

Name: _____

Student #: _____

BIOL2107 Fundamentals of Genetics

Midterm 2

Version 1

March 16, 2014

Use the scantron form to answer the 15 multiple choice questions. Use the space provided to answer any 2 of the 3 short answer questions. You may use additional space in the workbooks to complete short answer questions but make sure you indicate this on the midterm workspace.

Section A: Multiple Choice

Use the following DNA sequence information to answer questions 1 and 2:

Assume that the following DNA is transcribed from left to right.

5'-ATGTACTAAGCCGTAGCGTAA-3'

3'-TACATGATTCGGCATCGCATT-5'

1. What is the sequence of the template strand of DNA?

- (a) 5'-TACATGTAAGCCGTAGCGCAA-3'
 (b) 3'-ACGCGATAACGACTGTACATA-5'
 (c) 5'-ATGTACTCAGCCGTAGCGTAA-3'
 (d) 5'-TACATGATTCGGCATCGCATT -5'
 (e) **3'-TACATGATTCGGCATCGCATT-5'**

2. Translate the RNA sequence to amino acid sequence using the following table:

		Second Letter					
		U	C	A	G		
1st letter	U	UUU Phe UUC UUA Leu UUG	UCU UCC Ser UCA UCG	UAU Tyr UAC UAA Stop UAG Stop	UGU Cys UGC UGA Stop UGG Trp	U C A G	3rd letter
	C	CUU Leu CUC CUA CUG	CCU CCC Pro CCA CCG	CAU His CAC CAA Gln CAG	CGU CGC Arg CGA CGG	U C A G	
	A	AUU AUC Ile AUA AUG Met	ACU ACC Thr ACA ACG	AAU Asn AAC AAA Lys AAG	AGU Ser AGC AGA Arg AGG	U C A G	
	G	GUU Val GUC GUA GUG	GCU GCC Ala GCA GCG	GAU Asp GAC GAA Glu GAG	GGU GGC Gly GGA GGG	U C A G	

Which amino acid sequence is correct?

- (a) Met-Tyr-Val-Ala-Ser-Ala-Stop
 (b) Met-Tyr-Ser-Ala-Val-Ala-Leu
 (c) **Met-Tyr-Stop**
 (d) Leu-Arg-Tyr-Gly-Stop
 (e) Met-Tyr-Tyr-Ala-Val-Ala-Stop

3. Avery, MacLeod and McCarty confirmed that the “transforming principle” is composed of _____.
- (a) mRNA
 - (b) tRNA
 - (c) DNA**
 - (d) protein
 - (e) lipid
4. Humans have $2n=46$ chromosomes. How many linkage groups are present in an unfertilized egg?
- (a) 0
 - (b) 2
 - (c) 23**
 - (d) 46
 - (e) 48
5. The end of eukaryotic chromosomes are protected with repeat sequences called _____.
- (a) termini
 - (b) telomeres**
 - (c) telomerase
 - (d) terminase
 - (e) NHEJ
6. Ribosomes read mRNA in the _____ direction.
- (a) 5' to 3'**
 - (b) 5' to 2'
 - (c) 3' to 5'
 - (d) N-terminal to C-terminal
 - (e) C-terminal to N-terminal
7. The Hershey-Chase waring blender experiment used _____ to determine which macromolecule contained genetic information required to complete the T2 bacteriophage life cycle.
- (a) ^3H labelled RNA and ^{32}P labelled DNA
 - (b) ^{32}P labelled DNA and ^{35}S labelled protein**
 - (c) ^3H labelled RNA and ^{35}S labelled protein
 - (d) ^3H labelled DNA and ^{35}S labelled protein
 - (e) ^{32}P labelled RNA and ^{35}S labelled protein

8. Which of the following is a very common form of DNA base damage that results from the oxidation of a specific base.

- (a) DNA double strand break (DSB)
- (b) pyrimidine dimer (CPD)
- (c) depurination of guanine (AP site)
- (d) deamination of cytosine
- (e) 8-Oxo-2'-deoxyguanosine (8-oxodG)**

9. Which of the following DNA repair pathways is considered error-prone?

- (a) nucleotide excision repair.
- (b) SOS system.**
- (c) direct reversal
- (d) photolyase.
- (e) methyl-directed mismatch repair.

10. How many hydrogen bonds normally form between adenine and guanine in DNA?

- (a) 0**
- (b) 1
- (c) 2
- (d) 3
- (e) 4

11. Nonsense-mediated decay _____.

- (a) eliminates many mRNAs containing nonsense mutations.
- (b) may result from frameshift mutations.
- (c) is a form of mRNA decay.
- (d) prevents the expression of truncated proteins.
- (e) all of the above**

12. A man and a woman have 2 child. The parents are each heterozygous for a different disease-associated allele of the xeroderma pigmentosum group A gene (XPA). What is the probability that either of their children will be affected with the disease?

- (a) 0%
- (b) 25%
- (c) 50%
- (d) 75%
- (e) none of the above**

13. The DNA of a newly identified species of salamander contains 18% guanine. Approximately how much adenosine is predicted?

- (a) 25%
- (b) 50%
- (c) 18%
- (d) 32%**
- (e) 28%

14. How many histone proteins are present in the core nucleosome?

- (a) 0
- (b) 1
- (c) 2
- (d) 4
- (e) 8**

15. Which of the following is associated with actively transcribed regions of chromatin?

- (a) conditional heterochromatin
- (b) euchromatin**
- (c) protochromatin
- (d) facultative heterochromatin
- (e) constitutive heterochromatin

B. Short answers (Choose 2 of 3 questions, 5 marks each). Show all work.

1. A new ultraviolet (UV) sensitive syndrome (UVSS) was recently described in 6 unrelated patients (A-F). Skin cells derived from these patients are exquisitely sensitive to UV light and this characteristic was used to perform complementation analysis. Cells derived from these patients were fused together in pairs in the lab and then exposed to UV light. In these experiments, functional complementation between 2 fused cell lines resulted in a normal sensitivity to UV light (indicated by '+' in the table below) while a lack of complementation left fused cells sensitive to this DNA damaging agent (indicated by a '-'). Use the following table to answer the questions below.

	Patient A	Patient B	Patient C	Patient D	Patient E	Patient F
Patient A	-	+	+	-	+	-
Patient B		-	-	+	+	+
Patient C			-	+	+	+
Patient D				-	+	-
Patient E					-	+
Patient F						-

- (a) How many complementation groups are there? Show your work. (2 marks)
 (b) If patient A is female and she has children with patient E (male), what is the probability that their children will be affected with UVSS (1 mark)?
 (c) This disorder is consistent with an underlying defect in DNA repair. What DNA repair pathway is most likely to be affected (1 mark)?
 (d) Name at least 1 human disorder that shares some of these characteristics (1 mark).

(a) Patient A is not complemented by D or F so A, D and F are in 1 complementation group.

Patient B is not complemented by C so B and C make up a second group.

Patient E is complemented by all other patients so it forms its own complementation group.

Therefore, there are 3 groups:

A, D and F

B and C

E

(b) 0 % because A and E are in different complementation groups (ie a different gene is affected in each patient)

(c) nucleotide excision repair is involved in repair UV-induced DNA lesions like pyrimidine dimers. Translesion synthesis would also be acceptable.

(d) Acceptable disorders include:

Xeroderma pigmentosum

Cockayne syndrome

Trichothiodystrophy

2. Crossing over is an important source of new combinations of alleles.

(a) Outline the steps involved in crossing over initiated by the DMC1 protein (2 marks).

(b) Use a diagram to summarize the possible outcomes of both successful and failed crossing over (2 marks).

(c) What feature of both successful and failed crossover can lead to gene conversion and explain (1 mark)?

- (a)
- DMC1 induces a DNA double strand break
 - The ends are resected leaving single stranded 3' ends
 - The 3' ends invade the intact duplex (strand invasion or 1st strand invasion) forming a D-loop
 - branch migration results in heteroduplex formation
 - holiday junctions can be resolved in 2 planes yielding a crossover or aborted crossover.

(b) There are many ways of drawing the diagram. For full marks, the diagram should indicate that there were 2 possible planes to resolve holiday junctions. Crossover products, aborted crossover products and the heteroduplex should be labelled.

(c) Heteroduplex DNA generated by strand invasion and branch migration can alter the sequence if the crossover or aborted crossover is initiated in a region that isn't 100% identical at the DNA sequence level (site of SNP, indel etc... for example).

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3. Eukaryotic and prokaryotic gene expression differ in many respects. Identify and briefly explain any 5 differences in the processing required to convert DNA sequence to protein sequence.

Here are several examples to choose from but there are others:

Prokaryotes

No nucleus

no introns

no alternative splicing

no 5' cap

no poly A tail

1 RNA polymerase

unique initiator fMet tRNA

specific ribosome binding site

multiple binding sites allow translation of polycistronic transcripts

Shine-Dalgarno sequence

Terminator sequences define 3' end of mRNA

Eukaryotes

transcription and translation are spatially separated in nucleus and cytoplasm

introns break up gene/mRNA sequence

alternative splicing can lead to different proteins expressed from the same gene

mRNAs are 5' capped

mRNAs are polyadenylated

several different RNA polymerases transcribe different classes of RNA

Met tRNA used to initiate translation

ribosome binds cap and scans 5' UTR for AUG in appropriate context

initiates at first AUG with appropriate sequence context

Kozak consensus sequence

post-transcriptional cleavage defines 3' end of mRNA