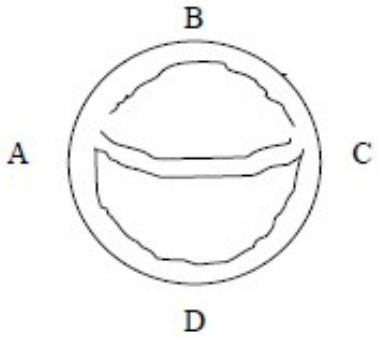
Questions- Replication, Transcription, & Protein Synthesis

A. DNA replication is studied in a newly discovered bacterium. It takes 30 min for the bacterium to complete a round of replication at 37°C. Autoradiography of the replicating DNA molecule shows the following structure.



A Meselson-Stahl-type experiment was also performed. The bacteria were grown for several generations in ^{14}N-medium and then switched to ^{15}N-medium. The DNA molecules were then analyzed. (Questions 1-7)

1._____ Which is a characteristic of Meselson-Stahl experiments?
- a) DNA molecules are separated based on size.
- b) DNA molecules reach an equilibrium position in the centrifuge tube.
- c) CsCl binds to the DNA and pulls it down through the solution.
- d) CsCl becomes separated into different bands when centrifuged.

2._____ If the mechanism of DNA replication in this bacterium were dispersive, what results would be found when the double-stranded DNA was analyzed in a CsCl gradient after two generations in ^{15}N-medium?
- a) One band would be observed containing all the DNA.
- b) Two bands would be observed containing equal amounts of DNA.
- c) Two bands would be observed containing unequal amounts of DNA.
- d) The DNA cannot form any bands if replication is dispersive.

3._____ If the mechanism of DNA replication in this bacterium were semi-conservative, what results would be found when the double-stranded DNA was analyzed in a CsCl density gradient after three generations in ^{15}N-medium?
- a) The DNA would form three bands: one with hybrid density, one with light density, and one with heavy density.
- b) The DNA would form one band with hybrid density.
- c) The DNA would form two bands: one with heavy density and one with hybrid density.
- d) The DNA would form two bands: one with light density and one with hybrid density.

4._____ After one generation in ^{15}N-medium, the DNA is denatured and analyzed in a CsCl gradient. If the single-stranded DNA forms two bands, one with heavy density and one with light density, what conclusion could be drawn about the mechanism of DNA replication in this bacterium?

a) The mechanism must be conservative.
b) The mechanism must be semi-conservative.
c) The mechanism could be either conservative or semi-conservative.
d) No conclusions about the mechanism can be made by analyzing single-stranded DNA.

5._____ Which conclusion can be made about DNA replication in this bacterium based **only** on the autoradiography structure?

a) Replication in this bacterium could occur bidirectionally from an origin at point A.
b) Replication in this bacterium could occur unidirectionally from an origin at point D.
c) Replication in this bacterium could terminate at point B.
d) Replication in this bacterium could terminate at point C.

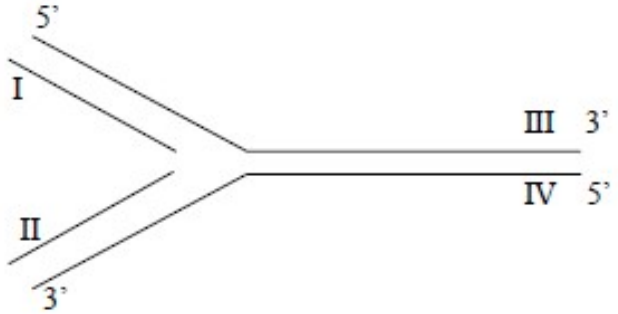
6._____ If this bacterium is similar to E. coli in its mechanism of DNA replication, then which will occur when the bacterium is grown at 37°C?

a) There will be two replication forks when replication occurs in poor medium.
b) There will be four replication forks when replication occurs in rich medium.
c) The rate of polymerization will vary depending upon the medium.
d) The frequency of initiation will be constant regardless of the medium.

7._____ If this bacterium is similar to E. coli in its mechanism of DNA replication, then which will occur when the bacterium is grown at 37°C?

a) At least one round of replication will be occurring at all times.
b) Only one round of replication can take place at a given time.
c) The newly synthesized DNA strands will bond together in a double-helix.
d) All rounds of replication start at a specific sequence on the chromosome.

B. The mechanism of DNA replication is studied in an E. coli replication fork. (Questions 8-13)



8._____ Which is a characteristic of this replication fork?

a) Strands I and II have base sequences that are identical to each other.
b) Strands II and IV have an antiparallel orientation as the fork moves to the right.
c) Strands I and III will be covalently bonded to each other when replication is completed.
d) Strands III and IV will be H-bonded to each other when replication is completed.

9._____ Which is a characteristic of this replication fork?

a) Strand I is replicated continuously while strand II is replicated discontinuously.
b) Strand III is a lagging strand template while strand IV is a leading strand template.
c) The double-helix containing strands I and III must be denatured in order for replication to continue.
d) The double-helix containing strands II and IV will form base-pairs using phosphodiester bonds.

10._____ Which is a property of Okazaki pieces in an E. coli replication fork?

a) Okazaki pieces are joined together by DNA polymerase I to form a long chain.
b) Okazaki pieces are polymerized in the 3′→ 5′ direction by DNA polymerase III.
c) An Okazaki piece for the leading strand is polymerized to a length of 1000-2000 nucleotides.
d) An Okazaki piece for the lagging strand has a base sequence complementary to its template.

11._____ Which is a property of RNA primers in an E. coli replication fork?

a) RNA primers are synthesized using a DNA template and NDPs.
b) Each RNA primer is joined to an Okazaki piece through a non-covalent bond.
c) Each RNA primer is both polymerized and degraded in the 5′→ 3′ direction.
d) RNA primers are synthesized and proof-read by the primase enzyme.

12. _____ When will this fork stop replicating DNA?

a) when its movement is halted by a Ter sequence
b) when it is denatured by the Tus protein
c) when it reaches the OriC region
d) when a topoisomerase removes supercoils

13._____ Which is a characteristic of an E. coli replication fork and a eukaryotic replication fork?

a) Both forks contain a leading strand and a lagging strand.
b) Polymerization occurs more rapidly in eukaryotes.
c) Okazaki pieces are smaller in prokaryotes.
d) Both forks can synthesize DNA only during S phase.

C. The proteins needed for all stages of DNA replication in E. coli are studied. (Questions 14-25)

14._____ During initiation of replication

a) DNA polymerases denature A-T rich sequences at the origin.
b) replication begins when Dna A protein binds the origin and synthesizes primers.
c) DnaB protein cleaves the double-helix to produce template strands.
d) two replication forks need to be created to establish bidirectional replication.

15._____ Which is a characteristic of E. coli DNA polymerases?

a) Pol I functions as a multimeric protein that participates in DNA repair.
b) Pol I functions as a core enzyme that clamps around the DNA.
c) Pol III functions as a holoenzyme that polymerizes DNA with high processivity.
d) Pol III functions as a single polypeptide chain that can form phosphodiester bonds.

16.____ Which property is shared by E. coli DNA polymerase I and DNA polymerase III?

a) Both enzymes require a template that can be either DNA or RNA.
b) Both enzymes require a primer that can be either DNA or RNA.
c) Both enzymes can use pyrophosphate as a substrate.
d) Both enzymes can make and break N-glycosidic bonds.

17._____ Which describes the role of primase during replication?

a) It catalyzes the formation of phosphodiester bonds using NTPs as substrates.
b) It coordinates synthesis of the leading strand and the lagging strand.
c) It functions as a holoenzyme that polymerizes in the 3'→ 5'direction.
d) It uses an exonuclease activity to remove incorrect nucleotides.

18._____ Which function can be carried out by DNA replication proteins?

a) Topoisomerases wind the DNA into a double-helix.
b) DNA ligase can initiate new DNA chains
c) SSB converts double-stranded DNA into single-stranded DNA.
d) Helicases break hydrogen bonds in the DNA.

19._____ Which protein can catalyze the formation of phosphodiester bonds?
a) DNA ligase
b) Dna A protein
c) Dna B protein
d) Tus protein

20._____ Which protein can break covalent bonds?
a) helicase
b) primase
c) SSB
d) DNA gyrase

21._____ Which mechanism contributes to accuracy during DNA replication?
a) The mismatch repair system recognizes an incorrect base-pair and corrects the mistake in the non-methylated strand.
b) Using primers increases accuracy because the first nucleotides in a new nucleic acid chain are more likely to be correct.
c) All DNA polymerases have a 5′→ 3′ exonuclease activity which can remove incorrect nucleotides during replication.
d) Base-stacking between nucleotides and the template DNA controls insertion of the correct nucleotide.

22._____ A mutation in an E. coli cell becomes active half-way through a round of replication. The cell completes the round of replication normally but then cannot start a second round. Which protein could be mutated?
a) DNA ligase
b) Dna B protein
c) HU protein
d) DNA gyrase

23._____ If DNA polymerase I were mutated so that all its enzymatic activities were inactive, which part of replication would be most affected?
a) synthesis of Okazaki pieces
b) joining of Okazaki pieces
c) proof-reading of DNA
d) adjusting of supercoiling

24._____ A mutated E. coli cell carries out and completes DNA replication, but the lagging strands are found to contain more errors than normal. These errors are not found evenly distributed throughout the lagging strands, but are found in clusters. Which enzymatic activity is missing from this cell?
a) the 3’→ 5’ exonuclease activity of pol III
b) the 5’→ 3’ exonuclease activity of pol III
c) the 3’→ 5’ exonuclease activity of pol I
d) the 5’→ 3’ exonuclease activity of pol I

25._____ A mutated strain of E. coli replicates DNA normally at 25^{O}C, but replication stops immediately when the temperature is raised to 37^{O}C. Which protein is likely to be non-functional at the higher temperature?

a) primase
b) gyrase
c) ligase
d) Tus protein

D. Transcription is studied in E. coli. (Questions 26-33)

26._____ Which is a characteristic of mRNA in E. coli?

a) mRNA will be polycistronic and double-stranded.
b) mRNA will be monocistronic and single-stranded.
c) mRNA will contain one or more non-coding spacer sequences.
d) mRNA will contain one or more coding leader sequences.

27._____ Which is a property of E. coli RNA polymerase?

a) It transcribes one DNA strand of a gene using an RNA primer for initiation.
b) It is a multimeric enzyme that catalyzes the formation of covalent phosphodiester bonds.
c) It has both a 3'→5' polymerase activity and a 3'→ 5'exonuclease activity.
d) It uses ribonucleoside triphosphates as substrates and removes supercoils.

28._____ Which characteristic is shared by both RNA polymerase and DNA pol III in E. coli?

a) Both function as holoenzymes that have polymerase and helicase activities.
b) Both use promoters to locate and bind to the starting point of genes.
c) Both produce nucleic acid molecules that become permanent cellular components.
d) Both use templates to synthesize an anti-parallel, complementary nucleic acid chain.

29._____ Which step occurs during the initiation of transcription in E. coli?

a) RNA polymerase binds to different promoters to different extents depending upon the base sequence.
b) Most E. coli promoters contain two consensus sequences located downstream of the transcription start site.
c) The σ subunit of RNA polymerase recognizes and transcribes the A-T-rich Pribnow box in the promoter.
d) The core enzyme of RNA polymerase binds to and denatures the upstream -35 sequence.

30._____ Which is an aspect of transcription in E. coli?

a) The σ subunit of RNA polymerase is required for initiation and termination of transcription but not for elongation.
b) Only 1-2 turns of the DNA double-helix are denatured at any given time which allows the mRNA and a DNA strand to base-pair.
c) Rho-independent termination sites use a series of weak G-C base-pairs to separate the DNA from the mRNA.
d) Rho-dependent termination sites use a hairpin composed of A-U base-pairs to slow down RNA polymerase.

31._____ Which characteristic is shared by transcription and replication in E. coli?

a) Both processes have an error rate of about 1 in 10^4-10^5 nucleotides.
b) Both processes have the same rate of nucleotide polymerization.
c) Both processes require breaking and making hydrogen bonds.
d) Both processes use a semi-discontinuous mechanism.

32._____ A mutated E. coli cell contains a slightly altered RNA polymerase which does not function normally but still allows the cell to survive Which problem is **unlikely** to be the result of this altered RNA polymerase?

a) Some genes may be transcribed more frequently than normal.
b) Some mRNA molecules may be longer than normal.
c) The non-template strand may be transcribed in some genes.
d) There may be an increased number of mRNA molecules with incorrect bases.

33._____ A normal E. coli cell produces a polycistronic mRNA for genes X, Y, and Z. This mRNA is significantly shorter in a mutated E. coli cell. Which component of transcription most likely contains an altered sequence in the mutated cell?

a) an intron region
b) a termination region
c) a promoter region
d) a spacer region

E. Post-transcriptional modification is studied in eukaryotes. (Questions 34-38)

34._____ Which property is found in eukaryotic RNA?

a) Before processing, tRNAs contain unusual bases.
b) Before processing, rRNAs contain 3'-leader sequences.
c) Before processing, pre-RNAs contain spacers.
d) Before processing, hnRNAs contain introns.

35._____ During the processing of pre-mRNA in eukaryotes

a) the spliceosome breaks covalent bonds at the 5'- and 3'-splice sites.
b) exons are joined together using polyadenylate polymerase.
c) a 5′-methylguanosine cap is added using a specific nuclease.
d) a 3′-poly A tail is attached using a 5',5' triphosphate bond.

36._____ Which is a property of the introns in most eukaryotic pre-mRNA?

a) Introns are extra coding sequences that can be removed by an RNA-protein complex.
b) Introns are non-coding sequences that separate exons in monocistronic pre-mRNA.
c) Introns are palindromic sequences that self-splice to form lariat structures.
d) Introns can remain in mature mRNA due to alternate splicing pathways.

37._____ Gene X codes for a protein in eukaryotes. A mutated eukaryotic cell contains an altered base-pair in an intron of gene X. Which would be the most likely effect of this mutation on the biomolecules in the cell?

a) The amount of pre-mRNA transcribed from gene X would be less than normal.
b) The amount of functional protein corresponding to gene X would be less than normal.
c) The ability of snRNAs to form a spliceosome would be diminished.
d) The breakdown of mature mRNA corresponding to gene X would be faster.

38._____ A mutated eukaryotic cell contains a mutation in the middle of an exon in gene Q. What will be the most likely result of this mutation?

a) The amount of transcription of gene Q would be greater than normal.
b) The mRNA produced from gene Q would be longer than normal.
c) The enzyme produced from gene Q would have less activity than normal.
d) The breakdown of the mRNA from gene Q would be slower than normal.

F. Protein synthesis is studied in E. coli. (Questions 39-41)

39._____ Which is a characteristic of the normal genetic code?

a) One codon can code for only one amino acid.
b) One amino acid can have only one codon.
c) One tRNA molecule can bind to only one codon.
d) One aminoacyl-tRNA synthetase can react with only one tRNA.

40._____ During protein synthesis in E. coli,

a) N-formylmethionine binds to EF-Tu to become the N-terminal amino acid.
b) a tRNA binds non-covalently to both an amino acid and to an codon.
c) the 16S rRNA correctly positions the start codon in the P site.
d) the 23S rRNA forms covalent peptide bonds between initiation factors.

41._____ The codon UUU in an mRNA molecule results in phenylalanine being inserted as the protein is made. Which will be a characteristic of this codon?

a) The tRNA molecule that binds to the UUU codon must have an AAA anticodon.
b) UUU could code for both phenylalanine and alanine during translation.
c) The aminoacyl-tRNA synthetase for phenylalanine binds only the UUU codon.
d) UUU is probably only one of several codons that code for phenylalanine.