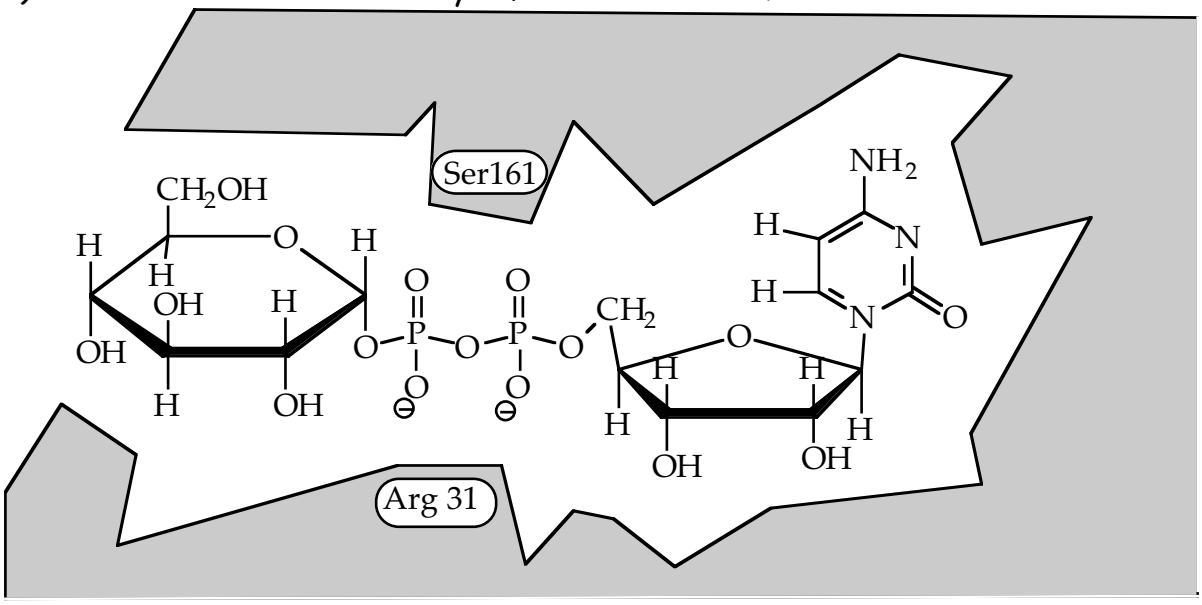
7.013 Practice Quiz 1

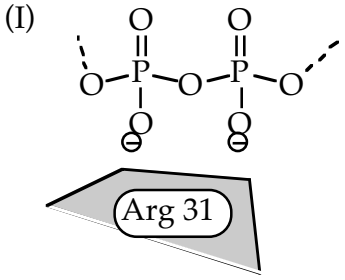
Question 1

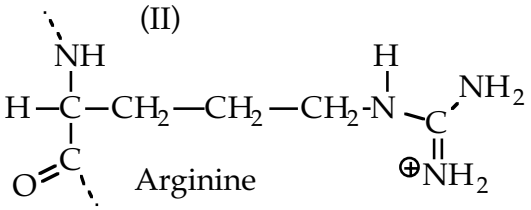
Shown below is a close up of a substrate (UDP-Glucose) bound to the active site of an enzyme (UTase). The shaded area is the enzyme; the structure of the substrate is shown.



Two amino acids of the enzyme are highlighted: Arg 31 and Ser 161.

a) Part (I) of the figure below shows the relative positions of Arg 31 and the portion of the substrate with which it interacts; part (II) shows the structure of arginine.

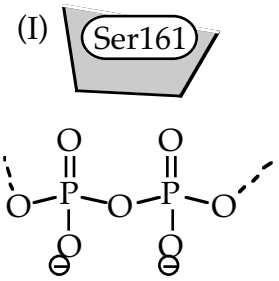


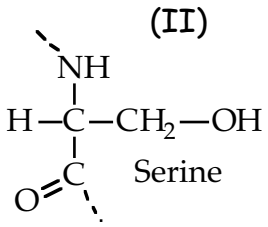


The side chain of Arg 31 interacts with the portion of the substrate shown above. What type of interaction(s) is/are possible between the side chain of Arg 31 and this portion of the substrate? (Circle all that apply.)

hydrophobic interaction	Hydrogen bond	Ionic bond	van der Waals interaction

b) The figure below shows the relative positions of Ser 161 and the portion of the substrate with which it interacts (I) ; (II) shows the structure of serine.





The side chain of Ser 161 interacts with the portion of the substrate shown above. What type of interaction(s) is/are possible between the side chain of Ser 161 and this portion of the substrate? (Circle all that apply.)

hydrophobic interaction	Hydrogen bond	Ionic bond	van der Waals interaction

c) Suppose that you are studying the interactions between the substrate and the enzyme. It is possible to make variant enzymes that differ from the one above by a single amino acid substitution. (For example, Asp 78 could be replaced with tryptophan). You could use this technique to investigate the roles of each amino acid shown above.

If you change Arg 31 to a lysine, would you predict that the substrate still binds, or that the substrate now fails to bind to the altered enzyme? Explain.

Question 2

a) You have started a UROP in the behavioral genetics department at the University of Monterrey in Mexico. For your first assignment, your advisor asks you to figure out the genetics of a particular species of honeybee that has just been discovered- a red killer bee! To begin your studies, you cross this true breeding red killer bee with the local true breeding blue gentle bee. The F1 progeny show the following phenotype:

54 red "feisty" bees

You have characterized the disposition as such:

gentle: will ignore humans and simply gather pollen

killer: will attack and sting without provocation

feisty: will approach humans threateningly, but will not sting

a) Write the genotypes of the P parental types and the F1 progeny.
(Be sure to indicate which particular phenotype corresponds to each parental genotype.)
Use "H" and "h" as your symbols for the alleles of the gene conveying color or hue and "D and d" as your symbols for alleles of the gene for disposition.

P

F_1

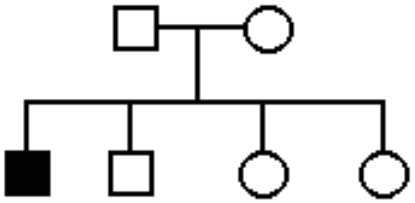
b) You want to determine if the gene for hue is linked to the gene involved in disposition. You decide to set up a test cross for the F1. Indicate the genotypes of the strains you choose for the cross.

c) Using your chosen strains indicate the ratio of genotypes and phenotypes of the progeny if the traits are NOT linked.

Question 3

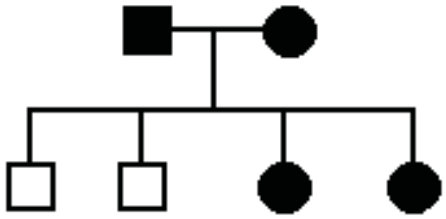
You have sought a job at a human genetic counseling clinic. They gave you an aptitude test shown below. Answer the yes/no questions concerning each of the four pedigrees. Assume that none of these traits is the result of a *de novo* mutation. Assume 100% penetrance for all pedigree problems in this problem set.

a) **Pedigree A**



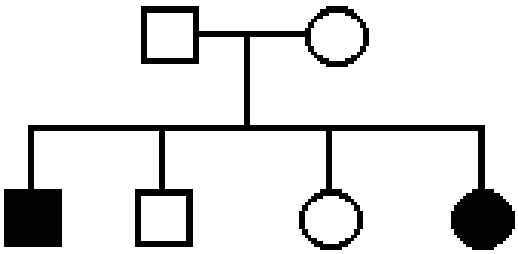
Could this trait be inherited as a simple **autosomal recessive**?	YES	NO
Could this trait be inherited as a simple **autosomal dominant**?	YES	NO
Could this trait be inherited as a simple **X-linked recessive**?	YES	NO
Could this trait be inherited as a simple **X-linked dominant**?	YES	NO

b) **Pedigree B**



Could this trait be inherited as a simple **autosomal recessive**?	YES	NO
Could this trait be inherited as a simple **autosomal dominant**?	YES	NO
Could this trait be inherited as a simple **X-linked recessive**?	YES	NO
Could this trait be inherited as a simple **X-linked dominant**?	YES	NO

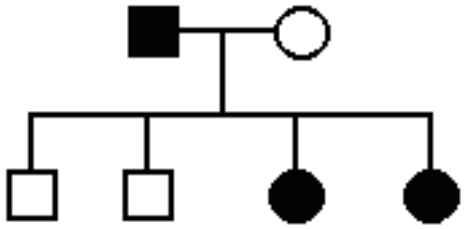
c) **Pedigree C**



Could this trait be inherited as a simple **autosomal recessive**?	YES	NO
Could this trait be inherited as a simple **autosomal dominant**?	YES	NO
Could this trait be inherited as a simple **X-linked recessive**?	YES	NO
Could this trait be inherited as a simple **X-linked dominant**?	YES	NO

d)

Pedigree D



Could this trait be inherited as a simple **autosomal recessive**?	YES	NO
Could this trait be inherited as a simple **autosomal dominant**?	YES	NO
Could this trait be inherited as a simple **X-linked recessive**?	YES	NO
Could this trait be inherited as a simple **X-linked dominant**?	YES	NO

e) On your first day of the job, a man with purple ears comes to your attention when he enters the office of the human geneticist with whom you are interning. You questioned the man and wrote down the following family history.

The man's mother and one of his sisters also had purple ears, but his father, his brother, and two other sisters had normal ears. The man and his normal-eared wife had seven children, including four boys and three girls. Two girls and two boys had purple ears.

Draw the family pedigree and indicate what form of inheritance that the purple-ear trait **most likely** follows. Assume 100% penetrance.

f) Another male patient comes in with red-green color blindness which you know is X-linked in humans. If the male is red-green color blind, and both his parents have normal color vision, which of the male's grandparents is **most likely** to be red-green colorblind?

a. maternal grandmother

b. maternal grandfather

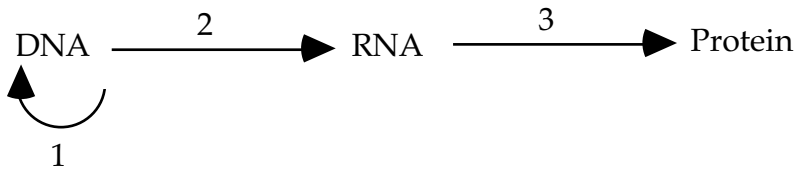
c. paternal grandmother

d. paternal grandfather

e. either grandfather is equally likely

Question 4

The term "central dogma" refers to the flow of biological information from DNA to RNA to protein.



a) i) In the spaces below, indicate the process that corresponds to each arrow.

1. _____ 2. _____ 3. _____

ii) Name the initiation site for each processes, and on which molecule this site exists.

1. _____2. _____3. _____

iii) What cellular machinery carries out each process?

1. _____ 2. _____ 3. _____

b) Indicate whether each of the following statements is **true** or **false**. If false, correct the statement or provide a brief explanation for why it is false.

i) DNA replication is initiated at promoter sequences in the DNA.

ii) RNA polymerase requires primers to initiate RNA synthesis.

iii) The 5' to 3' direction of DNA synthesis implies that deoxyribonucleotides are added to the 5' OH group on the growing strand.

iv) Transcription is terminated at stop codons in the mRNA.

c) Shown below is the DNA sequence of a gene from a virus that encodes a short viral peptide. Also shown is the sequence of the mRNA synthesized from this gene.

genomic DNA sequence:

5'-AGCTCATGTGCGAGTCCTGACGCTGACTAGG-3'
3'-TCGAGTACACGCTCAGGACTGCGACTGATCC-5'

mature mRNA sequence (G* = G cap):

5'-G*UCAUGUGCGAACGCUGACUAGGAAAAAAAA....-3'

i) In the genomic DNA sequence shown above, draw a box around each of the two exons in the gene.

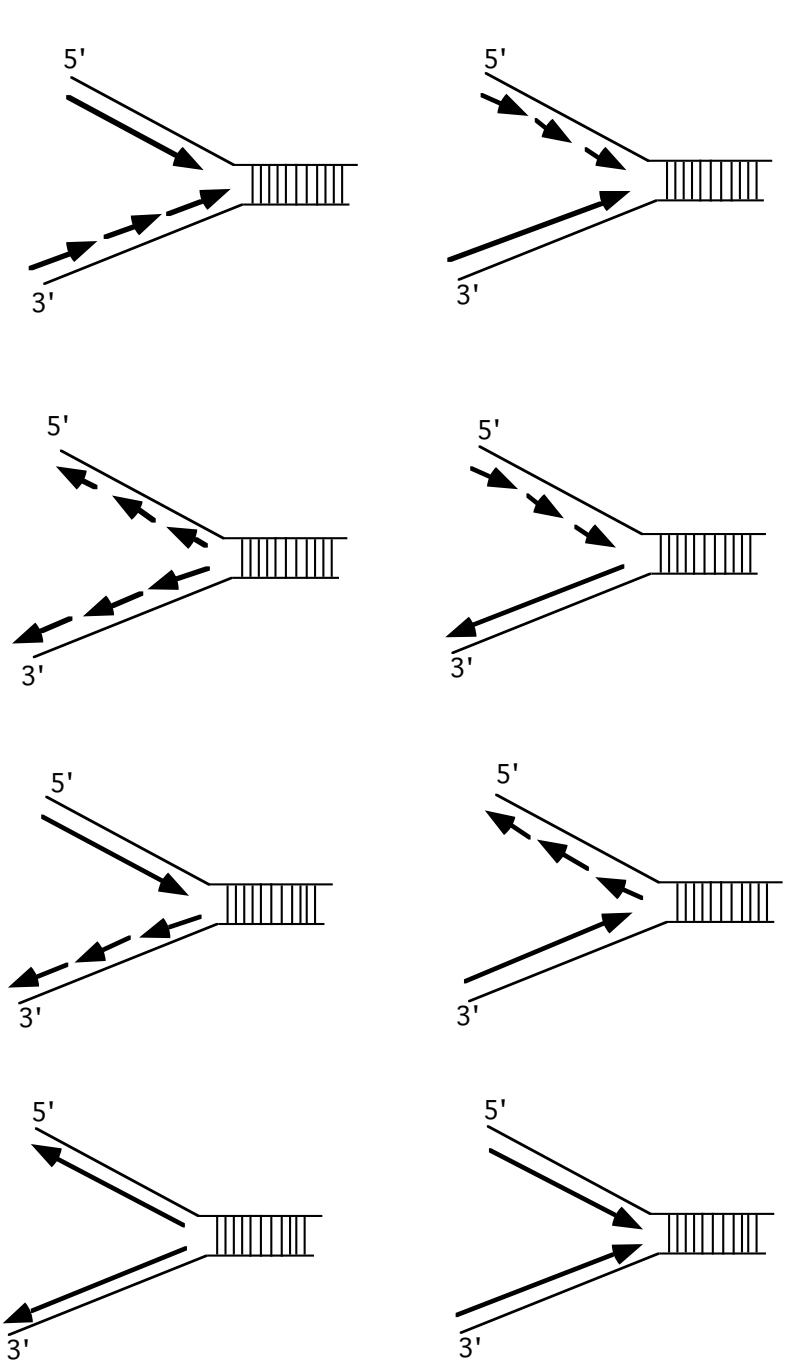
ii) In the mRNA above, some nucleotides are present that are not coded for in the genomic DNA sequence. Name the two processes that have occurred to add these nucleotides to the mRNA.

iii) How many amino acids are in the viral peptide encoded by this gene? _____

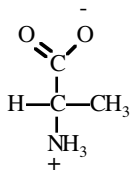
iv) Is this virus more likely to replicate in prokaryotic or eukaryotic cells? Briefly explain your reasoning.

	U	C	A	G	
U	UUU **phe (F)**	UCU **ser (S)**	UAU **tyr (Y)**	UGU **cys (C)**	UC
	UUC **phe (F)**	UCC **ser (S)**	UAC **tyr (Y)**	UGC **cys (C)**	A
	UUA **leu (L)**	UCA **ser (S)**	**UAA STOP**	**UGA STOP**	G
	UUG **leu (L)**	UCG **ser (S)**	**UAG STOP**	UGG **trp (W)**	
C	CUU **leu (L)**	CCU **pro (P)**	CAU **his (H)**	CGU **arg (R)**	UC
	CUC **leu (L)**	CCC **pro (P)**	CAC **his (H)**	CGC **arg (R)**	A
	CUA **leu (L)**	CCA **pro (P)**	CAA **gln (Q)**	CGA **arg (R)**	G
	CUG **leu (L)**	CCG **pro (P)**	CAG **gln (Q)**	CGG **arg (R)**	
A	AUU **ile (I)**	ACU **thr (T)**	AAU **asn (N)**	AGU **ser (S)**	U
	AUC **ile (I)**	ACC **thr (T)**	AAC **asn (N)**	AGC **ser (S)**	C
	AUA **ile (I)**	ACA **thr (T)**	AAA **lys (K)**	AGA **arg (R)**	A
	AUG met (M)	ACG **thr (T)**	AAG **lys (K)**	AGG **arg (R)**	G
G	GUU **val (V)**	GCU **ala (A)**	GAU **asp (D)**	GGU **gly (G)**	U
	GUC **val (V)**	GCC **ala (A)**	GAC **asp (D)**	GGC **gly (G)**	C
	GUA **val (V)**	GCA **ala (A)**	GAA **glu (E)**	GGA **gly (G)**	A
	GUG **val (V)**	GCG **ala (A)**	GAG **glu (E)**	GGG **gly (G)**	G

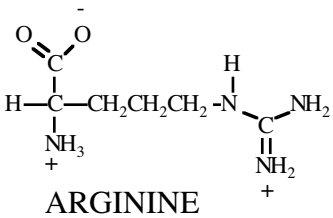
d) Circle the figures below that correctly depict the direction of replication of the leading and lagging strands at replication fork. All lines with arrows show the newly synthesized DNA and indicate the direction of polymerization. The 5′ and 3′ designations are indicated on the template DNA. Circle **all** that are correct.



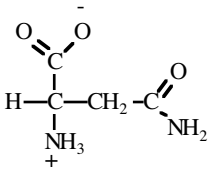
STRUCTURES OF AMINO ACIDS



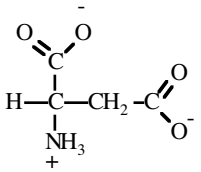
ALANINE
(ala)



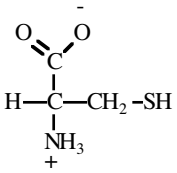
ARGININE
(arg)



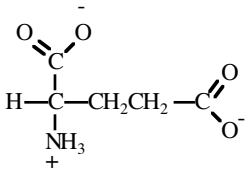
ASPARAGINE
(asN)



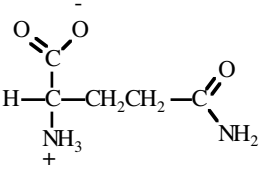
ASPARTIC ACID
(asp)



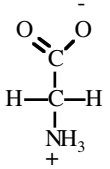
CYSTEINE
(cys)



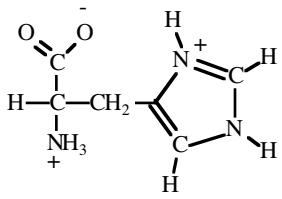
GLUTAMIC ACID
(glu)



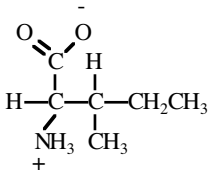
GLUTAMINE
(glN)



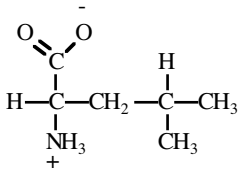
GLYCINE
(gly)



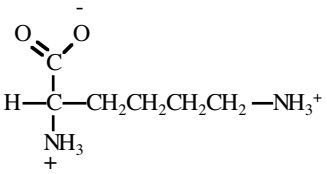
HISTIDINE
(his)



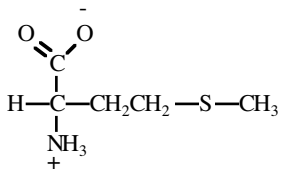
ISOLEUCINE
(ile)



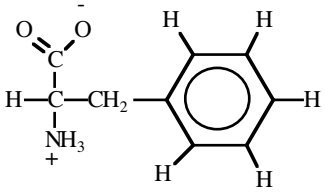
LEUCINE
(leu)



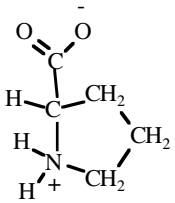
LYSINE
(lys)



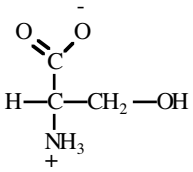
METHIONINE
(met)



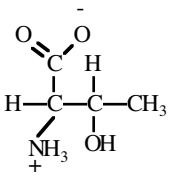
PHENYLALANINE
(phe)



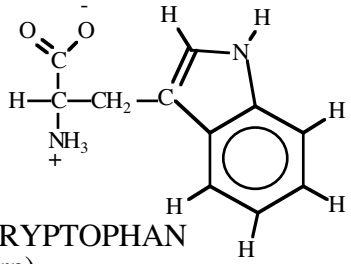
PROLINE
(pro)



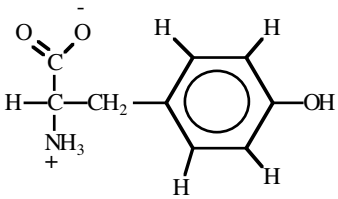
SERINE
(ser)



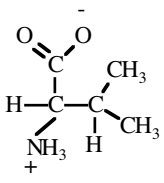
THREONINE
(thr)



TRYPTOPHAN
(trp)



TYROSINE
(tyr)



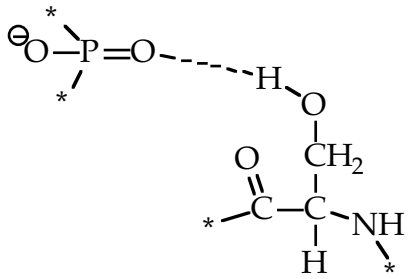
VALINE
(val)

Solutions to Practice Quiz 1

1) a) hydrogen and ionic bonds (vdw OK but not required).

b) i) hydrogen bond (vdw OK but not required).

ii)



(* indicates the connections to the backbone)

c) It should still bind because the lys is also (+) charged and can therefore still make an ionic with the (-) of the phosphate.

2) a) Write the genotypes of the F_0 parental types and the F1 progeny.

P HHDD (red killer) X hhdd (blue gentle)

F1 HhDd (red feisty)

b) HhDd X hhdd (the red feisty F1 against a pure breeding blue gentle bee)

c) Using your chosen strains indicate the ratio of genotypes and phenotypes of the progeny if the traits are NOT linked.

1 red feisty (HhDd) : 1 red gentle (Hhdd) : 1 blue feisty (hhDd) : 1 blue gentle (hhdd)

3) a) Yes, no, yes, no,

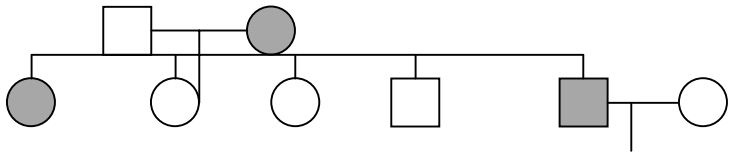
b) No, yes, no, yes

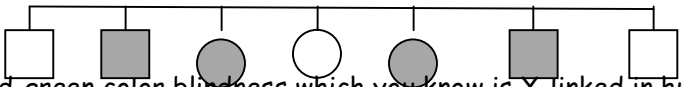
c) Yes, no, no, no,

d) Yes, yes, yes, yes

e) Draw the family pedigree and indicate what form of inheritance that the purple-ear trait **most likely** follows.

Autosomal dominant





b) Another male patient comes in with red-green color blindness which you know is X-linked in humans. If the male is red-green color blind, and both his parents have normal color vision, which of the male's grandparents is **most likely** to be red-green color blind?

a) maternal grandmother

b) maternal grandfather

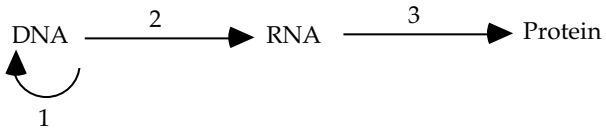
c) paternal grandmother

d) paternal grandfather

e) either grandfather is equally likely

4)

The term "central dogma" refers to the flow of biological information from DNA to RNA to protein.



a) i) In the spaces below, indicate the process that corresponds to each arrow.

1. *replication* 2. *transcription,* 3. *translation*

ii) Name the initiation site for each processes, and on which molecule this site exists.

1. Origin of replication, DNA
2. Promoter, DNA
3. Start codon (first AUG), mRNA

iii) What cellular machinery carries out each process?

*1. DNA polymerase 2. RNA polymerase 3. ribosome*c) genomic DNA sequence:

b) i) FALSE. DNA replication is initiated at the origin of replication. RNA polymerases bind to promoter sequences to initiate transcription.

ii) FALSE. RNA polymerase does not require primers to initiate RNA synthesis. DNA polymerase requires primers to initiate DNA replication..

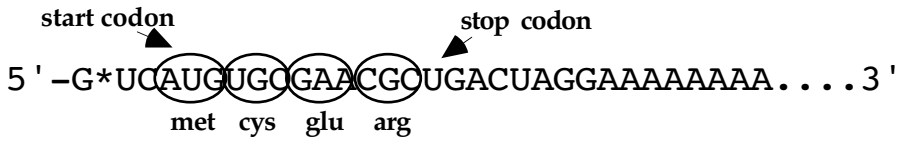
iii) FALSE. DNA synthesis occurs by addition of dNTPs to the 3' OH group of the nucleotide at the end of the growing strand.

iv) FALSE. Transcription terminates at the transcription termination sites in the DNA. Translation terminates at stop codons in the mRNA.

c)

5'–AGCTCATGTGCGAGTCCTGACGCTGACTAGG–3'
3'–TCGAGTACACGCTCAGGACTGCGACTGATCC–5'

mature mRNA sequence (G^* = G cap):



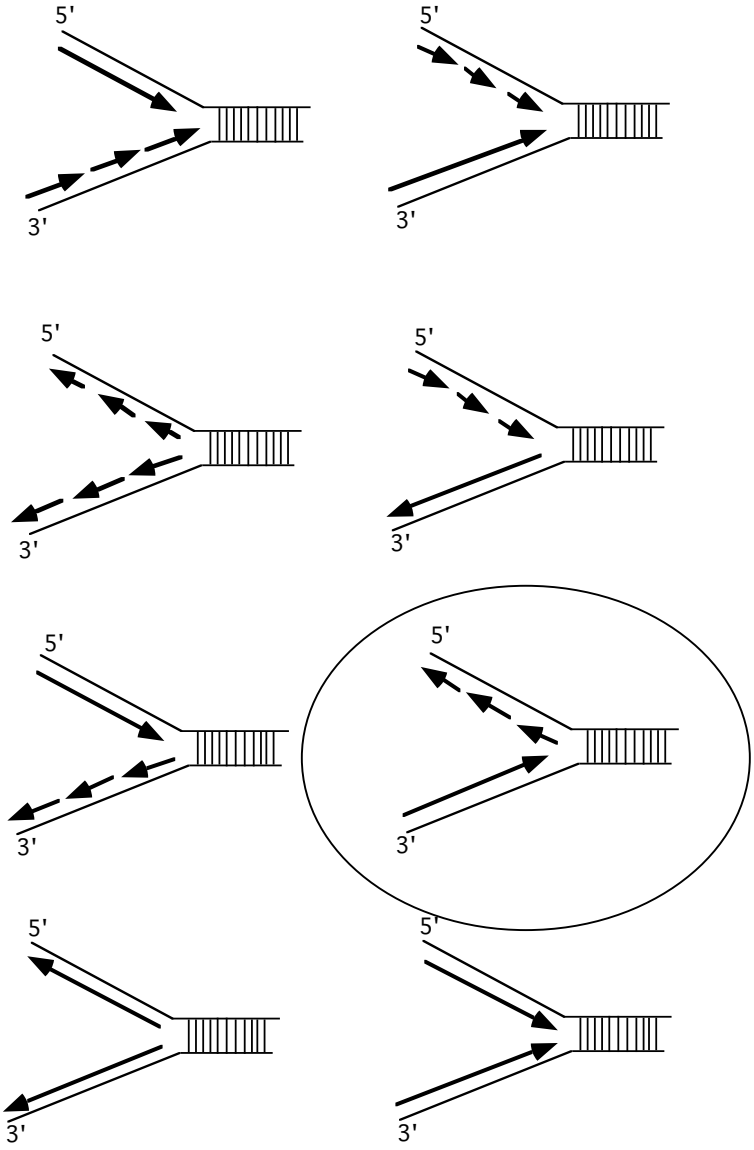
i) see DNA sequence above

ii) 1) 5' capping 2) 3' polyadenylation

iii) There are four amino acids in this viral peptide: NH_3^+-met-cys-glu-arg-COO^-

iv) In eukaryotic cells because the RNA processing and splicing machinery is only present in eukaryotes.

d)



d)