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國立清華大學 114 學年度碩士班考試入學試題

系所班組別：生命科學暨醫學院
甲組(生物與醫學科學組)

科目代碼：0404

考試科目：分子生物學

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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。
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國立清華大學 114 學年度碩士班考試入學試題

系所班組別：生命科學暨醫學院甲組、丁組

考試科目（代碼）：分子生物學(0404、0704)

(單選題，每題 2 分)

1. **A cell or organism that possesses two homologous copies of each of its chromosomes is described as:**
   A. Haploid
   B. Triploid
   C. Diploid
   D. Aneuploid
   E. Polyploid
2. **What type of bond links nucleotides together to form a strand of DNA or RNA?**
   A. Hydrogen bond
   B. Phosphodiester bond
   C. Peptide bond
   D. Glycosidic bond
   E. Ionic bond
3. **Which of the following best describes the function of histones in eukaryotes?**
   A. To negatively supercoil DNA.
   B. To act as enzymes that cut and paste DNA.
   C. To serve as a scaffold for RNA synthesis.
   D. To package and organize DNA into nucleosomes.
   E. To provide structural support to the cell membrane.
4. **What is the key difference between exonucleases and endonucleases?**
   A. Exonucleases remove nucleotides from the middle of a DNA strand, while endonucleases remove nucleotides from the ends of DNA strands.
   B. Exonucleases are found in eukaryotes, while endonucleases are found in prokaryotes.
   C. Exonucleases are used in DNA replication, while endonucleases are used in DNA repair.
   D. Exonucleases remove nucleotides from the ends of a DNA strand, while endonucleases remove nucleotides from within a DNA strand.
   E. Exonucleases only act on single-stranded DNA, while endonucleases only act on double-stranded DNA.

5. **A researcher is using degenerate primers to amplify a gene from a newly discovered organism. They designed the primers based on a short peptide sequence from a protein that they think is encoded by the gene. What is the most likely reason that a pool of different primers is needed for PCR amplification in this scenario?**
   A. The use of degenerate primers ensures that the PCR reaction has multiple binding sites on the DNA template, thus amplifying the sequence more efficiently.
   B. The use of degenerate primers ensures the amplification of multiple related. genes.
   C. Many amino acids are encoded by multiple codons, so there are several. possible DNA sequences that could code for the same peptide sequence.
   D. Degenerate primers help overcome the mispriming that can occur during PCR.
   E. Degenerate primers increase the specificity of the PCR reaction.
6. **What is the main advantage of using cDNA rather than genomic DNA when creating an expression library for eukaryotic genes?**
   A. cDNA is easier to isolate and purify than genomic DNA.
   B. cDNA is more stable than genomic DNA.
   C. cDNA contains promoter sequences that are needed for expression.
   D. cDNA lacks introns, which allows for proper expression in a bacterial host.
   E. cDNA is double-stranded, while genomic DNA is single-stranded.
7. **What is the function of dideoxynucleotides in Sanger sequencing?**
   A. To act as primers for DNA synthesis.
   B. To label DNA fragments with fluorescent markers.
   C. To cut the DNA at specific sequences.
   D. To terminate DNA synthesis at specific bases.
   E. To amplify the DNA for sequencing.
8. **Which is <u>true</u> for eukaryotic RNA polymerase (RNAP) I, II and III?**
   A. RNAP I and II are found in the nucleoplasm, while RNAP III are found in the nucleolus.
   B. Among three RNAPs, RNAP II is insensitive to alpha-amanitin.
   C. The 28S, 18S and 5S ribosomal RNA are synthesized by RNAP I, while tRNA and other small RNA are synthesized by RNAP III.

D. Rpb5, Rpb7, Rpb9, Rpb10 and Rpb12 are common subunits for all three RNAPs.

E. RNAP IIA contributes to transcription elongation, while RNAP IIO is involved in the formation of pre-initiation complex.

9. Which is true for the following experimental techniques?

A. Yeast two-hybrid analysis is useful for assaying DNA-protein interactions *in vitro*.

B. In chromatin immunoprecipitation (ChIP) analysis, formaldehyde is commonly used for protein-DNA crosslinking.

C. Far-western blot analysis is a method to analyze protein-RNA interactions.

D. The G-less cassette assay is often used to detect protein-protein interactions.

E. A Southern blot is used to detect specific protein in a tissue sample.

10. Which statement is not true for TATA-binding protein (TBP) of eukaryotic RNA polymerases (RNAPs)?

A. RNAP III is positioned at promoter by a TFIIIC, which contains TBP.

B. For RNAP II, TBP is a component of the general transcription factor TFIID.

C. For RNAP I in human, the general transcription factor SL1 is composed of TBP and three TAFs, and binds to the core promoter region.

D. TBP binds to the minor groove of DNA and bends consensus TATA DNA by approximately 80 degree.

E. In yeast, TFIIB binds specifically to TBP via its C-terminal domain.

11. Which statement is true for the general transcription factors in eukaryotic organisms?

A. TFIIE, TFIIF and TFIIH are not essential for transcription elongation, but they are required for promoter clearance.

B. The core-binding factor is the fundamental transcription factor required to recruit RNA polymerase I.

C. During transcription elongation, RNA polymerases may pause at specific sites near promoters, and this pause can be reversed by TFIIB.

D. Transcription of the 5S rRNA gene requires TFIIIA and TFIIIB, but not TFIIIC.

E. TAF2 and TAF5 can bind to TATA-less promoters that contains the Inr and DPE promoter elements to ensure the whole TFIID binding to the promoter.

12. Which of the following RNA undergoes two additional processes known as capping and tailing?

A. siRNA

B. tRNA

C. snRNA

D. 5S rRNA

E. hn RNA

13. Which is true for eukaryotic transcription activators?

A. A type II nuclear receptor exists an inactive form in cytoplasm before binding to its ligand.

B. Yeast Gal4 is a Cys2His2 zinc-finger protein, involving in regulation of galactose metabolism.

C. The basic region of a bHLH transcription factor is involved in protein dimerization.

D. Type III nuclear receptors are also known as orphan receptors and bind to DNA as homodimers.

E. In the bZIP transcription factor, the bZIP domain consists of two alpha-helix polypeptides, each with leucine residues separated by 5 amino acids.

14. Choose a correct statement for eukaryotic promoters.

A. Spacing between the core element and upstream promoter element (UPE) is not important for the transcription of class I promoters.

B. At least in Drosophila, TATA-less of class II promoters tend to have downstream promoter elements (DPEs) that are similar to TATA box, bound by TFIIB.

C. Inr (initiator) and the TATA box constitutes a core promoter for the adenovirus major late promoter.

D. The tRNA gene contains an internal promoter, which is split into three regions: box A, a short intermediate element, and Box C.

E. The AT-rich initiator (rINR) is a conserved sequence of class I promoters and is located within the upstream promoter element (UPE).

15. Which of the following statements is *INCORRECT* about the canonical microRNA (miRNA) biogenesis pathway in mammals?

A. Pri-miRNAs are typically transcribed by RNA polymerase II and contain a 5′ cap and poly(A) tail.

B. The Microprocessor complex, composed of Drosha and DGCR8, cleaves pri-miRNAs in the nucleus to generate pre-miRNA hairpins.

C. Exportin-5, in a Ran-GTP–dependent manner, exports pre-miRNAs from the nucleus into the cytoplasm.

D. Dicer cleaves the pre-miRNA in the cytoplasm, producing a short duplex (~22 nucleotides), which then undergoes strand selection.

E. The mature miRNA is incorporated into the RNA-induced silencing complex (RISC) through the Drosha–DGCR8 complex.

16. Which of the following is the primary biological function of microRNAs (miRNAs) in eukaryotic cells?

A. To serve as templates for the synthesis of small interfering RNAs (siRNAs) during immune response.

B. To promote the splicing of pre-mRNA by recognizing intron-exon junctions.

C. To regulate gene expression by binding to complementary sequences on target mRNAs, leading to translational repression or mRNA degradation.

D. To act as ribozymes that catalyze peptide bond formation during protein synthesis.

E. To serve as direct messengers in the nucleus that enhance transcription by interacting with RNA polymerase II.

17. Which of the following statements correctly describes a key difference between microRNAs (miRNAs) and small interfering RNAs (siRNAs)?

A. miRNAs primarily regulate gene expression through translational repression, while siRNAs often induce mRNA cleavage when binding to their target.

B. miRNAs typically bind to perfectly complementary sequences on target mRNAs, while siRNAs bind to partially complementary sequences.

C. siRNAs are derived from endogenous transcripts, while miRNAs are always of exogenous origin.

D. Both miRNAs and siRNAs are loaded onto the RNA-induced silencing complex (RISC), but only siRNAs recruit the Argonaute protein.

E. miRNAs are processed in the cytoplasm by Dicer, while siRNAs are processed exclusively in the nucleus.

18. What is the primary purpose of RNA polyadenylation in eukaryotic cells?

A. To prevent the formation of secondary structures in the coding region of the mRNA.
B. To enhance transcription elongation by stabilizing RNA polymerase on the DNA template.
C. To promote the export of mRNA from the nucleus and increase its stability and translational efficiency.
D. To remove introns from pre-mRNA during RNA splicing.
E. To initiate translation by providing a binding site for ribosomes at the 5' end of the mRNA.

19. Which of the following statements about RNA splicing is correct?

A. RNA splicing removes exons and joins introns to produce mature mRNA in eukaryotic cells.
B. The spliceosome removes introns and adds a poly(A) tail to the 5' end of the RNA molecule.
C. RNA splicing is a process exclusive to prokaryotes.
D. Alternative splicing allows a single gene to produce multiple protein isoforms.
E. Splicing occurs in the cytoplasm after transcription is complete.

20. Which of the following statements about alternative splicing is correct?

A. Alternative splicing occurs only in protein-coding genes and excludes non-coding RNA genes.
B. Alternative splicing is regulated by splice site selection influenced by RNA-binding proteins and cis-regulatory elements.
C. All alternative splicing events result in functional protein isoforms.
D. Alternative splicing is primarily limited to the removal of introns without any variation in exon usage.
E. Alternative splicing is a rare event occurring in only a small fraction of eukaryotic genes.

21. Which of the following statements about chromatin structure is correct?

A. Euchromatin is associated with active gene transcription and is less condensed compared to heterochromatin.
B. Heterochromatin is enriched with histone H3 lysine 4 methylation (H3K4me3), promoting transcriptional repression.
C. The nucleosome is composed of DNA wrapped around a complex of six histone proteins.
D. Chromatin structure is static and does not change in response to environmental or cellular signals.
E. Histone modifications, such as methylation and acetylation, do not influence chromatin accessibility or transcriptional activity.

22. Which of the following statements accurately compares translational initiation between eukaryotes and bacteria?

A. Bacterial translation begins with N-formyl-methionine carried by tRNA, which differs from the tRNA carrying interior methionine.
B. Bacterial translation requires the Kozak sequence to guide ribosomes to the start codon.
C. Eukaryotic translation requires the Shine-Dalgarno sequence to guide ribosomes to the start codon.
D. Eukaryotic translation begins with methionine carried by tRNA, which is the same as the tRNA carrying interior methionine.
E. Bacterial mRNAs contain a 5' cap structure.

23. What are the functions of IF3 in bacterial translation?

A. Binds the 50S ribosomal subunit.
B. Promotes reassociation of the 30S and 50S ribosomal subunits.
C. Facilitates the binding of fMet-tRNA to the 30S initiation complex.
D. Facilitates mRNA binding to the 30S initiation complex.
E. Helps align the Kozak sequence of mRNA with the 16S rRNA.

24. Which of the following statements about poliovirus are correct?

A. Poliovirus directly degrades host mRNA.
B. Poliovirus protease degrades eIF4G.
C. Poliovirus RNA harbors a 5' cap structure.
D. The IRES element is present in most mRNAs.
E. eIF4E facilitates the translation of picornavirus mRNAs.

25. Which of the following molecules do NOT function as GTPases?

A. IF2
B. EF-G
C. EF-Ts
D. EF-Tu
E. RF-3

26. Which statements inaccurately describe base pairing between codon and anticodon?

A. The first two bases in a codon determine coding specificity by forming strong Watson-Crick base pairs with the anticodon.
B. Isoaccepting tRNAs bind different amino acids but recognize the same codon.
C. Wobble occurs when the third base of a codon forms a non-Watson-Crick base pair with the anticodon.
D. Wobble allows the same aminoacyl-tRNA to pair with multiple codons.
E. The super-wobble hypothesis suggests that a single tRNA with U in the first anticodon position (5' position of the anticodon) can recognize codons ending in any of the four bases under certain conditions.

27. Which of the following antibiotics do NOT inhibit protein translation?

A. Puromycin
B. Thiostrepton
C. Penicillins
D. Chloramphenicol
E. Viomycin

28. The function of miRNA is based on inhibiting which of the following factors?

A. eIF1A
B. eIF2
C. eIF3
D. eIF4A
E. eIF4E

29. Which of the following is a primary function of the 3' UTR in eukaryotic mRNA?

A. Facilitating the initiation of transcription.
B. Determining the site of ribosome binding for translation initiation.
C. Regulating mRNA stability and translation efficiency.
D. Coding for signal peptides during protein synthesis.
E. Ensuring the proper splicing of introns from the pre-mRNA.

30. Which of the following best describes the function or characteristic of colicins?

A. Colicins are enzymes secreted by bacteria to degrade host DNA during infection.
B. Colicins are antimicrobial proteins produced by bacteria to kill or inhibit closely related bacterial strains.
C. Colicins are RNA molecules that regulate gene expression in bacterial populations.
D. Colicins are structural proteins involved in the formation of bacterial pili during conjugation.
E. Colicins are lipopolysaccharides that form part of the bacterial outer membrane.

31. Which of the following correctly differentiates rolling circle replication from binary replication in DNA replication?

A. Rolling circle replication involves bidirectional replication, while binary replication occurs unidirectionally.
B. Rolling circle replication is primarily used in prokaryotic chromosomal replication, whereas binary replication is exclusive to plasmid DNA.
C. Rolling circle replication generates single-stranded intermediates, while binary replication replicates both DNA strands simultaneously.

D. Rolling circle replication is initiated at multiple origins of replication, whereas binary replication starts at a single origin.
E. Rolling circle replication requires Okazaki fragments, while binary replication does not.

32. Which enzyme is commonly added when using a single restriction enzyme in cloning, and what is its purpose?
A. **T4 DNA polymerase**, to fill in 5' overhangs and generate blunt ends to increase ligation efficiency.
B. **Reverse transcriptase**, to synthesize cDNA from RNA prior to cloning.
C. **Exonuclease**, to degrade the unwanted DNA after restriction enzyme digestion.
D. **Alkaline phosphatase**, to prevent the vector from self-ligating by removing 5' phosphate groups.
E. **Topoisomerase**, to relieve supercoiling in the DNA fragment during cloning.

33. Which of the following statements about PCR is incorrect?
A. Quantitative PCR can directly quantify the relative concentration of mRNA.
B. The use of 95°C during the reaction process is to cause DNA denaturation.
C. The temperature setting for the annealing step will affect the specificity of the product.
D. The use of 72°C during the reaction process is for polymerization, and the time must be adjusted based on the product size.
E. The discovery of Taq DNA polymerase, which can withstand high temperatures, is the key to PCR technology.

34. Integration of Lamda phage into host genome is mediated by a process called:
A. Cut-and-paste transposition
B. Replicative transposition
C. Homologous recombination
D. Non-homologous end-joining
E. Site-specific mutagenesis

35. In addition to the Transposase Gene, what is the most important component of DNA transposons?

A. Inverted Repeats
B. Long Terminal Repeats
C. Direct Repeats
D. Internal Resolution Site
E. Resolvase Gene

(問答題，每題 6 分)

1. The complexities of translation. Match the terms in Column A with their descriptions in Column B.

   Column A

   1. Shine-Dalgarno sequence
   2. Internal ribosome entry site (IRES)
   3. Signal sequence

   Column B

   a. A sequence in prokaryotic mRNA that helps position the ribosome on the mRNA for translation.
   b. A sequence in mRNA that allows translation initiation without the need for a. 5'. cap.
   c. A sequence at the N-terminus of a protein that directs it to a specific location in the cell.

2. In eukaryotic organisms, different types of transcription regulatory regions are present on DNA. Please explain the differences between proximal promoter elements, enhancers and insulators.

3. Describe the Chromatin Immunoprecipitation (ChIP) Assay and its purpose.

4. List the enzyme involved in amino acid activation and its substrates in the process of aminoacylation.

5. Adding a tag, such as HA, to a protein of interest is a useful approach that enables subsequent applications. (A) Please describe two examples of the applications. (2pts) (B) If a tag is planned to be added to the C-terminus of a protein, please

elucidate two most important considerations for targeting the gene segment, which encodes for the tag, to the gene of interest. (4pts)