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並不得書寫、畫記、作答。


國立清華大學 111 學年度碩士班考試入學試題

系所班組別：生命科學院
丁組(醫學生物科技學程)

科目代碼：0704

考試科目：分子生物學

—作答注意事項—

1. 請核對答案卷(卡)上之准考證號、科目名稱是否正確。
2. 考試開始後，請於作答前先翻閱整份試題，是否有污損或試題印刷不清，得舉手請監試人員處理，但不得要求解釋題意。
3. 考生限在答案卷上標記「由此開始作答」區內作答，且不可書寫姓名、准考證號或與作答無關之其他文字或符號。
4. 答案卷用盡不得要求加頁。
5. 答案卷可用任何書寫工具作答，惟為方便閱卷辨識，請儘量使用藍色或黑色書寫；答案卡限用 2B 鉛筆畫記；如畫記不清(含未依範例畫記)致光學閱讀機無法辨識答案者，其後果一律由考生自行負責。
6. 其他應考規則、違規處理及扣分方式，請自行詳閱准考證明上「國立清華大學試場規則及違規處理辦法」，無法因本試題封面作答注意事項中未列明而稱未知悉。

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*請在【答案卡】作答

I. 選擇題 - multiple choice questions and select One or More Answer Choices according to the specific question directions (70 points, 2 points for each).

1. Chi sites are _____.

- (A) generated from Holliday junctions
- (B) inverted repeats
- (C) binding sites for RecA protein
- (D) specific sequences in prokaryotic genomes where crossovers occur
- (E) specialized single-stranded region

2. A single nucleotide deletion occurred in a gene. The change is indicated below. What is the consequence of the mutation?

..... AGT CGA TGA GTT AGC CTA → AGT CGA TGG TTA GCC TA.....

- (A) The mutation occurs in the third position of a codon so it is likely to be a silent mutation because of the Wobble effect.
- (B) It leads to frameshift so the downstream amino acid sequence will alter and the protein is unlikely to be functional.
- (C) It results in premature termination of translation so a truncated polypeptide will be produced.
- (D) A longer polypeptide will be made but the protein might still be functional.
- (E) It changes the single amino acid, which may or may not cause a problem.

3. What is the purpose of the inverted repeats at the ends of DNA-based transposons?

- (A) The inverted repeats are recognized by enzymes that move the elements.
- (B) The inverted repeats are the sites of transfer.
- (C) The inverted repeats are recognized by restriction enzymes that cut out the transposon.
- (D) The inverted repeats are magnets for nucleases.
- (E) The inverted repeats protect transposons from degradation.

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4. What is 5' UTR?

- (A) 5' untranscribed region: it refers only to the promoter region.
- (B) 5' untranscribed region: it includes promoter and enhancer.
- (C) 5' untranscribed region: it regulates transcription activity.
- (D) 5' untranslated region: it is removed during RNA splicing.
- (E) 5' untranslated region: it must contain the first exon.

5. Rolling circle replication _____.

- (A) begins when the origin of replication is pulled apart to generate a replication bubble
- (B) occurs at the origin of vegetative replication
- (C) begins when the origin of replication is nicked and one strand is unrolled
- (D) occurs when a plasmid replicates in step with host cell division
- (E) occurs bidirectionally that can rapidly synthesize multiple copies

6. Regarding molecular cloning using restriction enzyme and ligase.

- (A) Blunt end is clean and thus easier to be ligated.
- (B) Ligase also mediates joining of sticky ends by catalyzing the formation of hydrogen bonds.
- (C) Two sticky ends with complementary overhangs can be perfectly ligated but the restriction enzyme recognition site is not necessarily restored.
- (D) Restriction enzyme more efficiently cuts at the ends of DNA fragments.
- (E) Phosphatase treatment of both digested vector and digested insert reduces self-ligation so that correct ligation is enhanced.

7. The size of a gene in the genome is 3kb. What is the expected size of the polypeptide product encoded from the 3kb sequence? It appears as a single 60kD band on a SDS-PAGE gel. What could be the explanation for the difference?

- (A) 110kD; presence of introns
- (B) 110kD; protein degradation
- (C) 55kD; post-translational modifications
- (D) 55kD; amino acid composition bias
- (E) 30kD; dimer formation

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8. Which of the following factor(s) promote dissociation of 70S ribosome to 50S and 30S?

- (A) IF-2
- (B) IF-3
- (C) EF-Tu
- (D) EF-G
- (E) RRF

9. Which of the following factor(s) mediates the binding of the Shine-Dalgarno sequence with the complementary sequence of the 16S rRNA?

- (A) IF-2
- (B) IF-3
- (C) EF-Tu
- (D) EF-G
- (E) RRF

10. Which of the following descriptions is **NOT** correct for comparison of protein translation between eukaryotes and bacteria?

- (A) Bacterial translation begins with methionine
- (B) Bacterial translation requires Shine-Dalgarno sequence to show ribosomes where to start
- (C) Eukaryotic mRNA has caps at 5' end
- (D) Eukaryotic initiating tRNA is not same as tRNA for interior
- (E) Eukaryotic translation requires Kozak sequence to show ribosomes where to start

11. Which of the following factor(s) can bind Pab1p, a poly[A]-binding protein?

- (A) eIF1
- (B) eIF1A
- (C) eIF4A
- (D) eIF4E
- (E) eIF4G

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12. Which of the following factor(s) has an RNA helicase activity in translation initiation complex?

- (A) eIF1
- (B) eIF1A
- (C) eIF4A
- (D) eIF4E
- (E) eIF4G

13. Which of the following factor(s) are involved in dissociating improper complexes between 40S subunits and mRNA?

- (A) eIF1
- (B) eIF1A
- (C) eIF4A
- (D) eIF4E
- (E) eIF4G

14. Which of the following descriptions is NOT correct for the peptidyl transferase in ribosome?

- (A) The peptidyl transferase resides on the 50S ribosomal particle
- (B) The peptidyl transferase activity is GTP-dependent
- (C) Minimum components necessary for its activity are 23S rRNA and proteins L2 and L3
- (D) 23S rRNA is at the catalytic center of peptidyl transferase
- (E) puromycin can be its substrate

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15. Which of the following description about histone is (are) correct?

- (A) The molecular mass of Histone H4 is bigger than the other types of histones.
- (B) Histones H2A/H2B and H3/H4 dimerize through the non-covalent interaction of a highly conserved structural motif found in each core histone.
- (C) The histone H3 is extreme highly conserved from pea to cow, which differs by only two residues.
- (D) Histones H1 and H5 bind as monomers to nucleosomes and internucleosomal linker DNA to facilitate higher-order DNA compaction.
- (E) The heterogeneity of histone proteins is due to alternative splicing.

16. Which of the following description about histones modification is (are) correct?

- (A) Histone acetylation specifically occurs in the nucleus.
- (B) The bromodomain domain of HAT(histone acetyltransferase) recognizes acetylated lysine residues on the N-terminal tails of histones.
- (C) The type B HAT does not contain the bromodomain.
- (D) The SANT domain of the type A HAT binds to DNA instead of histone.
- (E) HDAC deacetylates lysine on the N-terminal tail of core histone, leading to activation of gene transcription.

17. Which of the following description about RNA polymerase II (Pol II) is (are) correct?

- (A) Pol II is a multiprotein complex that transcribes DNA into precursors of mRNA and microRNA.
- (B) The C-terminal domain (CTD) of the RNA polymerase binding protein (Rpb1) subunit of Pol II interacts with the splicing factor and stimulates splicing of substrates in organisms that use exon definition.
- (C) The facilitates chromatin transcription (FACT) complex is a histone chaperone comprising Spt16 and SSRP1, which is involved in transcription elongation by RNA polymerases II.
- (D) The CTD of the Rbp1 subunit is involved in capping and splicing but not in polyadenylation.
- (E) The cotranscriptional cleavage (CoTC) element is essential for transcription termination.

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18. Which of the following description about polyadenylation is (are) correct?

(A) The polyA binding protein I (PAB I) binds to mRNA Poly(A), which recruits polysomes and enhances the translatability of mRNA.

(B) Continuously translating mRNA to protein causes Poly(A) turnover, leading to mRNA degradation.

(C) PAB II is critical for the initiation of polyadenylation.

(D) Occurrence of pre-mRNA cleavage triggers the assembling the of precleavage complex bound to the cleavage site.

(E) The cleavage and polyadenylation specificity factor (CPSF) is required for both initiation and elongation phases of Poly(A).

19. Which of the following description about RNA editing is (are) correct?

(A) RNA editing occurs in kinetoplasts.

(B) RNA editing proceeds in a 5'→3' direction

(C) gRNAs form wobble base pairs with pre-mRNA and direct both insertion and deletion of UMPs in pre-mRNA

(D) The cytidine deaminases acting on RNA (CDAR) carries out C to G transversion for RNA editing.

(E) Endonuclease, terminal uridylyl transferase (TUTase), and ligase are required for removing UTP from pre-mRNA.

20. Which of the following is (are) involved in RNA interference?

(A) Dicer

(B) Argonaut 2 (ago2)

(C) ATP

(D) R2D2

(E) C3PO

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*請在【答案卡】作答

21. Which of the following is (are) description about miRNA is (are) correct?

- (A) miRNA blocks translation initiation and elongation
- (B) miRNA causes mRNA degradation
- (C) miRNA activates translation
- (D) miRNA can be processed from spliced introns
- (E) Biogenesis of miRNA occurs in both the nucleus and cytoplasm.

22. Recombinant spike protein of SARS-CoV-2 is currently used for COVID-19 vaccination. Which of the following approach is NOT applied for the recombinant protein production from eukaryotic cells?

- (A) Identify coding sequence of target protein from NCBI, gene bank or GIASID database
- (B) Generate an expression construct with the target gene driven by a T7 promoter
- (C) Generate an expression construct with the target gene driven by a CMV promoter
- (D) Incorporate the target gene with an extra tag (such as his, Fc, myc, flag etc) for purification
- (E) Transfection the expression construct into a cell line such as CHO cells

23. Which of the following approach is NOT generally used to reduce or diminish a specific target gene expression in the cell?

- (A) small interference RNA (siRNA)
- (B) CRISPR/Cas9
- (C) MicroRNA
- (D) Small hairpin RNA (shRNA)
- (E) Long non-coding RNA (lncRNA)

24. Which of the following epigenetic modification is NOT maintained in daughter cells after cell division?

- (A) DNA methylation
- (B) DNA phosphorylation
- (C) Histone methylation
- (D) Histone acetylation
- (E) Histone phosphorylation

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25. Which of the following enzyme is essential for the replication of a virus with a minus-strand RNA genome?

- (A) DNA-dependent DNA polymerase
- (B) RNA-dependent DNA polymerase
- (C) DNA-dependent RNA polymerase
- (D) RNA-dependent RNA polymerase
- (E) Reverse transcriptase

26. Which of the following approach does NOT discriminate the Omicron variant from the wild type SARS-CoV-2 in nasal swabs?

- (A) Next generation sequencing
- (B) RT-PCR using variant-specific primer sets
- (C) Neutralizing antibody detection
- (D) Viral antigen detection
- (E) Hybridization gene chip

27. What is the key enzyme complex which activity is blocked by the G2/M DNA damage repair mechanism before mitotic entry?

- (A) Cyclin A/Cdk2
- (B) Cyclin D/Cdk6
- (C) Cyclin A/Cdk1
- (D) Cyclin B/Cdk1
- (E) Cyclin D/Cdk4

28. Which of the following technology can be used for genome editing?

- (A) CRISPR/Cas9
- (B) Transcription activator-like effector nucleases (TALEN)
- (C) Zinc Finger Nuclease (ZFN)
- (D) Editing by Nucleobase Modification (BASE editing)
- (E) All of the above

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29. Small ribosome subunits scan for initiation sites on eukaryotic mRNA. Which of the following descriptions is not correct?

- (A) Cap binding complex contains eIF4G.
- (B) Cap binding complex contains eIF4A.
- (C) Cap binding complex contains eIF5.
- (D) 43S pre-initiation complex contains eIF1.
- (E) 43S pre-initiation complex contains eIF2.

30. Initiation Factor eIF2. Which of the following descriptions is not correct?

- (A) eIF2 unwinds secondary structure of mRNA.
- (B) eIF2 is a heterotrimeric protein.
- (C) eIF2 is active when bound to GTP.
- (D) eIF2 binds to Met-tRNA_i.
- (E) eIF2B is the GDP exchange factor for eIF2.

31. Bacteriophages. Which of the following descriptions is not correct?

- (A) Bacteriophages specifically infect bacteria.
- (B) Their genetic material is surrounded by a protein capsid.
- (C) This is connected to the elongated sheath by a collar region.
- (D) The sheath forms a hollow tube through which the viral proteins are injected into the host.
- (E) At the bottom is the base plate.

32. Spliceosome Assembly. Which of the following descriptions is not correct?

- (A) The commitment complex is the E complex.
- (B) The E complex contains U13 snRNP bound at the 5' splice site
- (C) The E complex contains the protein U2AF bound to a pyrimidine tract.
- (D) U2AF is a heterodimer consisting of the U2AF65 and U2AF35.
- (E) The E complex progresses to the A complex in the presence of ATP.

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33. Iron-response element (IRE). Which of the following descriptions is not correct?

- (A) IRE consists of multiple stem-loop structures.
- (B) The affinity of the IRE-binding protein for the IRE is altered by iron binding.
- (C) The IRE-binding protein exhibits low affinity when its iron-binding site is full.
- (D) The IRE-binding protein exhibits high affinity when its iron-binding site is not full.
- (E) The IRE-binding protein destabilizes the mRNA.

34. MicroRNA. Which of the following descriptions is not correct?

- (A) The precursor is primary miRNA (pri-miRNA).
- (B) Pri-miRNAs fold into stem-loop structures.
- (C) The loop region of pri-miRNA is cut by Drosha.
- (D) The pre-miRNA exits the nucleus.
- (E) The pre-miRNA is trimmed by Dicer to form miRNA.

35. Using the genetic code. Which of the following descriptions is not correct?

- (A) The bases of mRNA are read off in groups of three, the codon.
- (B) There are 128 different codons in the genetic code.
- (C) Bases are read from 5' to 3'.
- (D) UAA, UAG, and UGA have signal stop.
- (E) AUG act as start codons.

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II. 簡答題 - essay questions (30 points, 6 points for each)

36. Which molecular biology method is the most reliable approach to examine the current status of SARS-CoV-2 infection? What kind of viral information is required for the assay? Please explain how CT value is determined and what it means.

37. What is a TA vector and how is TA cloning done?

38. Please describe how post-transcriptional control of transferrin receptor (TfR) expression by cytosolic aconitase under high and low cellular iron levels (4 points). Please predict the outcomes if a mutation prevents aconitase from binding iron in the cell that contains abundant TfR mRNA (2 points).

39. SARS-CoV-2 is a coronavirus that causes the COVID-19 pandemic. The virus carries a positive strand “polycistronic” RNA genome.

Please explain “polycistronic RNA”? (2 points)

Please explain the mechanism of “ribosomal frameshifting” for the translation of viral products of SARS-CoV-2. (4 points)

40. Non-coding RNAs (ncRNAs) do not code for proteins. Column I lists ncRNAs. Match each one in column I to its correct description in Column II.

Column I

small cytoplasmic RNAs (scRNA)

small nuclear RNA (snRNA)

small nucleolar RNA (snoRNA)

Column II

A. RNAs that are present in the cytoplasm.

B. One of many small RNA species confined to the nucleus; several of them are involved in splicing or other RNA processing reactions.

C. A small nuclear RNA that is localized in the nucleolus.