BSc. Biological Chemistry study programme
State exam Molecular Biology & Genetics question (as compiled/collated 25. 07. 2022 – AWB)
Students are randomly picking THREE questions.

Q1. Describe the molecular structure of the DNA molecule. With reference to the three originally proposed models of DNA replication, describe which model was experimentally proved to be true (and how); proceed to explain in detail how DNA replication occurs according to this model.

Q2. How do ribosomes translate the information in mRNA sequences into proteins? Describe in detail the catalytic process in terms of initiation, elongation and termination phases. Highlight the main differences between eukaryotic and prokaryotic translation initiation.

Q3. In experimental molecular biology, what is a western blot and what is it used for? Describe the apparatus and principles behind western blotting.

Q4. What are microRNAs (miRNAs) and how are they derived? What is the function of microRNAs in eukaryotic cells in relation to the probability that specific mRNAs will be translated? Are there any other mechanisms (naturally occurring or experimentally derived) that can regulated whether or not mature mRNAs will be translated?

Q5. Describe the main differences between mature prokaryotic and eukaryotic mRNAs. How do the processes of eukaryotic and prokaryotic protein coding gene transcription initiation differ and how are they regulated (*using terms such as operons and transcription factors*)?

Q6. In experimental molecular biology, what are Southern, northern and western blots and what are they used for? Taking each in turn, describe the apparatus and principles behind these three blotting techniques.

Q7. Describe how the dideoxynucleotide trisphosphate (ddNTP) chain terminator DNA sequencing method developed by Fred Sanger works. How has his original method been developed, refined and improved up to the current day? Provide examples of large-scale experimental strategies or projects that rely on DNA sequencing and what they can achieve.

Q8. Define the term ‘DNA sequence mutation’. What different consequences can DNA mutations have if they occur within the protein coding regions of gene? Describe, with examples, how DNA mutations can arise in genomes; either spontaneously or by induced mechanisms.

Q9. Describe the techniques that could be employed to detect and measure the levels of specific gene mRNAs, from a tissue/cell culture sample, providing experimental/ technical details and their advantages and disadvantages.

Q10. mRNA stability is a critical regulator of gene expression. Describe the ways in which eukaryotic cells can regulate mRNA stability and how this relates to the probability of an mRNA being translated into a protein?

Q11. Describe the methods by which the presence or absence of a particular protein can be detected in a biological sample? Give relevant technical details and explanations for each of the experimental steps.

Q12. Identify classes of small non-coding RNAs found in eukaryotic cells. Provide examples of how specific small non-coding RNAs can regulate gene expression (providing relevant mechanistic details).

Q13. In eukaryotic cells, what is chromatin. How can the structure of chromatin be modified and how can this regulate specific gene expression?

Q14. What is the genetic code? How does a protein's amino acid sequence relate to a gene's DNA sequence? Describe the possible effects of DNA mutations with a genes protein coding region. Describe the experiments used to decipher the genetic code?

Q15. What is the central dogma in molecular biology (describe each of the constituent parts/step in detail)?

Q16. Describe the process of transcriptional initiation and termination in prokaryotes. How does this contrast with the situation in eukaryotes?

Q17. Describe the various steps in eukaryotic mRNA processing and the reasons for these processing steps?

Q18. Describe the different levels of protein structure and how they are achieved. What is protein folding and cite examples of how protein folding is regulated (using terms such as 'chaperones').

Q19. What happens to proteins that are no longer required by the cell and how are they disposed of?

Q20. What is a bacterial operon, in relation to regulation of gene transcription (cite specific examples)?

Q21. In eukaryotes what are the 'general transcription factors (GTFs)' and how do they functionally differ from the 'sequence specific transcription factors'? How do each of these two classes influence gene transcription?

Q22. What is RNA editing (provide examples)?

Q23. What are the possible mechanisms by which DNA mutations can arise?

Q24. What is recombinant DNA? What are restriction enzymes and how are they useful in recombinant DNA technology? Outline the principle of DNA cloning.

Q25. Describe molecular biological techniques that take advantage of complementary base-pairing/ nucleic acid hybridisation to detect specific DNA fragments of defined DNA sequence (not including PCR)?

Q26. Define the term Restriction Fragment Length Polymorphism (RFLP) and describe the technique by which they may be utilised to detect SNPs in DNA sequence/genomes (you can provide specific examples)?

Q27. Describe the general purpose of PCR and theoretically how it works. Give examples of techniques that utilise PCR. What is Taq and why is it necessary to modern PCR? Why do we have three cycle steps? What is RTPCR?

Q28. How does real-time PCR differ from conventional PCR? What is a TaqMan probe?

Q29. What is 'next generation DNA sequencing' and how does it compare to conventional 'Sanger'-based' sequencing? Give examples as relevant.

Q30. In eukaryotes, what is mRNA splicing and what are the possible consequences of splicing? How is splicing regulated in the cell? What is the process of non-sense-mediated decay?

Q31. What are the possible mechanisms by which DNA mutations may arise naturally or be induced? Outline specific types of DNA damage and possible mechanisms by which they may be repaired.

Q32. Define the 'Chromosome Theory of Inheritance' and how it was validated by the experiments of Thomas Hunt Morgan using the fruit fly model, *Drosophila melanogaster*.