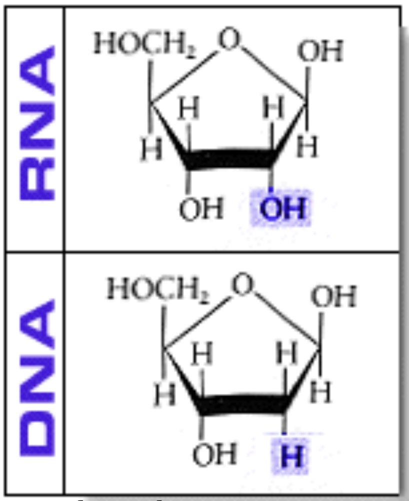
Transcription and Translation notes

We often talk about how DNA is the blue print of an organism. At this point, we know that DNA is found in the nucleus of a cell, and that DNA can be replicated through the process of mitosis. The variation in our organisms and offspring depends on the process of meiosis where chromosomes crosses over with each other between genes. So the question now is how do these genes actually get expressed or changed into what we see? We know some genes are dominant, recessive with having some that are codominant and incomplete dominant but how do these genes actually expressed into our eye color or hair color which we often talk about?

The process in which DNA is read, and finally expressing into the protein is what scientists classify as the "Central Dogma". Every protein that gets expressed whether they are the color in our hair, or the various cell parts found in cells, it has to be coded in our DNA. In other words, the Central Dogma basically is stating how our genetic material, DNA is read, transcribed, and then translated into proteins. We can think of the Central Dogma as a basketball playbook where it showcases numerous plays (The DNA), but in order for the plays (the protein) to be demonstrated by the players, it must be *transcribed* or interpreted by the coach, then the coach's instructions (RNA) is then *translated* into the actual game play(Protein).

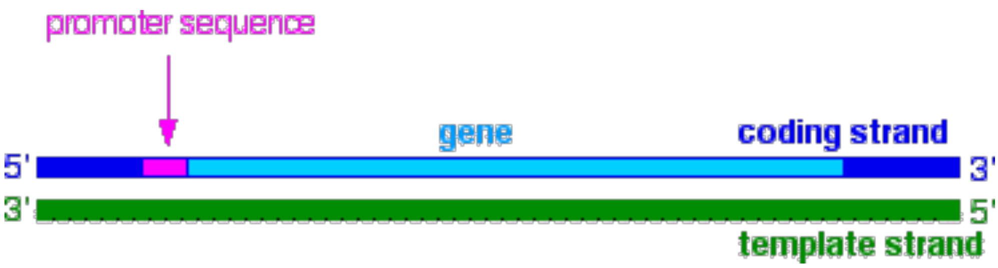
How DNA is read

How DNA is read into the respective proteins requires 2 steps. First, the DNA must be *transcribed* into another set of molecules called RNA (ribonucleic acid) and the second step is *translation* into proteins. The structure of RNA is similar to DNA except that RNA (stands for *RIBOnucleic* acid) has 1 extra oxygen atom on its ribose sugar while DNA (stands for *DEoxyribonucleic acid)* has 1 less oxygen. Another difference between RNA and DNA is that RNA has a different nitrogenous base called Uracil. Instead of Thymine pairing with Adenine, Uracil in RNA pairs with Adenine. The last difference is that RNA is a single stranded structure while DNA is a double stranded helical structure.



DNA has 1 less oxygen atom than RNA structure.

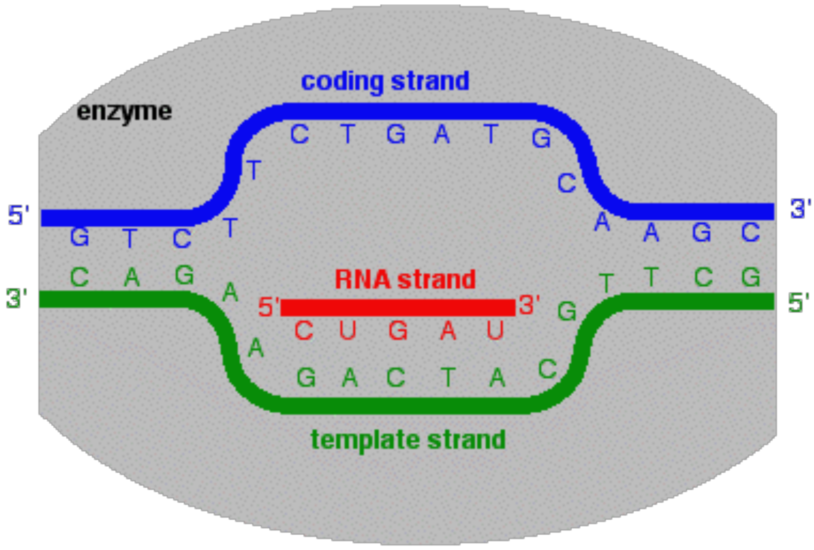
When the cell needs a protein, it must be read from the DNA segment that encodes for that particular protein. That particular segment of DNA is read by an enzyme, and it must now be *transcribed into RNA* and then *translated into the protein.* The transcription process from DNA to RNA is quite the elaborate process. There are numerous new key players that you are required to know. Make sure that you complete your summary sheet (see attached) to help you understand the process.



Transcription

Initiation stage:

Again, the main purpose of transcription is to change the DNA into RNA. There are three main steps of transcription: initiation, elongation, and termination. During the initiation stage, an enzyme called *RNA* polymerase attaches to the *promoter* region (above). The *promoter* region is a specific region of the DNA strand that encodes the "start" of the gene. As the double helix of DNA unwinds, the RNA polymerase binds onto the promoter and starts transcribing the DNA bases into RNA bases. Recall that RNA has the nitrogenous base Uracil that pairs with Adenine of DNA. As the RNA polymerase creates a new strand of RNA, this single stranded RNA is called the Messenger RNA or mRNA for short. The mRNA is basically the message that has been interpreted into RNA from the DNA strand. After the transcription has been initiated, the mRNA elongates in the 5' to 3' direction while reading the DNA in the 3' to 5' direction. In the diagram below, the RNA strand will add complementary bases in the 3' end of the RNA. Thus, the next base would be G (to complement the C on the template strand) and C (to complement the G on the template strand).



How does the enzyme know when to stop transcribing into mRNA?

As the enzyme continues to unwind and fill in the complementary base pairs of the mRNA, it will eventually reach the *termination sequence* of DNA. The termination sequence tells the enzyme to stop transcribing and ends the elongation process. The mRNA detaches from the DNA and leaves the nucleus into the cytoplasm.

Translation process (Into proteins)

Once the mRNA enters the cytoplasm, it binds onto ribosomes (remember ribosomes are where protein synthesis occurs!) where it will initiate the translation process.

The translation process starts when the mRNA message has to be further translated into proteins. Since proteins are made up of amino acids linked together, the mRNA message has to be translated into individual amino acids. The carrier that brings the amino acid molecules to the mRNA message is called the transfer RNA (tRNA). The tricky part starts here. In the mRNA message, it has been transcribed into the RNA message. What the tRNA will now do is to read the mRNA in triplets (3 bases at once) called codons. These codons in triplets, code for different amino acids (see table below). For example, a codon with bases ACT will account for Thr (threonine), or AGT will codes for Ser (Serine).

Example:

DNA Template strand:

	3' – A C G G C T T A C G T C A C G G G C T A A C C G A T T– 5'
mRNA	5' – U G C C G A A U G C A G U G C C C G A U U G G C U A A – 5'
Read by tRNA and brings the amino acid	MET GLN CYS PRO ILE GLY STOP

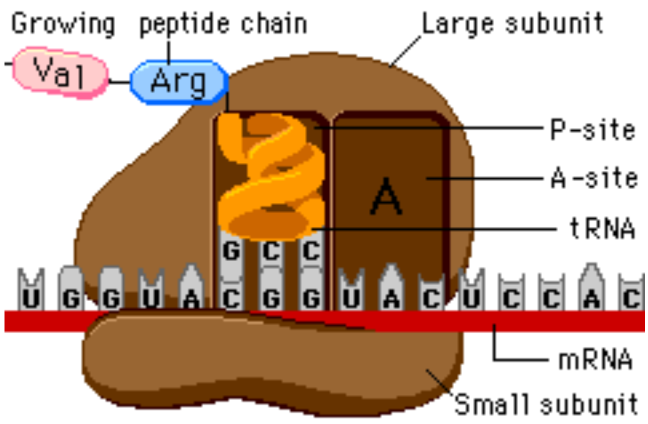
When does the protein know where to start the translation? There is a start codon that initiates the translation process. The start codon is AUG, which codes for methionine. All proteins will start with the start codon. While there is a start codon, there are also stop codons. The STOP codons are the codons that tell the enzyme to STOP translating. There are 3 codons that account for the stop codon, UAA, UAG and UGA.

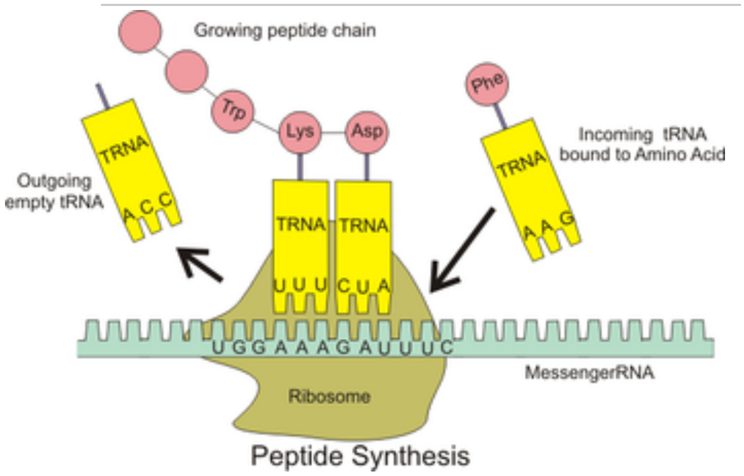
	U	C	A	G
U	UUU = phe	UCU = ser	UAU = tyr	UGU = cys
	UUC = phe	UCC = ser	UAC = tyr	UGC = cys
	UUA = leu	UCA = ser	UAA = stop	UGA = stop
	UUG = leu	UCG = ser	UAG = stop	UGG = trp
C	CUU = leu	CCU = pro	CAU = his	CGU = arg
	CUC = leu	CCC = pro	CAC = his	CGC = arg
	CUA = leu	CCA = pro	CAA = gln	CGA = arg
	CUG = leu	CCG = pro	CAG = gln	CGG = arg
A	AUU = ile	ACU = thr	AAU = asn	AGU = ser
	AUC = ile	ACC = thr	AAC = asn	AGC = ser
	AUA = ile	ACA = thr	AAA = lys	AGA = arg
	AUG = met	ACG = thr	AAG = lys	AGG = arg
G	GUU = val	GCU = ala	GAU = asp	GGU = gly
	GUC = val	GCC = ala	GAC = asp	GGC = gly
	GUA = val	GCA = ala	GAA = glu	GGA = gly
	GUG = val	GCG = ala	GAG = glu	GGG = gly

RNA Codon chart

You might be wondering, do all proteins start with Methionine since it is the start codon? That is a great question, but it is not quite true. Some proteins will start with methionine but some methionine will cleave off after its synthesis.

As the individual amino acids are added on to build the protein chain, this is all happening on ribosomes or ribosomal RNA (rRNA) (See right). As tRNA brings the amino acid with its anticodon, it enters the A site (amino site). The anticodon is basically the complementary base pairs of the mRNA. In the diagram on the right, the anticodon on the tRNA is GCC, which is complementary to CGG on the mRNA. After the amino acid as been brought to the sequence, the amino acid then gets transferred on to the growing peptide chain on the P site (peptide site) – the amino acid shifts over. The P site grows in the amino acid chain creating growing protein chain. The protein chain stops once the stop codon is read where the protein is then cleaved off the P site. The diagram on the right shows the mRNA strand, the tRNA bringing in the amino acid, and the two large blobs as your ribosomes. The Val and Arg make up the growing protein chain.





Summary:

The transcription and translation process is indeed a complicated one. As you go further into the sciences, more details regarding the process will be revealed.

Purpose of transcription:

To create proteins from the blueprints of DNA.

Useful videos:

Check out my biology playlist for more helpful videos: username: sciyeung

http://www.youtube.com/playlist?list=PLGwer6ZhE4tSSnIhw3Ql7HVVxtYGrrlCt

As a summary, here is a stepwise fashion on transcription and translation

1. From DNA – RNA polymerase recognizes the start sequence called the promoter
2. DNA is read and transcribed nto mRNA
3. mRNA leaves nucleus and enters cytoplasm to ribosomal sites
4. tRNA brings start codon AUG (Met)
5. tRNA brings other amino acids according to the codon triplets
6. tRNA reads any one of the 3 stop codons and ends translation
7. Amino acids are added on ribosomes on the A site
8. Protein chain lengthens in the P site eventually reaching to the end of the protein chain.
9. Protein chain is cleaved and protein is made