UNIVERSITY OF GHANA

29½

BSC. MED. SCI/MB CHB, INTERIM ASSESSMENT #1: 2016/2017

BAHS 233: GENES IN HEALTH AND DISEASE

INSTRUCTIONS: ATTEMPT ALL QUESTIONS. SECTION A: MULTIPLE CHOICE QUESTIONS. Each question is followed by suggested answers lettered A-D or A-E, select the one lettered answer that is best in each case. SECTION B: PROVIDE SHORT ANSWERS TO ALL THE QUESTIONS

TIME ALLOWED: ONE AND HALF (11/2) HOURS

1. The glycosidic bond of DNA (dA, dT, dG, dC) and RNA (rA, rU, rG, rC) can be hydrolyzed by acids. Order of stability:
   A. dA, dG < rA, rG < rC, dT < dC, rU
   B. dA, rG < rA, dG < dC, dT < rC, rU
   C. rA, dG < dA, rG < dC, dT < rC, rU
   D. dA, dG < rA, rG < dC, dT < rC, rU
   E. All of the above

2. Akiola noticed that his recently sequenced DNA molecule contained 20 adenine nucleotides, 30 cytosine nucleotides, 25 guanine nucleotides, and 22 thymidine nucleotides. How many of each base is found in the complete double stranded molecule?
   A. A=40, G=50, C=60, T=44
   B. A=42, G=55, C=55, T=42
   C. A=44, G=60, C=50, T=40
   D. A=45, G=45, C=52, T=52
   E. A=50, G=47, C=50, T=47

3. Bon Papa has an upper respiratory infection with jaundice and no consanguinity. His father had few cases of hyperbilirubinemia, and his paternal grandmother had had episodic fatigue with mild scleral icterus. What is the plausible inheritance pattern of this hyperbilirubinemia?
   A. Mitochondrial
   B. X-linked dominant
   C. X-linked recessive
   D. Autosomal dominant
   E. Autosomal recessive

4. Lamie undergoes genetic testing for hemochromatosis, an autosomal recessive disorder characterized by abnormal levels of serum iron that leads to organ toxicity. He is positive for mutation and is diagnosed with the disease. However, he never develops any symptom. Which of the following best describes Lamie?
   A. Low mosaicism
   B. Low lyonization
   C. Low expressivity

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D. Low penetrance
E. None of the Above

5. All these are forms of sex – linked inheritance except:
   A. Myopia
   B. Color blindness
   C. Haemophilia
   D. Blood group
   E. All of the Above

6. A chromosome with a short arm and a very long arm is termed
   a) Acrocentric
   b) Metacentric
   c) Telocentric
   d) Sub-metacentric

7. Telomeres:
   a) contain repeated nucleotide sequences that are required for the ends of chromosomes.
   b) allow duplicated chromosomes to become attached separated during M phase.
   c) cap the ends of the DNA molecule and prevent them from being recognized by the cell as broken DNA in need of repair.
   d) A and C only
   e) B and C only

8. Patients with Hurler's syndrome (252800) are known to have mutations at the L-iduronidase locus. The diagnosis of Hurler's syndrome is most efficiently made by analyzing a patient's DNA for
   a) A region of DNA that does not encode RNA
   b) Alternative forms of the L-iduronidase gene
   c) The entire set of genes in one leukocyte
   d) A nucleotide substitution in the L-iduronidase gene
   e) The position of the L-iduronidase gene on a chromosome

9. The DNA in eukaryotic chromosomes is folded into a compact form by interactions with:
   a) RNA.
   b) histones
   c) euchromatin.
   d) microtubules.
   e) centromeres.

10. A sample of human DNA is subjected to increasing temperature until the major fraction exhibits optical density changes due to disruption of its helix (melting or denaturation). A smaller fraction is atypical in that it requires a much higher temperature for melting. This smaller, atypical fraction of DNA must contain a higher content of
   a) Adenine plus cytosine
   b) Cytosine plus guanine
   c) Adenine plus thymine
   d) Cytosine plus thymine
   e) Adenine plus guanine

11. Which of the following statements correctly describes eukaryotic nuclear chromosomal DNA?

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a) Each discontinuous piece making up the chromosomes of eukaryotes is about the same size as each prokaryotic chromosome
b) Unlike bacterial DNA, no histones are associated with it
c) It is not replicated semiconservatively
d) It is a linear and unbranched molecule
e) It is not associated with a specific membranous organelle

12. Compounds that generate nitrous acid (such as nitrites, nitrates, and nitrosamines) change DNA molecules by:
A) breakage of phosphodiester bonds.
B) deamination of bases.
C) depurination.
D) formation of thymine dimers.
E) transformation of A → T.

13. The Meselson-Stahl experiment established that:
A) DNA polymerase has a crucial role in DNA synthesis.
B) DNA synthesis in bacteria proceeds by a conservative mechanism.
C) DNA synthesis in bacteria proceeds by a semiconservative mechanism.
D) DNA synthesis requires dATP, dCTP, dGTP, and dTTP.
E) newly synthesized DNA in *E. coli* has a different base composition than the preexisting DNA.

14. When a DNA molecule is described as replicating bidirectionally, that means that it has two:
A) chains.
B) independently replicating segment.
C) origins.
D) replication forks.
E) termination points.

15. An Okazaki fragment is a:
A) fragment of DNA resulting from endonuclease action.
B) fragment of RNA that is a subunit of the 30S ribosome.
C) piece of DNA that is synthesized in the 3′→5′ direction.
D) segment of DNA that is an intermediate in the synthesis of the lagging strand.
E) segment of mRNA synthesized by RNA polymerase.

16. Which one of the following statements about enzymes that interact with DNA is true?
A) Bacteria DNA polymerase I is unusual in that it possesses only a 5′→3′ exonucleolytic activity.
B) Endonucleases degrade circular but not linear DNA molecules.
C) Exonucleases degrade DNA at a free end.
D) Many DNA polymerases have a proofreading 5′→3′ exonuclease.
E) Primases synthesize a short stretch of DNA to prime further synthesis.

17. Bacteria DNA polymerase III:
A) can initiate replication without a primer.
B) is efficient at nick translation.
C) is the principal DNA polymerase in chromosomal DNA replication.
D) represents over 90% of the DNA polymerase activity in bacteria cells.
E) requires a free 5′-hydroxyl group as a primer.

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18. The proofreading function of DNA polymerase involves all of the following *except*:
A) a 3′→ 5′ exonuclease.
B) base pairing.
C) detection of mismatched base pairs.
D) phosphodiester bond hydrolysis.
E) reversal of the polymerization reaction.

19. The 5′→ 3′ exonuclease activity of bacteria DNA polymerase I is involved in:
A) formation of a nick at the DNA replication origin.
B) formation of Okazaki fragments.
C) proofreading of the replication process.
D) removal of RNA primers by nick translation.
E) sealing of nicks by ligase action.

20. Prokaryotic DNA polymerase III:
A) contains a 5′→ 3′ proofreading activity to improve the fidelity of replication.
B) does not require a primer molecule to initiate replication.
C) has a β subunit that acts as a circular clamp to improve the processivity of DNA synthesis.
D) synthesizes DNA in the 3′→5′ direction.
E) synthesizes only the leading strand; DNA polymerase I synthesizes the lagging strand.

21. Which of the following is ***not*** involved for DNA replication and /or repair in bacteria?
A) DnaB (helicase)
B) DnaG (primase)
C) Dam methylase
D) DNA ligase
E) none of the above

22. At the replication forks in bacteria:
A) DNA helicases make endonucleolytic cuts in DNA.
B) DNA primers are degraded by exonucleases.
C) DNA topoisomerases make endonucleolytic cuts in DNA.
D) RNA primers are removed by primase.
E) RNA primers are synthesized by primase.

23. Eukaryotes unlike prokaryotes have multiple origins of replication. Which of the following is one of the reasons why eukaryotes have this multiple origins?
A. eukaryotes have linear chromosomes
B. eukaryotes have nucleus compared to prokaryotes
C. the cell cycle of eukaryotes takes a shorter time than those of prokaryotes
D. prokaryotes tend to have larger genomes compared to eukaryotes
E. eukaryotes have a larger genome which must be replicated within a specific time during cell division.

24. The function of the eukaryotic DNA replication factor PCNA (*p*roliferating *c*ell *n*uclear *a*ntigen) is similar to which of the following bacterial DNA polymerase III factor?
A) β_2-clamp
B) α-subunit
C) τ-subunit
D) γ-complex
E) δ-subunit

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25. In a mammalian cell, ...
A) are extraordinar...
B) are generally ...
C) can repair ...
D) can rep...
E) norm...

26. Which ...

25. In a mammalian cell, DNA repair systems:
A) are extraordinarily efficient energetically.
B) are generally absent, except in egg and sperm cells.
C) can repair deletions, but not mismatches.
D) can repair most types of lesions except those caused by UV light.
E) normally repair more than 99% of the DNA lesions that occur.

26. Which of these enzymes is ***not*** directly involved in methyl-directed mismatch repair in bacteria?
A) DNA glycosylase
B) DNA helicase II
C) DNA ligase
D) DNA polymerase I
E) Exonuclease

27. The role of the Dam methylase is to:
A) add a methyl group to uracil, converting it to thymine.
B) modify the template strand for recognition by repair systems.
C) remove a methyl group from thymine.
D) remove a mismatched nucleotide from the template strand.
E) replace a mismatched nucleotide with the correct one.

28. When bacterial DNA replication introduces a mismatch in a double-stranded DNA, the methyl-directed repair system:
A) cannot distinguish the template strand from the newly replicated strand.
B) changes both the template strand and the newly replicated strand.
C) corrects the DNA strand that is methylated.
D) corrects the mismatch by changing the newly replicated strand.
E) corrects the mismatch by changing the template strand.

29. In base-excision repair, the first enzyme to act is:
A) AP endonuclease.
B) Dam methylase.
C) DNA glycosylase.
D) DNA ligase.
E) DNA polymerase.

30. The ABC endonuclease in bacteria is essential in:
A) base-excision repair.
B) methyl-directed repair.
C) mismatch repair.
D) nucleotide-excision repair.
E) Direct reversal of the damage

31. The repair of cyclobutane pyrimidine dimers in bacterial involves the cofactor:
A) Base excision repair
B) Is repaired using methyl-directed mismatch repair
C) Is repaired using only nucleotide excision repair
D) Can be repaired by using only DNA photolyase
E) Can be repaired by using both DNA photolyase and nucleotide excision repair

32. The repair mechanism used to repair a thymidine dimer in eukaryotic DNA is usually?
A) mismatch repair

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B) base-excision repair
C) nucleotide-excision repair
D) through DNA photolyase activity
E) bypass of the lesion

33. Which mechanism is used to repair the presence of hypoxanthine in DNA?
A) mismatch repair
B) base-excision repair
C) nucleotide-excision repair
D) direct repair
E) bypass of the lesion

34. Alkylated DNA usually results in DNA mutations if not repaired. Which of these pairs of proteins are involved in dealkylation of damaged DNA?
A. Photolyase and O-6 methyl-guanine methyl transferase (MGMT)
B. MGMT and the DNA glycosylases
C. AlkB and MGMT
D. AlkB and photolyases
E. DNA glycosylases and photolyases

35. Which of the following statements about bacteria RNA polymerase is *incorrect*?
A) Core enzyme selectively binds promoter regions, but cannot initiate synthesis without a sigma factor.
B) RNA polymerase holoenzyme has several subunits.
C) RNA produced by this enzyme will be completely complementary to the DNA template.
D) The enzyme adds nucleotides to the 3′ end of the growing RNA chain.
E) The enzyme cannot synthesize RNA in the absence of DNA template.

36. Which of the following statements about bacteria RNA polymerase (core enzyme) is *false*?
A) In the absence of the σ subunit, core polymerase has little specificity for where initiation begins.
B) The core enzyme contains several different subunits.
C) The core enzyme has no polymerizing activity until the σ subunit is bound.
D) The RNA chain grows in a 5′→3′ direction.
E) The RNA product is complementary to the DNA template.

37. RNA polymerase from bacteria (core enzyme alone) has all of the following properties *except* that it:
A) can extend an RNA chain and initiate a new chain.
B) is required for the synthesis of mRNA, rRNA, and tRNA in bacteria.
C) produces an RNA polymer that begins with a 5′-triphosphate.
D) recognizes specific start signals in DNA.
E) requires all four ribonucleoside triphosphates and a DNA template.

38. The sigma factor of bacteria RNA polymerase:
A) associates with the promoter before binding core enzyme.
B) combines with the core enzyme to confer specific binding to a promoter.
C) is inseparable from the core enzyme.
D) is required for termination of an RNA chain.
E) will catalyze synthesis of RNA from both DNA template strands in the absence of the core enzyme.

39. After binding by *E. coli* RNA polymerase, the correct order of events for transcription initiation is:
A) closed complex formation, open complex formation, promoter clearance, start of RNA synthesis.
B) closed complex formation, open complex formation, start of RNA synthesis, promoter clearance.
C) open complex formation, closed complex formation, start of RNA synthesis, promoter clearance.
D) start of RNA synthesis, closed complex formation, open complex formation, promoter clearance.
E) start of RNA synthesis, open complex formation, closed complex formation, promoter clearance.

40. One strand of a section of DNA isolated from E. coli reads:
5'-GTAGCCTACCCATAGG-3'.
Suppose that an mRNA is transcribed from this DNA using the complementary strand as a template. What will the sequence of the sequence of the mRNA in this region be?
A. 5'-GUAGCCUACCCAUAGG-3'.
B. 5'-CCUAUGGGUAGGCUAC-3'
C. 5'-GGAUACCCAUCCGAUG-3'
D. 5'-CAUCGGAUGGGUAUCC-3'
E. 5'-GTUGCCTUCCCATAGG-3'

41. Which one of the following statements about eukaryotic RNA polymerases is correct?
A) All three eukaryotic RNA polymerases recognize the same promoters as prokaryotic polymerases.
B) None of the eukaryotic RNA polymerases recognizes prokaryotic promoters.
C) Only eukaryotic RNA polymerase I recognizes prokaryotic promoters.
D) Only eukaryotic RNA polymerase II recognizes prokaryotic promoters.
E) Only eukaryotic RNA polymerase III recognizes prokaryotic promoters.

42. Which of the following is *not* known to be involved in initiation by eukaryotic RNA polymerase II?
A) DNA helicase activity
B) DNA polymerase activity
C) Formation of an open complex
D) Protein binding to specific DNA sequences
E) Protein phosphorylation

43. Processing of a primary mRNA transcript in a eukaryotic cell does ***not*** normally involve:
A) attachment of a long poly(A) sequence at the 3′ end.
B) conversion of normal bases to modified bases, such as inosine and pseudouridine.
C) excision of intervening sequences (introns).
D) joining of exons.
E) methylation of one or more guanine nucleotides at the 5′ end.

44. The 5′-terminal cap structure of eukaryotic mRNAs is a(n):
A) 7-methylcytosine joined to the mRNA via a 2′,3′-cyclic linkage.
B) 7-methylguanosine joined to the mRNA via a 5′→ 3′ diphosphate linkage.
C) 7-methylguanosine joined to the mRNA via a 5′→ 5′ triphosphate linkage.
D) N^6-methyladenosine joined to the mRNA via a 5′→ 5′ phosphodiester bond.

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E) O^6-methylguanosine joined to the mRNA via a 5'→ 5' triphosphate linkage.

45. The excision (splicing) of many group I introns requires, in addition to the primary transcript RNA:
A) a cytosine nucleoside or nucleotide and a protein enzyme.
B) a guanine nucleoside or nucleotide (only).
C) a protein enzyme only.
D) a small nuclear RNA and a protein enzyme.
E) ATP, NAD, and a protein enzyme.

46. A branched ("lariat") structure is formed during:
A) attachment of a 5' cap to mRNA.
B) attachment of poly(A) tails to mRNA.
C) processing of preribosomal RNA.
D) splicing of all classes of introns.
E) splicing of group II introns.

47. Splicing of introns in nuclear mRNA primary transcripts requires:
A) a guanine nucleoside or nucleotide.
B) endoribonucleases.
C) polynucleotide phosphorylase.
D) RNA polymerase II.
E) small nuclear ribonucleoproteins (snurps).

48. Cancer cells turn to maintain telomerase activity thereby making them divide indefinitely. How does the telomerase contribute to the indefinite division of the tumor cells?
A. It extends the ends of chromosomes in the tumor cells
B. It extends the centromere of the tumor cells
C. It maintains the ends of the chromosomes in the tumor cells
D. It shortens the ends of the chromosomes in the tumor cells
E. It maintains the kinetochores of the chromosomes in the tumor cells

49. An altered form of a replicative DNA polymerase lacks 3' → 5' exonuclease activity. This alteration would most likely result in which of the following?
A. A decrease in processivity
B. An increased mutation rate
C. An ability to replicate DNA without a primer
D. An inability to replicate DNA
E. An inability to remove RNA primers

50. The main enzyme to polymerize leading strand of eukaryotic DNA is:
A. DNA polymerase α
B. DNA polymerase β
C. DNA polymerase γ
D. DNA polymerase δ
E. DNA polymerase ∑

51. Muscle, skin, liver cells differ from each other due to
A. Different mutations arisen in each cell type
B. Different expression of genes in each cell type
C. Different genes present in different cell types
D. Different location of cell types in the organism

52. In humans, mutation in the XP-B and XP-D subunits of TFIIH usually causes xeroderma pigmentosum, an inherited disorder suggesting that TFIIH is involved in the DNA damage repair pathway. What crucial role is played by the XP-B and the XP-D in the repair pathway?

A. Unwinding of DNA around damaged regions.
B. DNA synthesis at the damaged site.
C. Ligating of the DNA fragments at the damaged site.
D. Reannealing of the repaired DNA to the template DNA.
E. It dealkylates the damaged DNA regions.

53. The process of DNA replication involves:

A. Multiple origins of replication per chromosome in eukaryotes
B. Binding of ribosomes to origins of replication
C. Continuous synthesis on both strands of the double helix
D. Conservative replication, with one original double helix and one totally new double helix as products.

54. The information carried by a DNA molecule is in:

A. the sugars and phosphates forming its backbone
B. the total number of nucleotides it contains
C. the order of the nucleotides in the molecule
D. its amino acid sequence
E. the RNA units that make up the molecule

55. Alternative RNA processing may result in:

A) a shift in the ratio of mRNA produced from two adjacent genes.
B) attachment of the poly(A) tail to the 5′ end of an mRNA.
C) inversion of certain exons in the final mRNA.
D) the production of the same protein from two different genes.
E) the production of two distinct proteins from a single gene.

56. Compared with DNA polymerase, reverse transcriptase:

A) does not require a primer to initiate synthesis.
B) introduces no errors into genetic material because it synthesizes RNA, not DNA.
C) makes fewer errors in synthesizing a complementary polynucleotide.
D) makes more errors because it lacks the 3′→ 5′ proofreading exonuclease activity.
E) synthesizes complementary strands in the opposite direction that is from 3′→ 5′.

57. Which of these polymerases does not require a template?

A) RNA polymerase I
B) RNA polymerase II
C) Reverse Transcriptase
D) Polyadenylate polymerase
E) DNA polymerase I

58. In the bacterial cell, which of the following proteins is required for resolving catenated DNA during replication?

A) Helicase
B) Topoisomerase
C) DNA ligase
D) DNA polymerase I
E) Primosome

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59. Which of the following processes will **not** be affected by the phosphorylation of the c-terminal domain (CTD) of RNA polymerase II?

A. polyadenylation
B. alternative splicing
C. formation of the cap structure
D. promoter clearance
E. transcription of the lac operon genes

60. During mRNA transcription in eukaryotes, all the following transcription factors binds to enhancer sequences as specific transcription factor to drive cell specific gene expression, except:

a. Zinc finger motifs
b. Helix-loop-helix motifs
c. Transcription factor IIH (TFIIH)
d. Helix-turn-helix motifs
e. Basic leucine zipper motifs

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SECTION B: SHORT ESSAY

Q1. The picture below represents a bacterial replication fork. RNA primers are indicated by: ~~~~

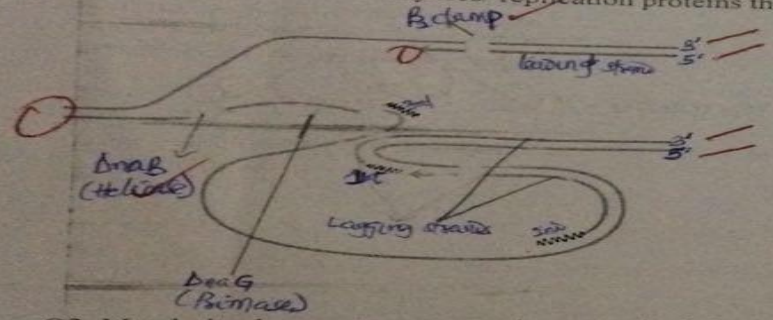
On the picture **indicate by labelling**:

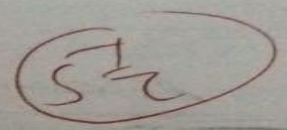
a) The polarities of all DNA strands. 2.5pts 1

b) On the RNA primers the order in which they were synthesized (indicate by 1 the first RNA primer synthesized, 2 the second, 3 the third). 1.5pts 1 - 5

c) The location of the leading and the lagging strands.1pt 1

d) The names of 2 enzymes/ replication proteins that you can recognize. 2pts 2





Q2. Match the damage type or repair step at the left with a related enzyme at right. Only one answer will be the most direct for each. 10pts

e	cytosine deamination	(a) hypoxanthine-*N*-glycosylase
b	base loss	(b) AP endonuclease
a	adenine deamination	(c) mutH protein
c	binds to GATC sequences	(d) DNA polymerase I
f	binds to mismatch in DNA	(e) uracil *N*-glycosylase
d	DNA synthesis in gaps	(f) mutS-mutL complex
j	seals nicks	(g) ABC endonuclease
i	O^6-methylguanine	(h) DNA photolyase

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H direct chemical reversal of pyrimidine dimer formation

I endonuclease activity in nucleotide excision repair

G O^6-methylguanine methyltransferase

J DNA ligase

10/10

Q3a. Consider the following small hypothetical gene. The DNA bases corresponding to the first and last mRNA nucleotides are highlighted and indicated by a "+" and a "*" respectively. Give the sequence(s) of the mRNA strand(s) produced by this gene, assume that transcription is from left to right (that is using the bottom strand as the template). 5pts

```
      +                   *
5'-GGCTATGTACGTAGCTACGTA-3'
   | | | | | | | | | | | | | | | | | | | | |
3'-CCGATACATGCATCGATGCAT-5'
```

mRNA Sequence: 5'-GCUAUGUACGUAGCUACGU-3' 5

Q3b. For each of the following statements, indicate with a **P** if the statement applies only to prokaryotes, an **E** if the statement applies only to eukaryotes, and an **E & P** if the statement applies to both eukaryotes and prokaryotes. 10pts

P RNA synthesis is blocked by actinomycin D.

P A single RNA polymerase transcribes genes that encode mRNAs, tRNAs, and rRNA.

E Transcription of mRNA is blocked by α-amanitin.

P Sigma (σ) subunit detaches from RNA polymerase shortly after transcription has initiated.

P The 5' end of the *mature* mRNA begins with a triphosphate.

E The primary mRNA transcript cannot be used as template for protein synthesis.

P Transcription is coupled to translation.

E Promoter clearance requires the phosphorylation of the RNA polymerase

E&P Transcription is regulated by the varying sequences at the promoter region

E Gene-specific transcription factors determine cell-specific gene expression

9/10

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