Name: _____ Period: _____ Date: _____

How DNA Controls the Cell

SECTION I: Transcription

Part 1: DNA, Transcription, Translation

1.If DNA were a boss… **2. If DNA were a king…**	1. It would be a boss that never left the _____. 2. It would be a king that never left the _____.
3-5. How does DNA stay in control?	3. DNA stays in the _____, but sends chemical messages out to the _____. 4. In the cytoplasm, _____ read the messages and make _____. 5. The messages are made of _____, a single stranded _____ acid.
6. DNA, RNA, and protein in diagram form	
7. What is transcription?	When information in genes (in the _____) is changed into _____
8. What is translation?	When information in _____ is changed into _____
9. The big problem in translation	DNA has only _____ bases. There are _____ amino acids in proteins. How can 4 letters specify 20 different things?

Part 2: Checking Understanding

1. A nucleic acid that always stays in the nucleus:_____
2. A nucleic acid that goes from the nucleus to the cytoplasm: _____
3. The cell's protein factory: _____
4. The process of changing DNA into RNA: _____
5. The process of changing RNA into protein: _____
6. Review: what's the monomer of protein: _____
7. Review: All of the monomers of protein are similar in that …

   They differ in that…

Part 3: *TWO ANALOGIES FOR INFORMATION TRANSFER FROM FOUR NUCLEOTIDES TO TWENTY AMINO ACIDS*

A	***B***	***C***	***D***	***E***	***F***	***G***	***H***	***I***	***J***	***K***	***L***	***M***	***N***	***O***
aaa	aac	aca	agg	agu	auu	caa	cau	cgu	cgg	cuu	gag	gac	gau	gca
P	***Q***	***R***	***S***	***T***	***U***	***V***	***W***	***X***	***Y***	***Z***	***.***	***:***	***,***	
gcu	gta	guc	guu	uaa	uac	uau	uca	ucc	ucu	uua	uuc	uuu	aau	

Now, here's a coded message. Try to decipher it:

___	___	___	___	___	___	___		___	___	___	___		
caa	agu	gau	agu	uaa	cgu	aca		cgu	gau	auu	gca		
___	___		___	___	___	___	___		___	___	___		
cgu	guu		aca	gca	agg	agu	agg		auu	gca	guc		
___	___		___	___	___		___	___	___				
cgu	gau		uaa	cau	agu		agg	gau	aaa				
___	___	___	___	___	___		___	___	___	___	___		
aac	aaa	guu	agu	guu	uuu		aaa	aau	aca	aau	uaa		
___	___	___		___	___								
aaa	gau	agg		caa	uuc								

Reflect! This exercise shows how…

It relates to what happens in cells because…

The "MESSAGE"

& ; >]~=:[? }/ {(}&>:[:* \:=> &;:* /:(*& &;> <[~

,}< > :* ,}{:> < &;>[&;:* < ://>(>[& ,}< > :*

&(~[*\~&> <

Code One

!	@	#	$	%	^	&	*	(	)	{	}	[	]	\	=	+	:	;	?	/	>	<	,	.	~
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26

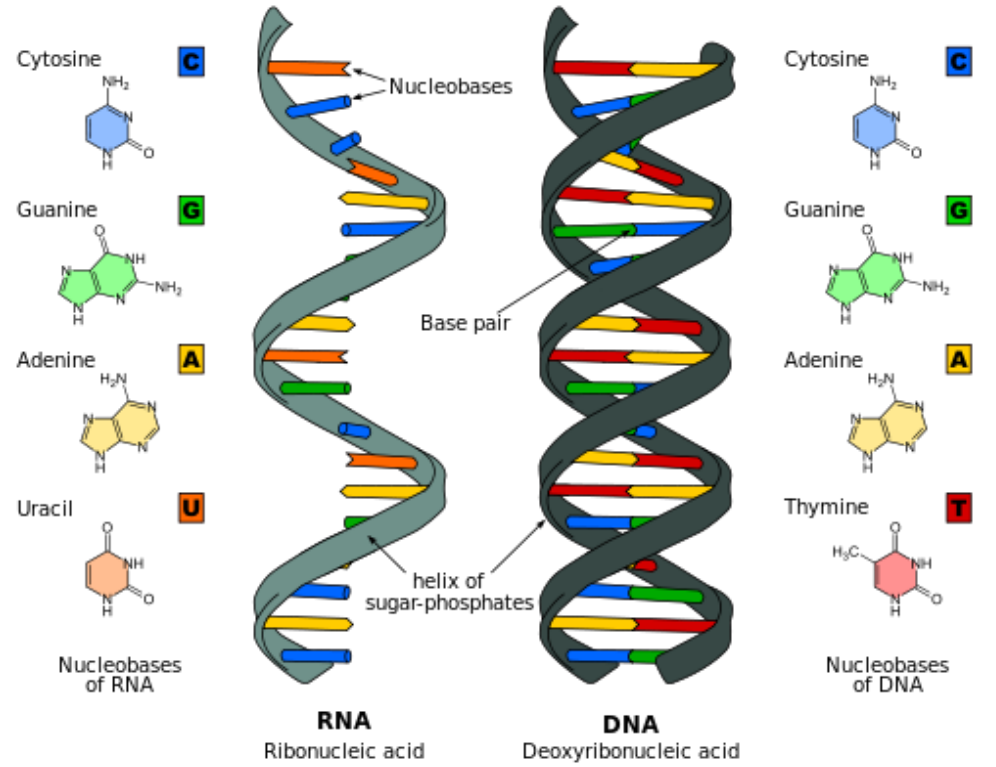
Code Two

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
Z	Y	X	W	V	U	T	S	R	Q	P	O	N	M	L	K	J	I	H	G	F	E	D	C	B	A

Reflect! This exercise shows how…

It relates to what happens in cells because…

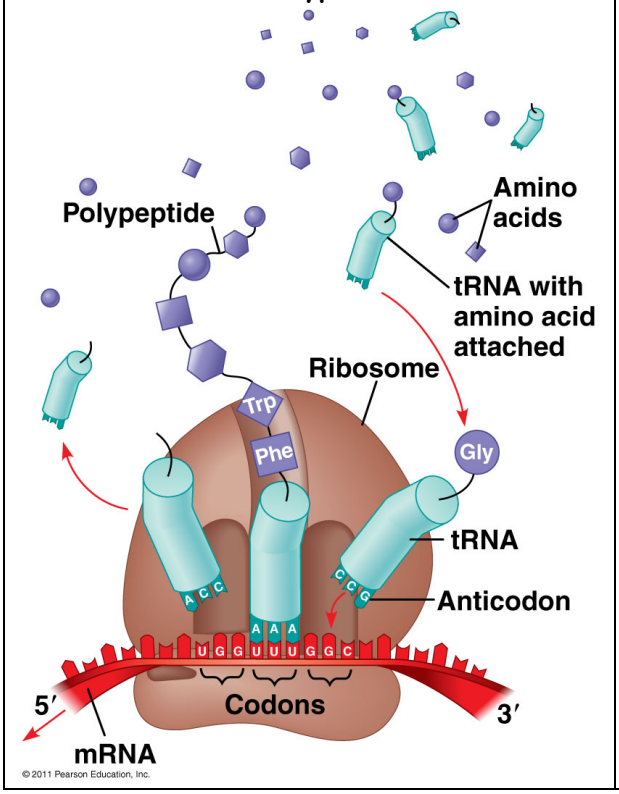
Part 4: What are the key properties of RNA?



RNA v. DNA

1. RNA is _____ stranded.
2. RNA uses the base _____ in place of _____.
3. RNA stands for _____ _____ _____, and has _____ as its sugar

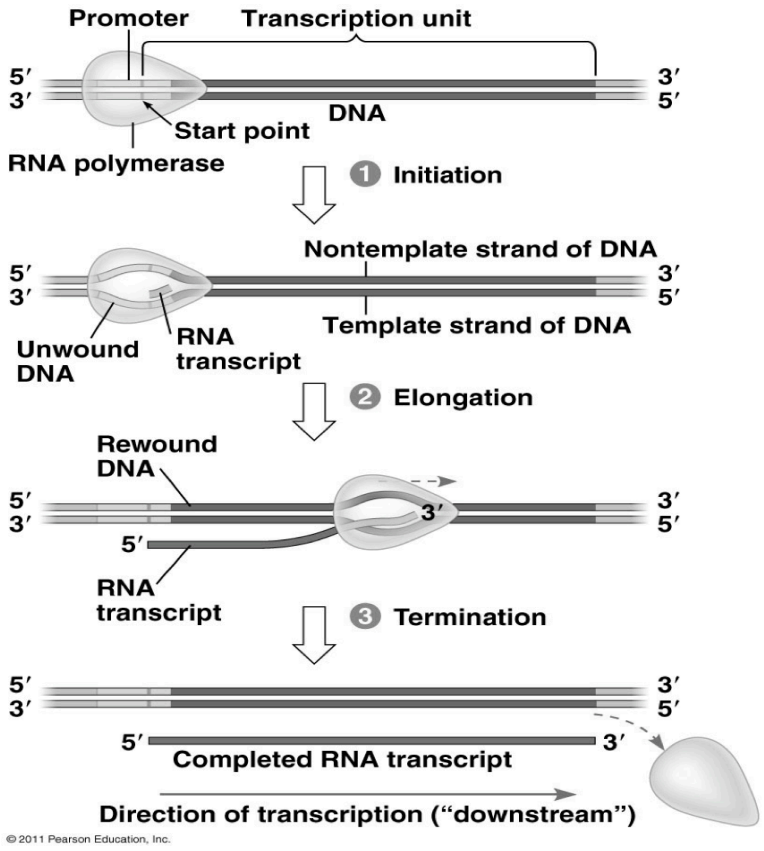
What are the three types of RNA?



4. mRNA is _____ RNA. It makes up the _____ sent from the _____ to the ribosomes.
5. rRNA is _____ RNA: it makes up _____ (along with some protein)
6. tRNA is _____ RNA. tRNAs bring _____ _____ to ribosomes so that the ribosomes can make _____.

Part 5: How does transcription work?

1. An enzyme (RNA polymerase) attaches to a _____, a region of DNA at the _____ of a gene
2. RNA polymerase _____ the double helix
3. RNA polymerase matches _____ RNA nucleotides to one of the DNA strands
4. The new RNA molecule is _____.

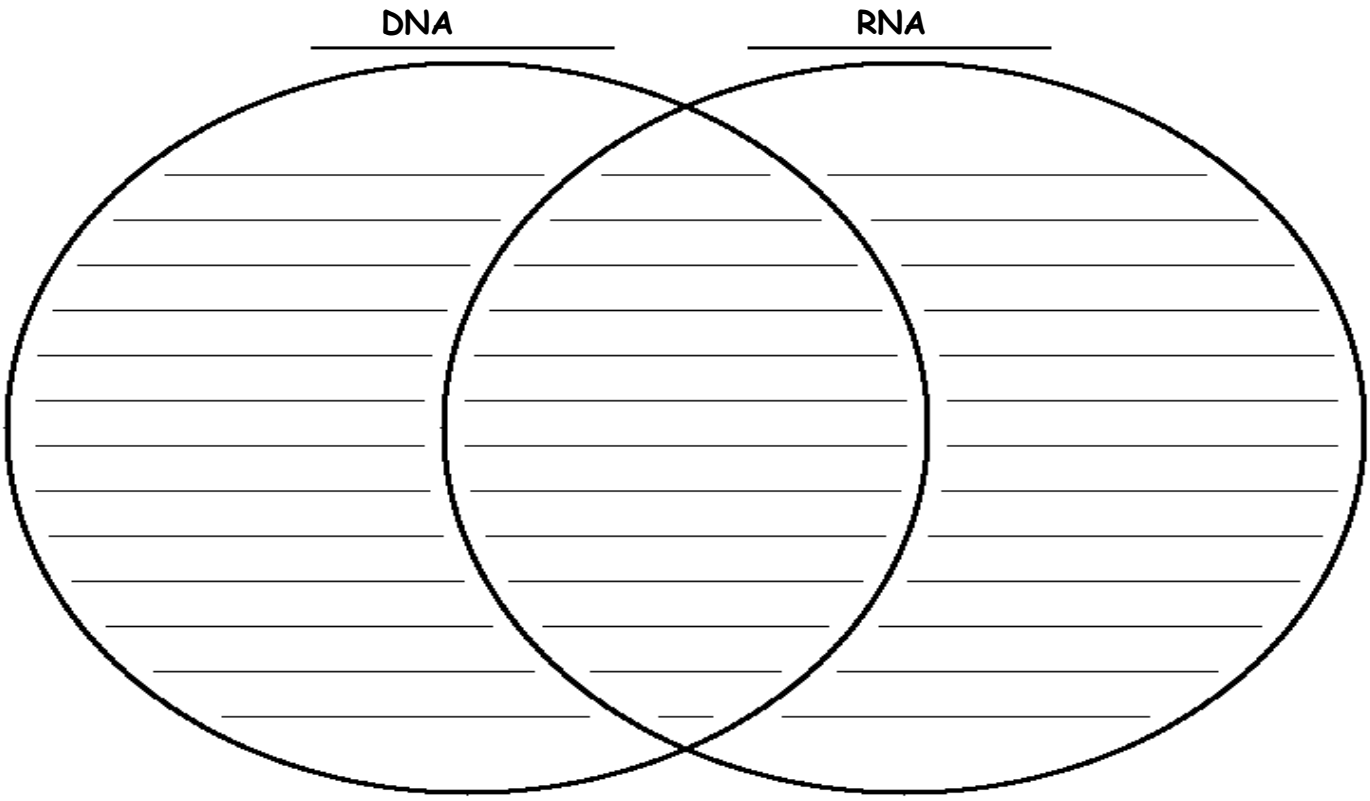


Part 6. Transcription practice. If you were DNA polymerase, how would you transcribe....

DNA: T T A C G C **RNA: _____**	**DNA: A T T C G G A** **RNA: _____**	**DNA: T T C A G G T C A A** **RNA: _____**

Checking understanding: Pretend that you're RNA polymerase. Explain the steps by which you would transcribe some DNA into RNA.

Sequencing words:	
• first, second • next, later, then • before/after • beginning, middle, end • while • now • finally • earlier • For the past • previously • since • eventually • initially • meanwhile • immediately • during • prior to • subsequently • simultaneously • preceding • following • concluding	



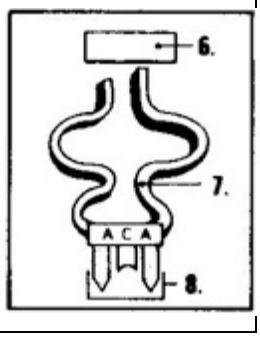
Compare and contrast • *are similar because* • *have in common* • *difference between* • *on the other hand* • *just like* • *in contrast* • *compared to* • as opposed to • a distinction between • share common attributes • synonymous with • just as • whereas • by comparison	Part 7. Write a few sentences comparing and contrasting DNA and RNA..

SECTION II. Translation and the Genetic Code

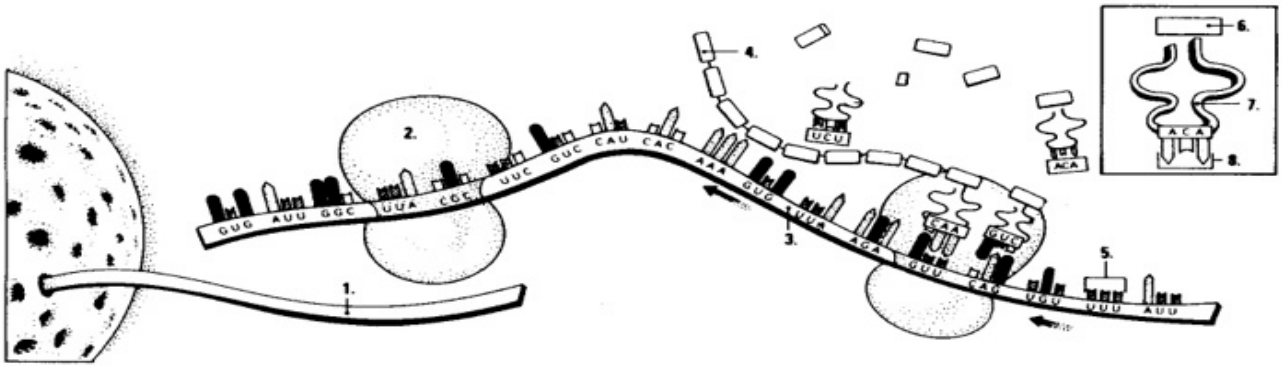
1. Review: transcription	During *transcription*, RNA polymerase attaches to the beginning of a *gene* (a segment of DNA that gets translated into a protein). A sequence of bases known as a *promoter* in the DNA "tells" the RNA polymerase where to bind. The RNA polymerase then pries open the DNA. One strand of the DNA serves as a *template* that allows complementary RNA nucleotides to form hydrogen bonds with it. As a matching RNA nucleotide binds with its complementary DNA partner, the RNA polymerase catalyzes a sugar-phosphate bond between one RNA nucleotide and the next, creating an RNA polymer. When the RNA polymerase reaches the end of the gene, it releases the RNA. In a prokaryotic cell, the RNA is then ready for action. In a eukaryotic cell, that RNA is usually modified, and then has to find its way out of the nucleus and into the cytoplasm.

Briefly summarize the process of transcription in six steps:

1.	2. RNA pol. pries open...	3.	4	5. Polymerase reaches the end of the gene.	6.

2. Genetic code and codons	Messenger RNA is a code. The ribosome translates this code into protein. This code is called the GENETIC CODE. It's a universal code, pretty much the same in all living things. In this code, THREE RNA bases code for ONE amino acid. These three bases are known as a CODON (from "code + one").
3.tRNAs anti-codons, and translation	As with any cellular process, translation gets carried out without any "higher intelligence." There's no one in the cell who can read, think, etc. The translator in this process is transfer RNA (tRNA) tRNAs (7, at right) are bilingual molecules. One end of a tRNA consists of 3 RNA bases that complement an RNA codon. These three bases are called an "anti-codon." (8) The other end carries a specific amino acid (6). The process of translation starts with a molecule of messenger RNA coming out of the nucleus and entering the cytoplasm (shown at 1). Next, a ribosome (2) attaches to the mRNA, and starts moving along its length. The mRNA sits on the ribosome in a way that exposes the mRNA codons (shown at 5). The complementary match between codon (5) and tRNA anticodon (8) ensures that only the correct amino acid (6) will be brought by a tRNA (7) to the ribosome. The ribosome catalyzes peptide bonds between adjacent amino acids, resulting in the formation of a protein (4). **tRNA** 

4. Translation Overview



Key to diagram. Use the text above ("tRNAs, anticodons, and translation") to identify all the parts in the diagram.

1. _____	4. _____	7. _____
2. _____	5. _____	8. _____
3. _____	6. _____	

Summarize the process of translation in 5 steps.

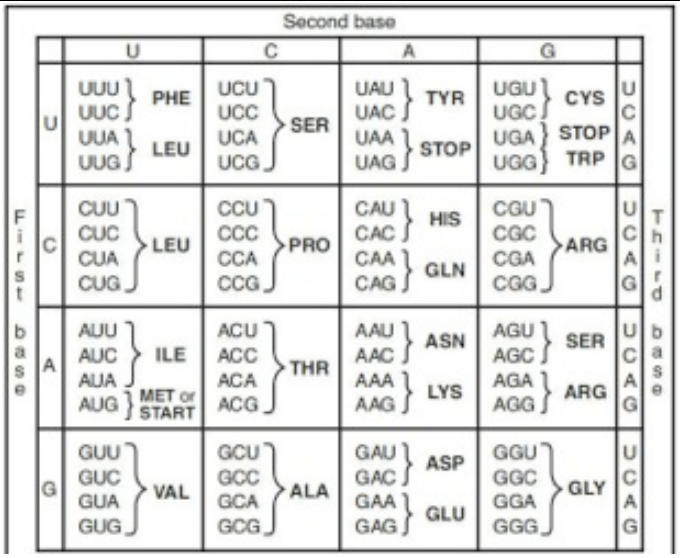
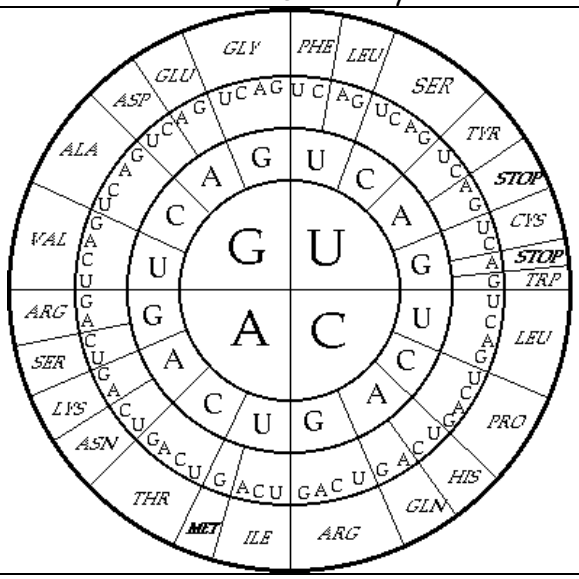
1.	2.	3.	4	5. Ribosome reaches the end of mRNA and releases the protein

5. The Genetic Code and Protein Synthesis

Ala= alanine	Gln = glutamine	Leu= leucine	Ser=serine
Arg= arginine	Glu= glutamate	Lys= lysine	Thr=threonine
Asn= asparagine	Gly = glycine	Met = methionine	Trp= tryptophan
Asp= aspartate	His= histidine	Phe= phenylalanine	Tyr = tyrosine
Cys= cysteine	Ile= isoleucine	Pro= proline	Val= valine

The **central dogma** of molecular genetics is ***DNA makes RNA makes protein***. As we've seen, how this happens involves some complicated cellular machinery, but figuring out what protein will be made from DNA or RNA is easy. It involves reading a "genetic code dictionary."

The dictionary is always based around RNA and its four bases A, U, C, and G. Two versions are shown below. In either case, you always start by breaking the RNA into codons (groups of 3 bases).

Standard, Tabular Dictionary	Circular Dictionary
	
Find the 1st base on the left, the second base on top, and the 3rd base on the right.	Find the 1st base in the center, the second in the middle ring, and the last in the outermost ring.

Example: Translate the following mRNA into protein. mRNA: AUG CGU UUC GGU UAC UGA Amino acids: MET ARG PHE GLY TYR STOP	Problem 1 mRNA: AUG CCC AAA GGG UUU UAG Amino acids
Problem 2: Transcribe the DNA into RNA, then translate the RNA *(advice: Use lines to divide the bases into triplets)* DNA TACGCAAAGCCAATGACT mRNA: Amino acids	Problem 3: same instructions as problem 2 DNA TACAGCCTCGACAAG mRNA: Amino acids
Problem 4: Figure out which RNA and DNA would code for the following sequence of amino acids (multiple answers are possible) DNA mRNA: Amino acids: GLY ASN VAL LEU CYS VAL	Problem 5: Figure out the DNA and amino acids from the following mRNA DNA mRNA: CUCAAGUGCUUC Amino acids

SECTION III. Understanding Protein Synthesis

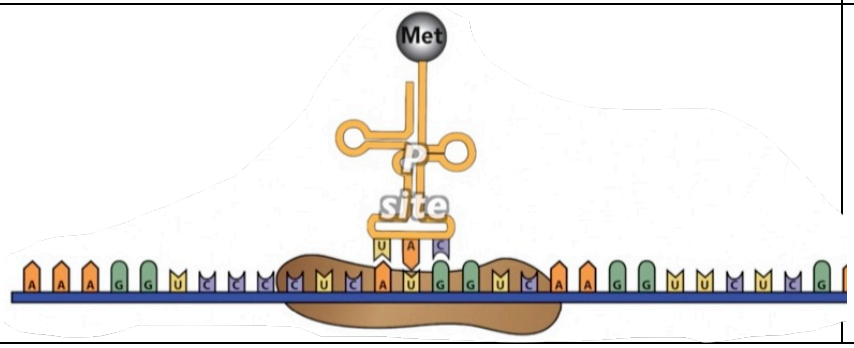
1. Protein Synthesis: The details

The first phase of protein synthesis is called **initiation**. Initiation begins as a strand of mRNA leaves the nucleus. The small subunit of a ribosome attaches to the leading end of the mRNA. A tRNA carrying the amino acid methionine binds with the start codon AUG. Initiation ends as the large subunit of the ribosome binds with the small subunit, completing the ribosome.

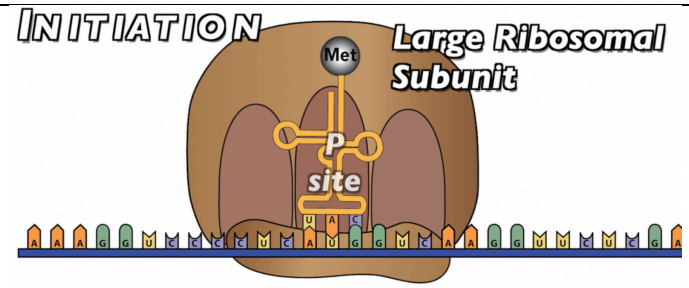
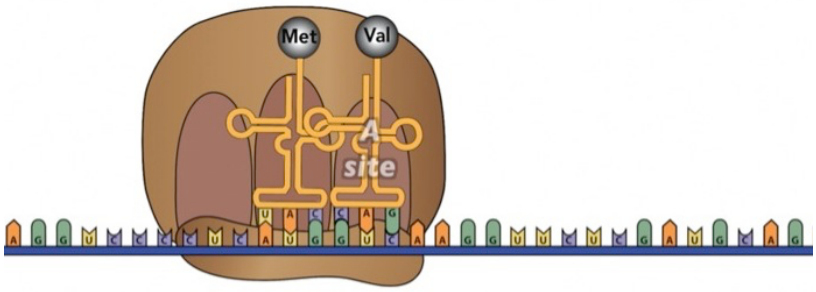
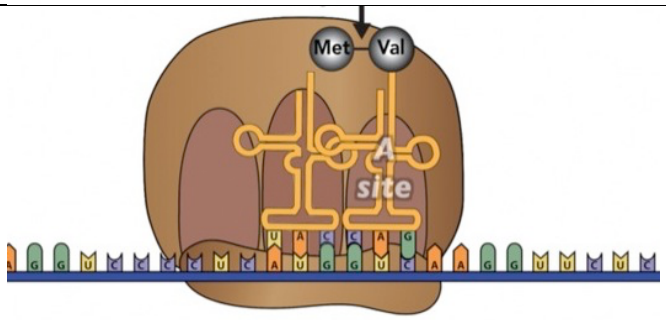
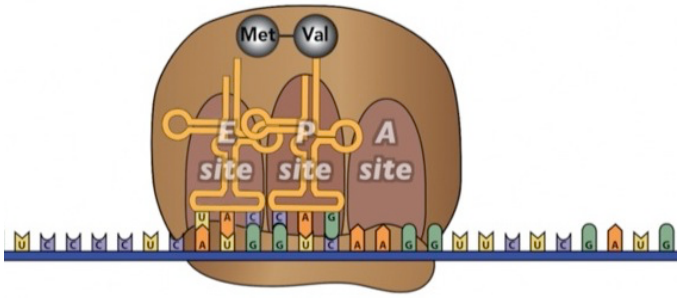
Elongation involves synthesis of an increasingly long chain of amino acids, or **polypeptide**. A second tRNA, carrying a second amino acid, comes to the ribosome, and sits on the codon immediately adjacent to the start codon. The ribosome catalyzes a peptide bond between the first amino acid that had been brought to the ribosome, and this new amino acid, forming a dipeptide (a mini-protein with two amino acids). Next, the ribosome moves over to the next mRNA codon. As another tRNA bearing a third amino acid comes to the ribosome, the first tRNA gets discharged into the cytoplasm. The ribosome then catalyzes another peptide bond, forming a tri-peptide (a chain of three amino acids). This process of ribosomal movement from one codon to the next, arrival of new tRNAs with new amino acids, and formation of new peptide bonds results in an increasingly long polypeptide.

The process ends only when the ribosome reaches a stop codon. This codon, instead of coding for an amino acid, codes for a protein called a *release factor* to enter the ribosome. The release factor causes the polypeptide to disconnect from the last tRNA, and for the entire initiation complex (ribosome, tRNA, and mRNA) to fall apart. The polypeptide folds up into its three dimensional shape, completing the protein synthesis process.

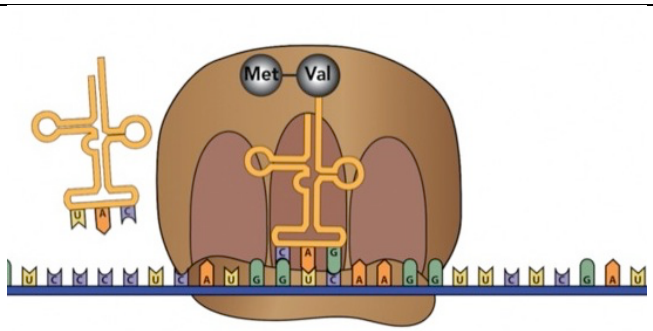
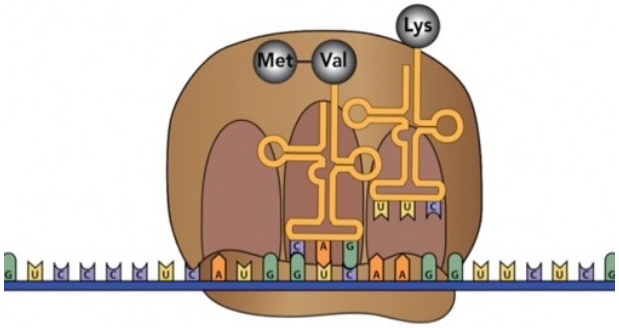
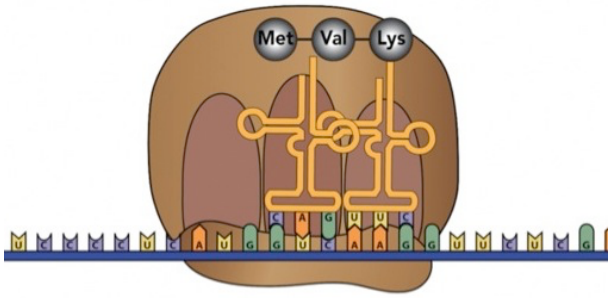
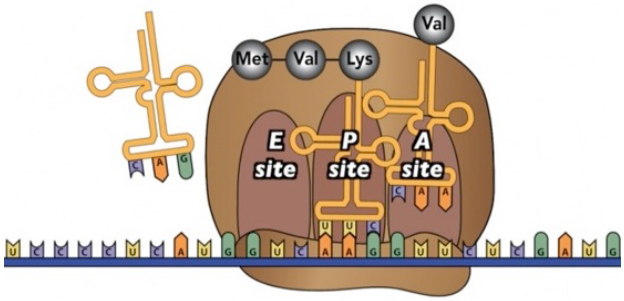
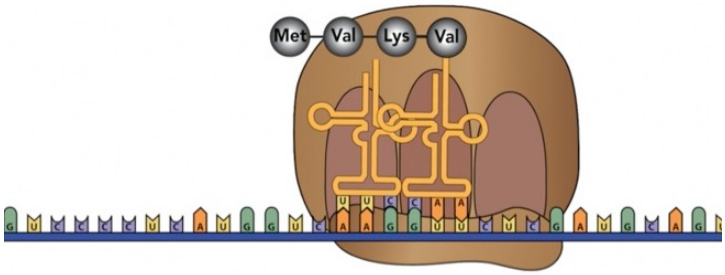
2. A storyboard for protein synthesis. Complete the text in the right column below.

1		First, the _____ leaves the _____
2		The _____ subunit of the ribosome slides along the _____ until it reaches the _____ _____.
3		The first _____, bearing the amino acid _____, binds with codon _____. The first tRNA binds because it has a complementary _____-codon, _____. This anti-codon binds at the _____ site.

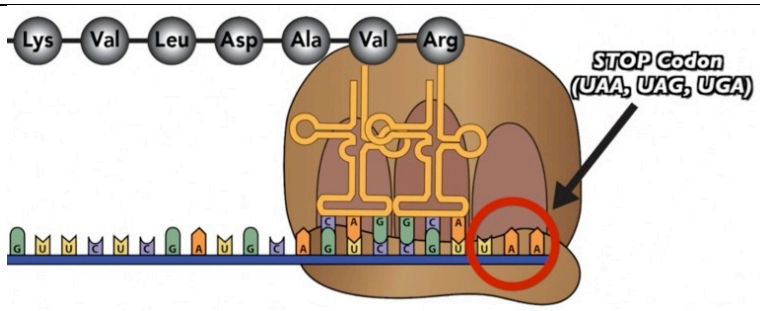
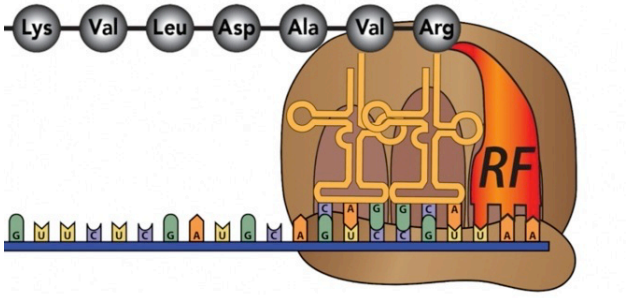
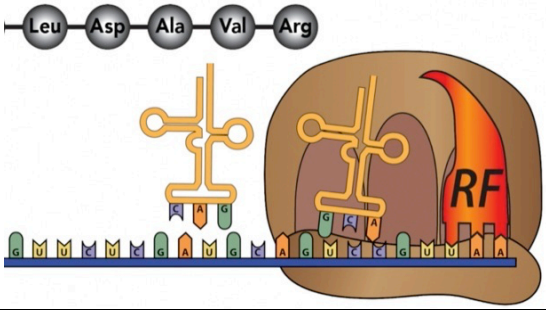
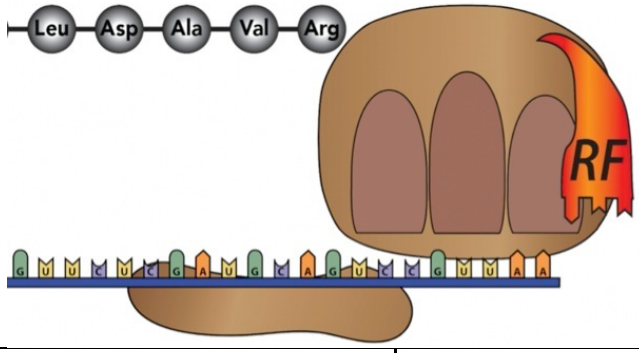
Anti-	mRNA	start codon
AUG	nucleus	tRNA
methionine	P	UAC
mRNA	small	

4		The _____ subunit of the _____ binds with the small subunit.
5		The next tRNA binds with the second _____, which is at the "__" site. Note that many tRNAs "try" to bind: the only one that sticks is the one with a _____ anti- _____. They stick through _____ bonds.
6		Now the ribosome acts as an _____. It catalyzes a _____ bond between the two amino acids.
7		The entire ribosome moves one _____ over in a move called _____. This moves the 1st tRNA into the "___" site, and leaves the ____ site open.

A	Complementary	Peptide
A	E	Ribosome
Codon	Enzyme	translocation
Codon	Hydrogen	
Codon	Large	

8		The first _____ is discharged from the ribosome.
9		Another _____, with an anti-codon that is _____ to the next codon, binds with the mRNA at the exposed "A" site."
10		The third _____ _____ joins with growing polypeptide chain as the _____ catalyzes another peptide bond.
11		This process, known as _____, continues. As it does, the _____ chain continues to lengthen.
12		After each peptide bond is formed, the ribosome _____ one _____ over

amino acid	elongation	translocates
codon	polypeptide	tRNA
complementary	ribosome	tRNA

13		Finally, the ribosome reaches a _____ codon. This codon has no corresponding _____.
14		Instead of another tRNA, a protein known as a _____ factor binds at the _____ codon.
15		This causes the polypeptide to _____ from the ribosome.
16		Finally, the _____ falls apart. _____ of this mRNA is done

detach	Stop	translation
release	stop	
ribosome	tRNA	

Writing About Protein Synthesis

Use the sequencing words below to write about protein synthesis from several perspectives.

Sequencing words:			
· first, second · next, later, then · before/after · beginning, middle, end · while	· now · finally · earlier · For the past · previously · since	· eventually · initially · meanwhile · immediately · during · prior to	· subsequently · simultaneously · preceding · following · concluding

Use these content specific terms

· mRNA, nucleus, small subunit of the ribosome, large subunit of the ribosome, codon, anti-codon, amino acid, peptide bond, protein, release factor,

Pretend that you're a ribosome. From the ribosome's perspective, describe how protein synthesis occurs.

Now pretend that you're mRNA. From mRNA's perspective, describe how protein synthesis occurs. Use the same sequencing and content specific words listed above.

Replication, Transcription, Translation

1. Compare and contrast these three processes:

	Replication	Transcription	Translation
What does it produce?			
Why is this process important?			
Where does it happen?			
Key enzymes/cell parts			
How does the process work?			

2. Now write a few paragraphs comparing and contrasting replication, transcription, and translation.

Some key content terms:

- complementary
- DNA polymerase
- RNA polymerase
- Ribosome
- polymerization
- monomers
- polymers
- nucleus
- cytoplasm

Compare and contrast terms

- *are similar because*
- *have in common*
- *difference between*
- *on the other hand*
- *just like*
- *in contrast*
- *compared to*
- as opposed to
- a distinction between
- share common attributes
- synonymous with
- just as
- whereas
- by comparison

Protein Synthesis Rap

http://www.sciencemusicvideos.com/protein-synthesis-rap-music-video/

Look at what's coming out of the nucleus
Destined for a ribosome, a strand of mRNA
It's got the code, the information,
For the protein we'll be making today

The RNA message is organized
Into codons, that's a sequence of bases three
That spell out one and only one amino acid
A genetic code that works universally

A codon has its match in an anti-codon
Three bases on a tRNAs bottom side
tRNA, it's job is to bring amino acids
To ribosomes so proteins can be synthesized

CHORUS
mRNA, tRNA and ribosomes
plus amino acids make a protein making machine
Read the codon, make a polypeptide
That's translation – cells synthesizing proteins

The small subunit of a ribosome binds
With that mRNA's leading end
And slides until it reaches start codon AUG
Indicating where translation begins

A ribosome has three binding sites
Where tRNAs can bind
The "A" site's first, "P"s next, then "E"
And the E's got an exit sign

The first tRNA in this translation process
Binds the start codon in binding site "P"
And that tRNA carries an amino acid
That goes by the name of Methionine.

And now to finish this initiation
The ribosome needs to be made complete
The large subunit binds the small subunit
Now we're ready for translation to proceed.

CHORUS

Now we're ready for next step: elongation
An amino acid carried by a new tRNA
With an anticodon matching with the second codon
Binds at the site called "A"

Then the ribosome carries out an enzymatic action.
Binding these amino acids with a peptide bond
So a dipeptide hangs on the "A" site tRNA
Watch translation move along!

Next the ribosome shifts exactly one codon over
In a move that we call "translocation"
So the "A" site's empty, and the "P" site's loaded
And the first tRNA's in the "E" location

"E" site tRNA makes its exit
And the next tRNA fills the site called "A"
And the ribosome catalyzes away
In your cells it happens every second, every day

And watch that polypeptide, see it get longer
As each and codon gets translated
Ribosomal robots reading RNA instructions
As proteins get created!

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Bridge
Protein synthesis!
Translation!
(repeat 4X)

We started with initiation, which was followed
By part two of translation: elongation
Now it's time to finish synthesizing this protein,
With a finale called termination.

When the ribosome gets to a stop codon
There's no tRNA anti-codon that matches
So "A" site's bound by a release factor:
The polypeptide detaches

tRNAs at P & E sites float away
Ribosome breaks apart, no longer one
The polypeptide folds into functional protein
Translation is done!

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