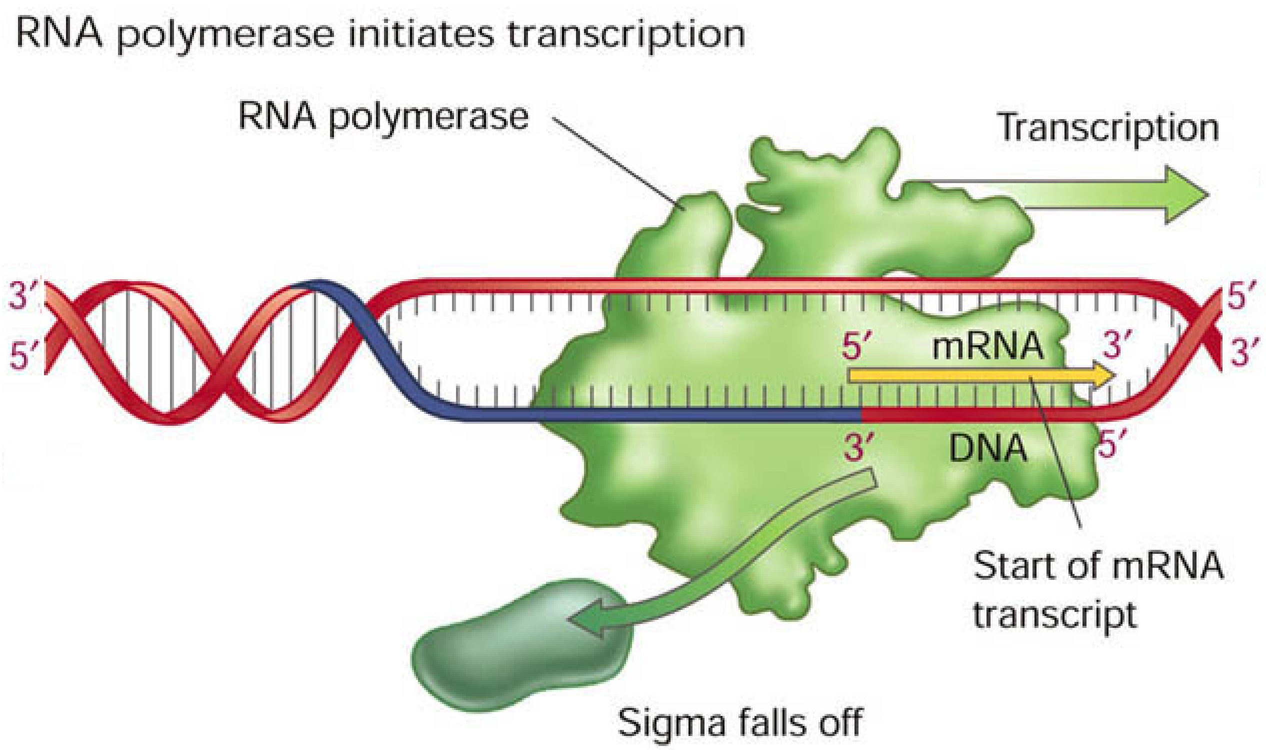
http://www.library.csi.cuny.edu/~davis/Bio100/Molecules/types_funct_RNA.htm

Figure 7: Initiation of Transcription



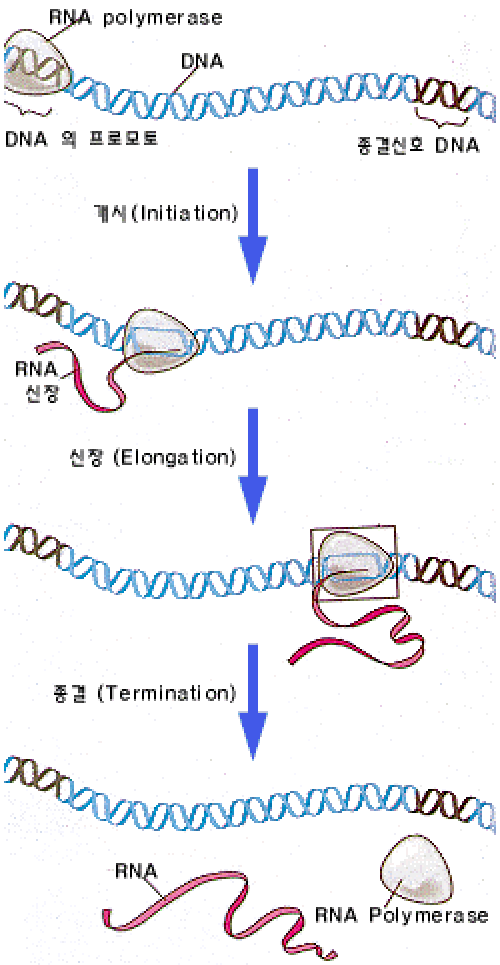
http://www.blackwellpublishing.com/11thhour/book5/about/images/c5t4_1.gif

Figure 7a: RNA Polymerase



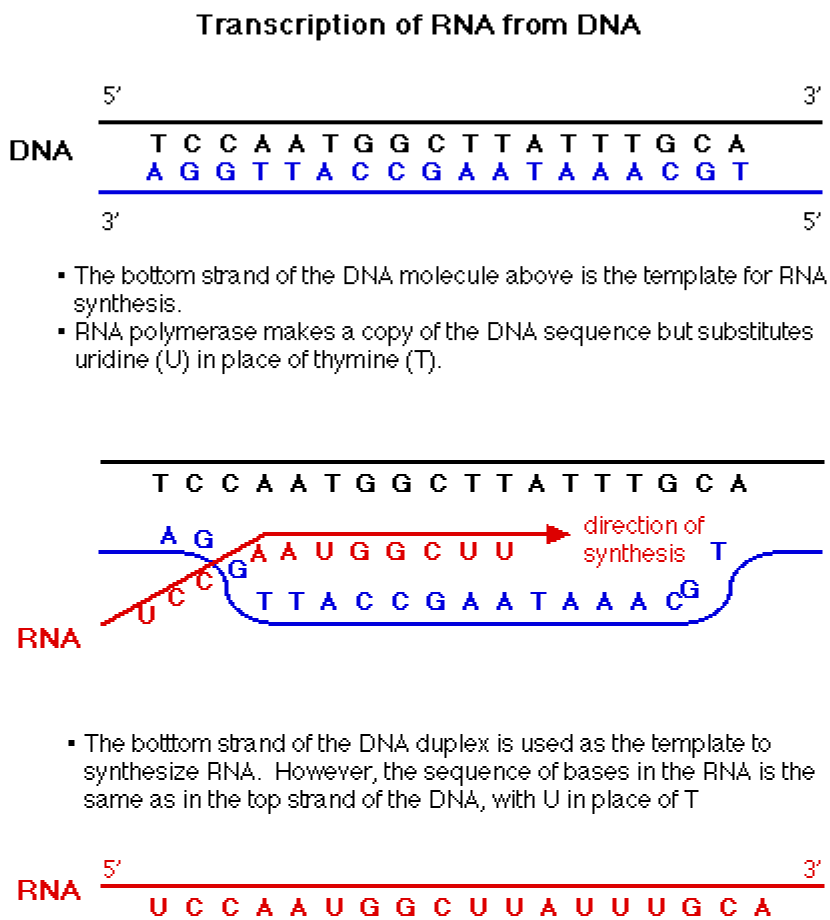
http://fig.cox.miami.edu/~cmallery/150/gene/sf13x5b.jpg

Figure 7b: Steps in Transcription



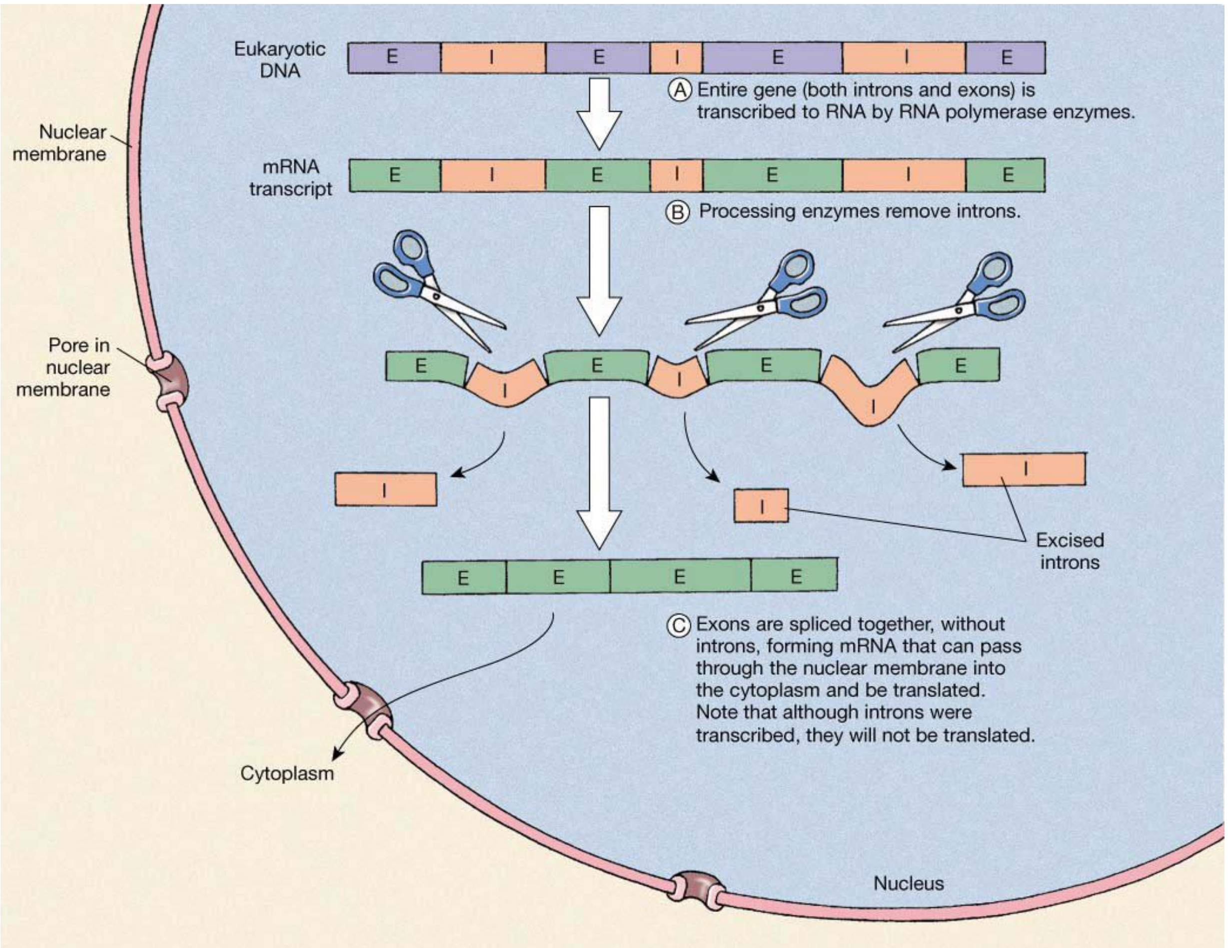
http://cont1.edunet4u.net/cobac2/scientist/image/RNA%20Polymerase.gif

Figure 7c. Steps in RNA transcription



http://www.hort.purdue.edu/hort/courses/HORT250/pict.gif%20images/l4%20rna%20transcription%20pict.gif

Figure 8: Splicing Introns



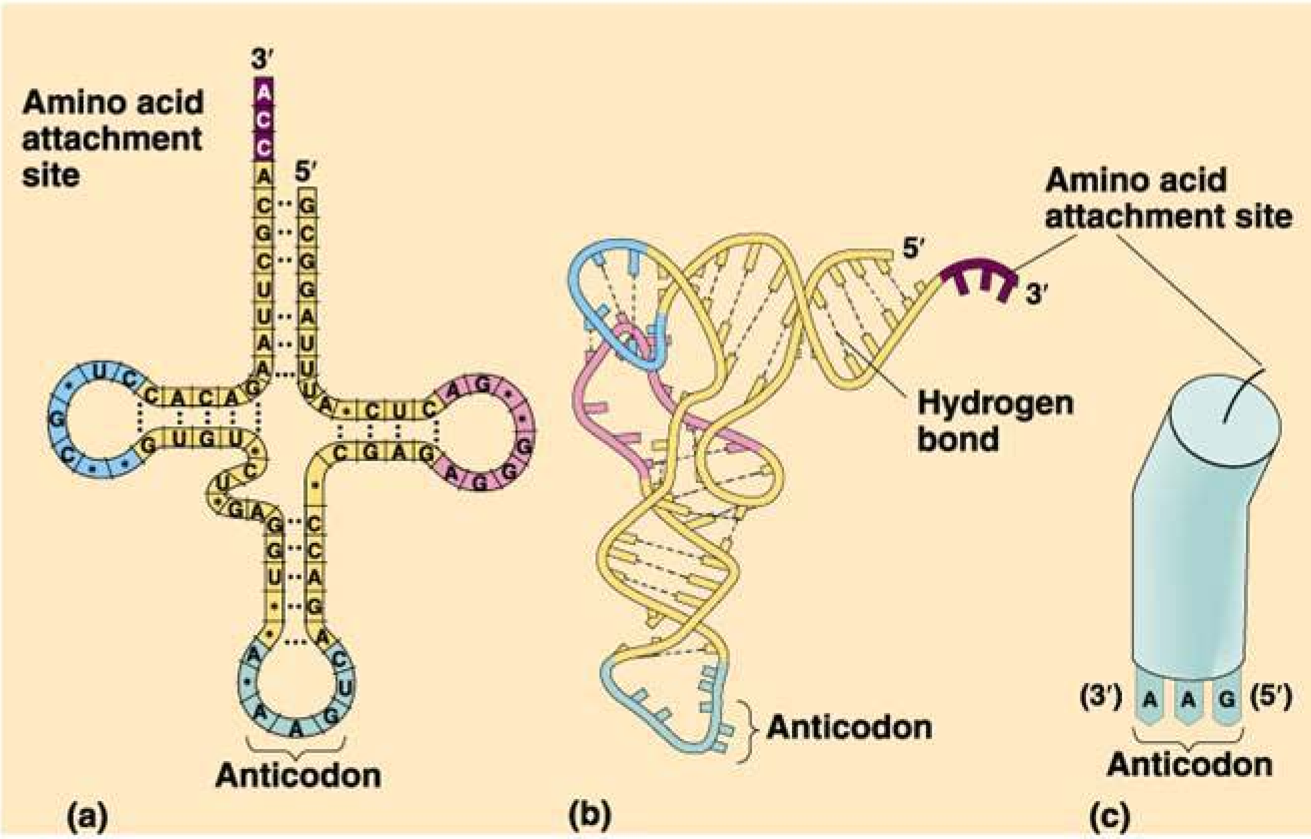
http://www.uccs.edu/~rmelamed/MicroFall2002/Chapter%207/introns.jp

Table 2: The Genetic Code

First letter	Second letter: U	Second letter: C	Second letter: A	Second letter: G	Third letter
U	UUU Phe	UCU Ser	UAU Tyr	UGU Cys	U
U	UUC Phe	UCC Ser	UAC Tyr	UGC Cys	C
U	UUA Leu	UCA Ser	UAA Stop	UGA Stop	A
U	UUG Leu	UCG Ser	UAG Stop	UGG Trp	G
C	CUU Leu	CCU Pro	CAU His	CGU Arg	U
C	CUC Leu	CCC Pro	CAC His	CGC Arg	C
C	CUA Leu	CCA Pro	CAA Gin	CGA Arg	A
C	CUG Leu	CCG Pro	CAG Gin	CGG Arg	G
A	AUU Ile	ACU Thr	AAU Asn	AGU Ser	U
A	AUC Ile	ACC Thr	AAC Asn	AGC Ser	C
A	AUA Ile	ACA Thr	AAA Lys	AGA Arg	A
A	AUG Met	ACG Thr	AAG Lys	AGG Arg	G
G	GUU Val	GCU Ala	GAU Asp	GGU Gly	U
G	GUC Val	GCC Ala	GAC Asp	GGC Gly	C
G	GUA Val	GCA Ala	GAA Glu	GGA Gly	A
G	GUG Val	GCG Ala	GAG Glu	GGG Gly	G

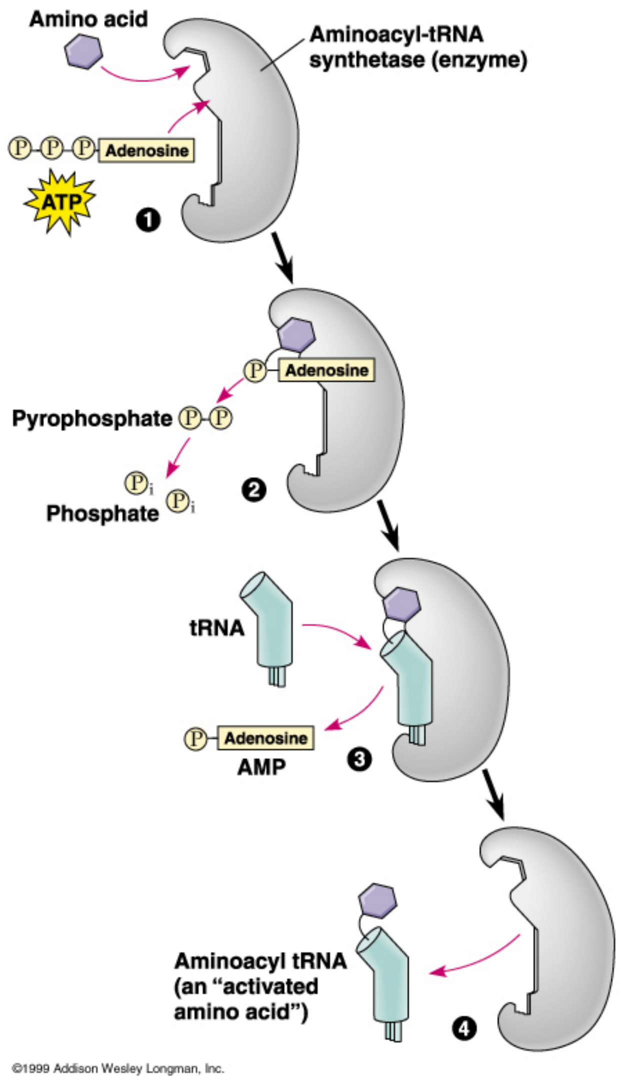
http://web.umr.edu/~rfrank/Evolution/Genetic_Code.jpg

Figure 9: tRNA



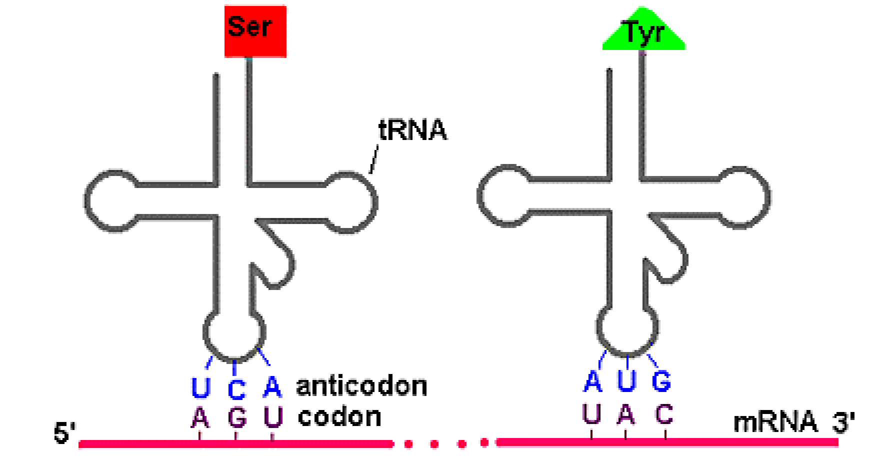
http://fajerpc.magnet.fsu.edu/Education/2010/Lectures/27_Protein_Synthesis_II.htm

Figure 9a: Aminoacyl t-RNA synthetase



http://departments.oxy.edu/biology/Franck/Bio130S_2002/Images/Ch17/fig17_13.JPG

Figure 9b: tRNA and the genetic code



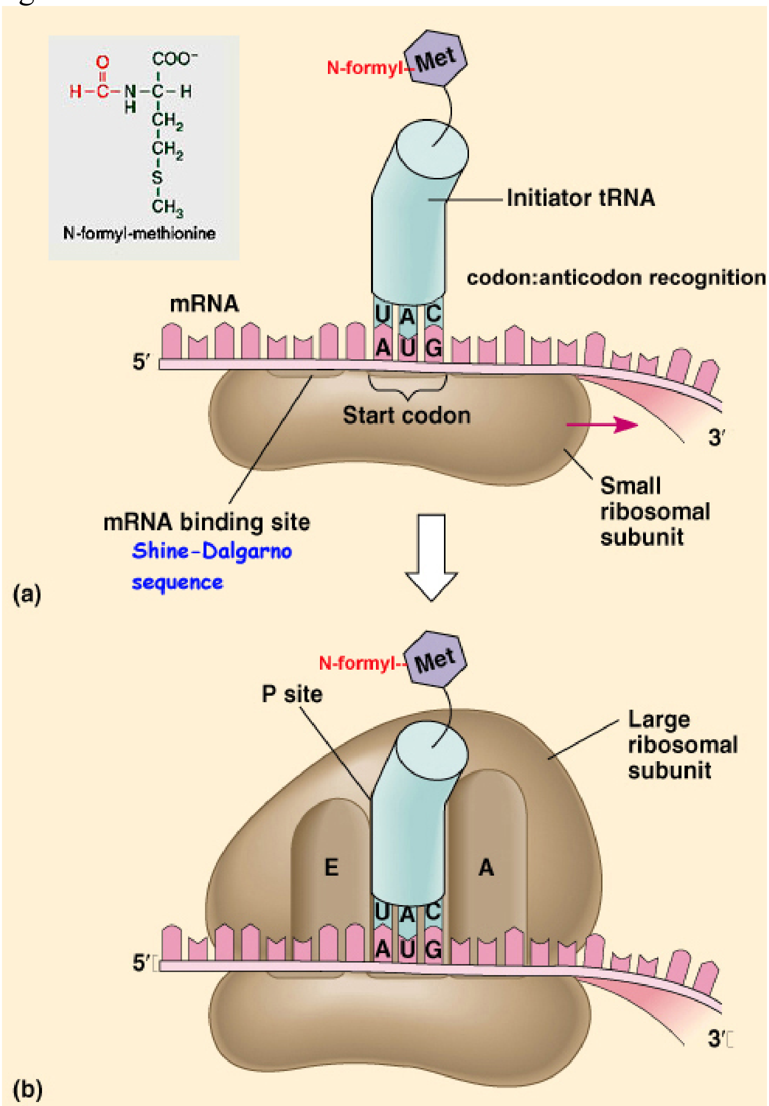
2nd base in codon

1st base in codon	U	C	A	G	3rd base in codon
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

The Genetic Code

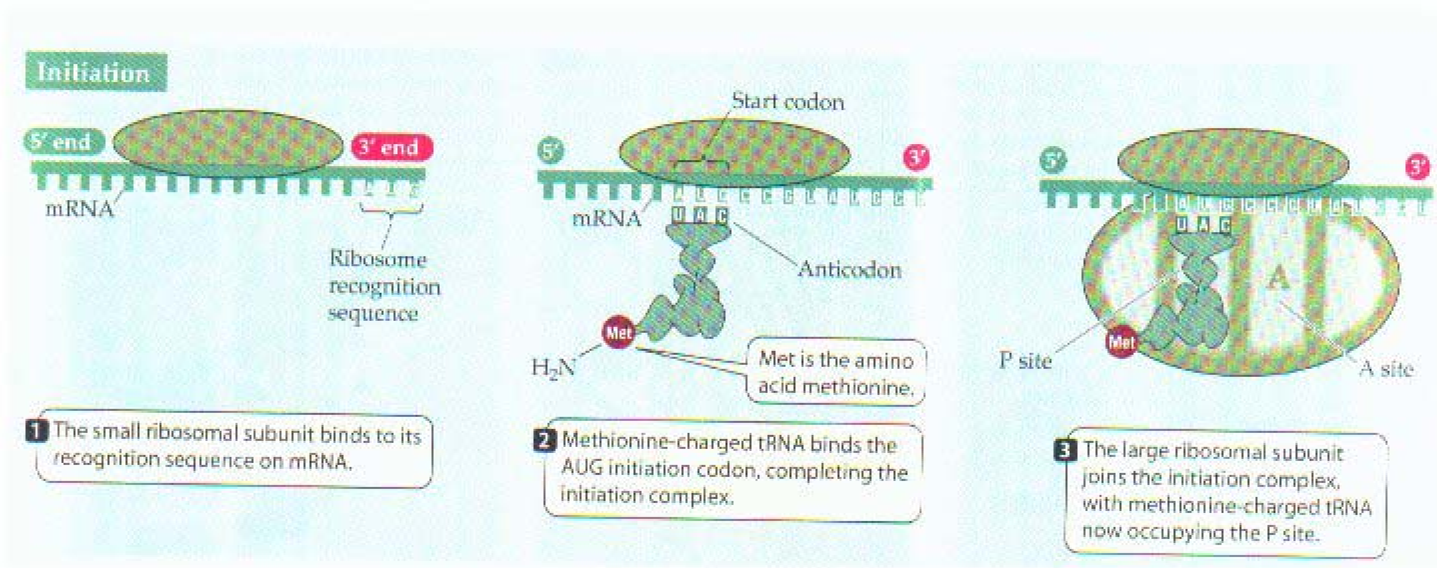
http://www1.imim.es/~eblanco/seminars/docs/geneid/geneid1024x768/images/genetic.gif

Figure 10.



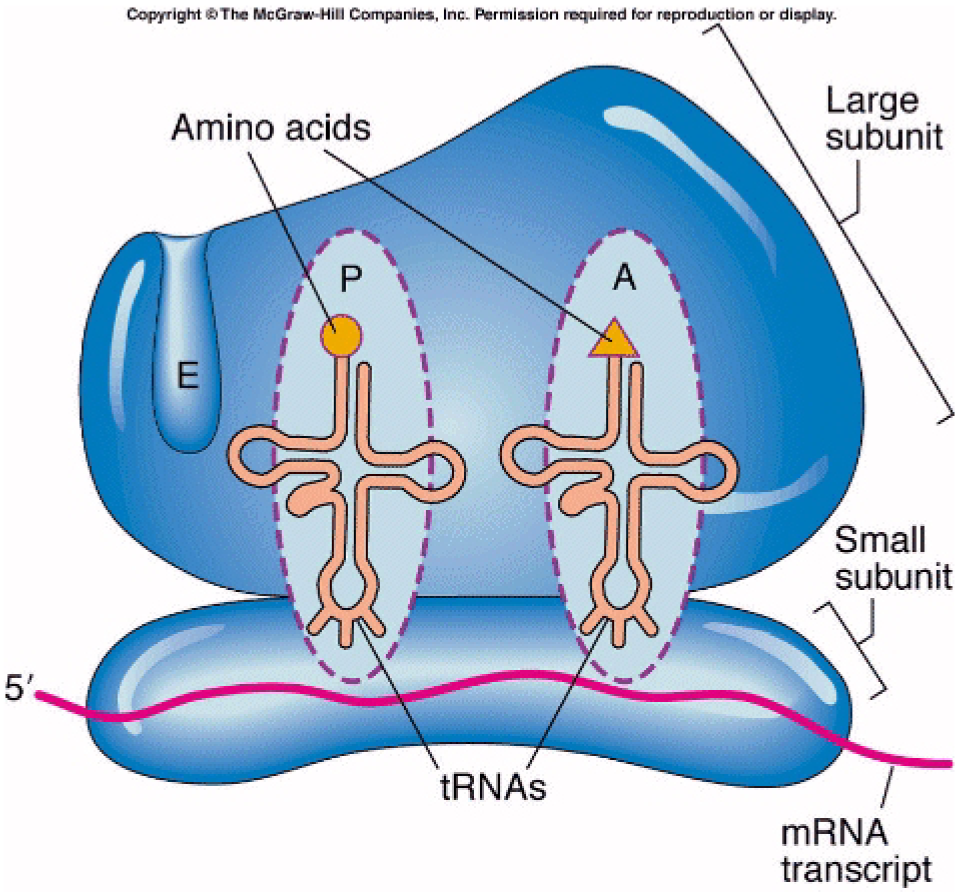
http://fig.cox.miami.edu/~cmallery/150/gene/17x15.jpg

Figure 10a. Initiation



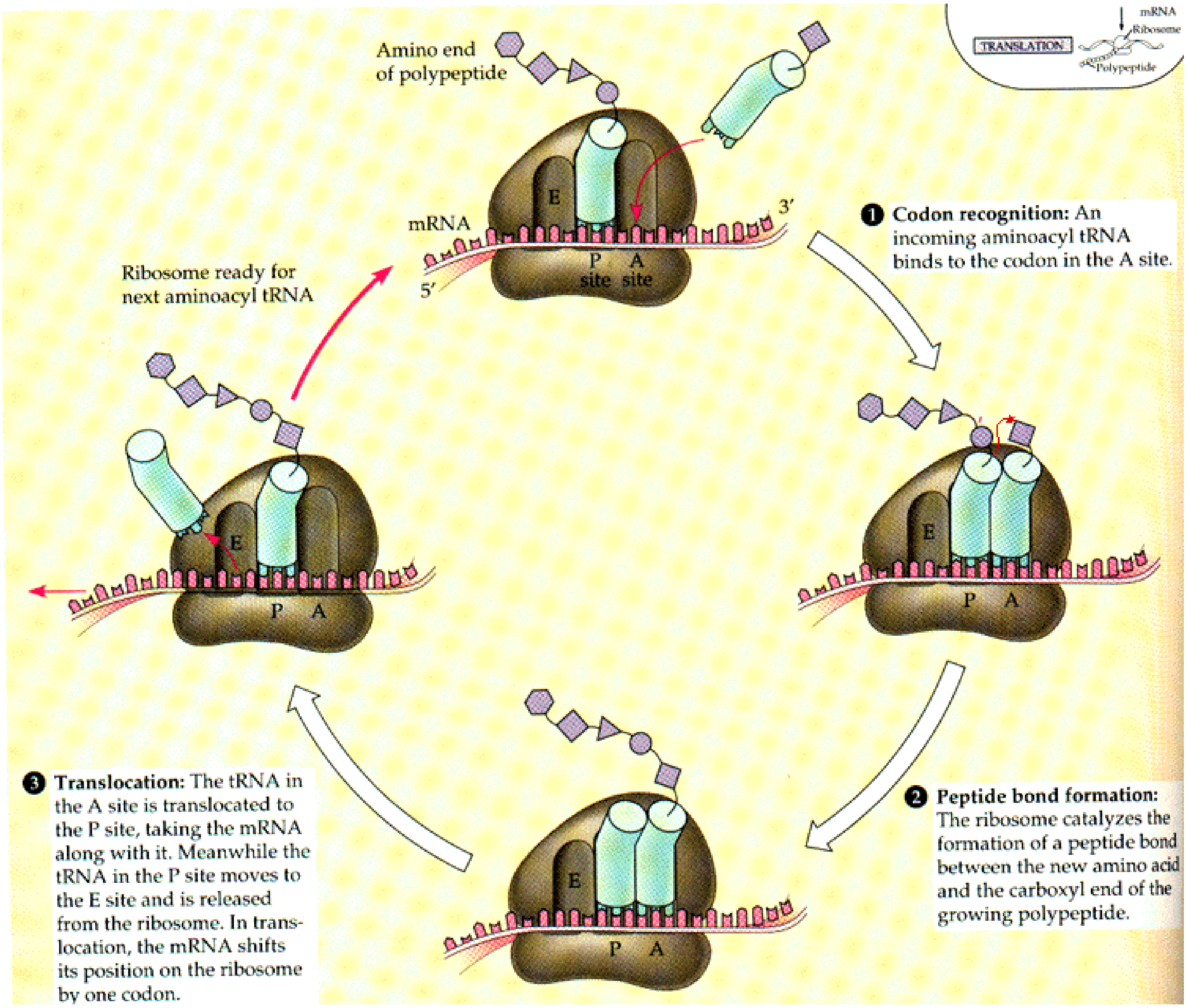
http://www.prism.gatech.edu/~gh19/b1510/7tran1.jpg

Figure 10b. Ribosome units and A,P,E sites



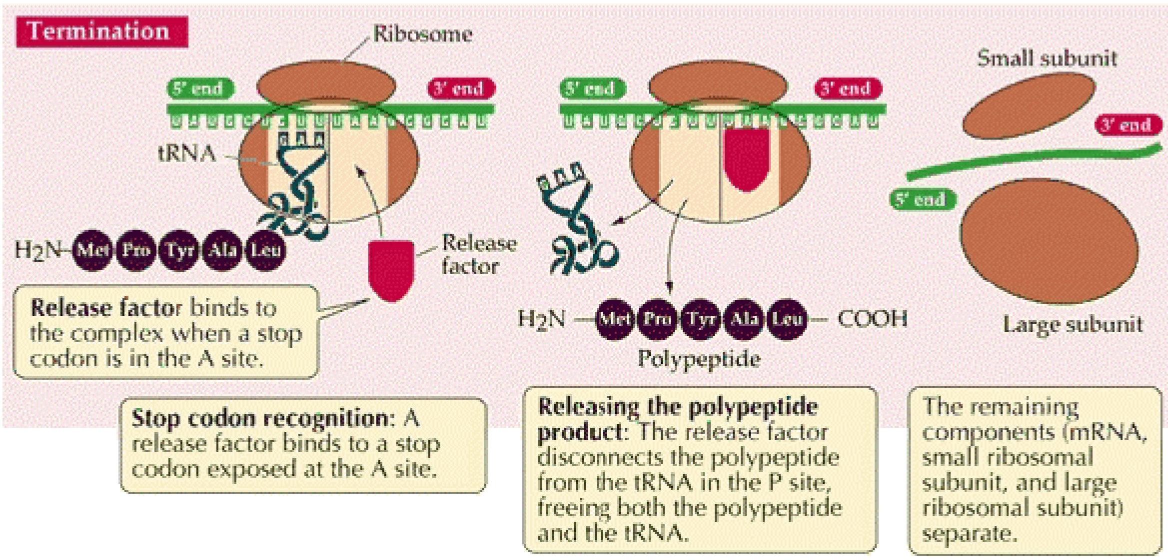
http://academic.pg.cc.md.us/~kroberts/lecture/lecture/chapt9/ribosome.jpg

Figure 10b. Elongation



http://bio.winona.edu/berg/ILLUST/fig17-16.gif

Figure 10c. Termination



http://www.bioloj.ca/biotech/dna/translation.html