

Bio 366: Biological Chemistry II
Test #3, 100 points

READ THIS: Take a numbered test and sit in the seat with that number on it. Remove the numbered sticker from the desk, and stick it on the back of the last page of the test. Print the last four digits of your social security number on the back of the test, and your name on the front top of each page. When you have finished, hand in your test and sign your name on the sign-out sheet by the door. The answers will be posted outside of my office (Bio 229) by early next week. If you wish to challenge an answer, give me a written explanation as soon as possible. If you wish to question the grading of this exam, you must also give me a written explanation, and hand it back to me with your whole test, which will be completely regraded (*i.e.*, you could lose points).

- A. Explain what "transition" and "transversion" nucleotide substitutions are, illustrating with a diagram. Include a discussion of the expected and observed ratios of these mutations in DNA. (5 points)

B. Match the enzyme/protein/process (1 point each; 20 points total): Write the letter of the correct answer(s) in the blank next to the statement. Some have more than one correct answer; list them all for full credit. The same letter may be used for more than one answer, or may not be used at all.

- | | | | |
|----|---|----|---------------------------|
| a. | ATP-dependent helicase | k. | HIV reverse transcriptase |
| b. | Aminoacyl-tRNA synthetase, Class I | l. | Inorganic pyrophosphatase |
| c. | Aminoacyl-tRNA synthetase, Class II | m. | Photolyase |
| d. | DNA ligase | n. | PNCA protein |
| e. | DNA gyrase | o. | Primase |
| f. | <i>E. coli</i> DNA polymerase I | p. | RNase H |
| g. | <i>E. coli</i> DNA polymerase II | q. | Rho factor |
| h. | <i>E. coli</i> DNA polymerase III | r. | Sigma factor |
| i. | <i>E. coli</i> RNA polymerase "core enzyme" | s. | Topoisomerase |
| j. | <i>E. coli</i> RNA polymerase "holoenzyme" | x. | none of the above |

1. _____ Binds to unoccupied C-rich regions in RNA, then advances 5' to 3' until it reaches a transcription bubble, where it catalyzes unwinding of mRNA and DNA template.
2. _____ This enzyme helps render many biochemical reactions essentially irreversible.
3. _____ Apparently gives eukaryotic DNA polymerase δ unlimited processivity.
4. _____ Removes supercoils from DNA during transcription.
5. _____ Links ATP, GTP, CTP and TTP in the order specified by base pairing with a DNA template.
6. _____ Is one of the largest known soluble proteins, at about 100 Å diameter.
7. _____ Has a subunit structure of $\alpha_2 \beta \beta'$.
8. _____ Is also called "photoreactivating enzyme"
9. _____ A protein sometimes involved in transcription termination in prokaryotes.
10. _____ Has a turnover number of about 9,000 deoxyribonucleotides polymerized per minute per molecule (at 37°C).
11. _____ Esterifies a specific amino acid to the 3' end of its cognate tRNA molecule.
12. _____ Has both 3' → 5' and 5' → 3' exonuclease activities.
13. _____ Transfers activated aminoacyl-adenylate directly to the 3'-OH of the ribose on the terminal thymine of tRNAs.
14. _____ Its holoenzyme form can replicate an entire *E. coli* genome without dissociating.
15. _____ Has a subunit structure of $\alpha_2 \beta \beta' \sigma$.
16. _____ Synthesizes the short RNA primers used during DNA replication in prokaryotes.
17. _____ Binds nonspecifically to DNA and migrates until the transcription start site is located.
18. _____ It has RNA-dependent DNA-polymerase activity, RNaseH activity, and DNA-dependent DNA-polymerase activity .
19. _____ Has three separate active sites on its single polypeptide chain: polymerase, 3'-exonuclease, and 5'-exonuclease.
20. _____ Degrades the template genomic RNA and the RNA primer during viral replication.

C. True or False. Circle the correct answer. (1 point each, 25 points total.)

1. T F The linear sequence of nucleotides in a messenger RNA specifies the linear sequence of amino acids in a protein.
2. T F The "nick translation" activity of *E. coli* DNA polymerase I appears to have a DNA repair function, and does not result in net synthesis of new DNA.
3. T F A typical promoter region of an *E. coli* protein-coding gene contains a "Pribnow box" and a "-35 region".
4. T F In the "standard" genetic code, 61 of the 64 codons specify amino acids.
5. T F In the "standard" genetic code, the amino acids arginine, leucine, and cysteine each have six codons.
6. T F About 10% of the bases in DNA are in their rare tautomeric forms at any time.
7. T F Nitrosoguanidines are chemical mutagens that cause alkylation of bases.
8. T F Codons representing chemically similar amino acids often (but not always) differ by single nucleotide substitutions.
9. T F You have printed your name at the top of each page and the last four digits of your social security number on the back of the last page.
10. T F Transitions are the most common type of point mutation caused by chemical mutagens.
11. T F If damaged, both DNA and RNA molecules are repaired by eukaryotic cells.
12. T F During polyacrylamide gel electrophoresis of DNA sequencing reactions, DNA molecules differing in length by a single nucleotide can be resolved.
13. T F The base-specific chemical cleavage method of DNA sequencing is known as the "Maximum Gilbert" method (so named after its inventor, Walter Gilbert).
14. T F The accuracy of transcription is quite high, with the wrong nucleotide being incorporated only about once every $1/10^2$ polymerization reactions.
15. T F Microsatellites are short repeat sequences (of about 2 to 5 base pairs) in DNA that mutate at a high frequency.
16. T F DNA sequencing methods use tiny amounts of DNA, therefore quite sensitive methods of detection are needed to "visualize" the DNA sequences.
17. T F HIV reverse transcriptase has a high error rate, causing the virus to mutate rapidly.
18. T F In *E. coli*, replication of the genomic DNA requires at least 15 proteins, some of which have several subunits.
19. T F Most eukaryotic cells have several different DNA polymerases in the nucleus, as well as a separate one in the mitochondria.
20. T F Mutations in somatic cell DNA are not heritable, but may lead to cancer.
21. T F James Watson and Francis Crick published the first (correct) prediction of the structure of DNA in the journal *Nature* in 1953.
22. T F Base analogs that become incorporated into DNA can induce mutations through changes in base-pairing possibilities.
23. T F The degree to which an enzyme remains associated with template during successive rounds of polymerization is referred to as its "associativity".
24. T F The Klenow fragment of *E. coli* DNA polymerase I is used in the laboratory to radioactively label DNA for experimental purposes.
25. T F During RNA tumor virus replication, the primer is a specific cellular tRNA.

- D. Draw a simplified structure of a generic tRNA molecule, explaining how it is involved in accurate translation. (You do not need to include information about any specific aminoacyl-tRNA synthetase and its cognate tRNA.) (5 points)
- E. Draw a thymine dimer. Briefly explain how this DNA lesion is formed and repaired in cells. (5 points):

- F. Describe the first three stages of transcription (through elongation, but not termination) in prokaryotes, illustrating with diagrams. Include a description of the 3-D structure of RNA polymerase, and how it is involved in this process. You may write on two pages, but please be succinct. (4 points for each stage, plus 3 points for RNA polymerase structure; 15 points total)

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Continuation page for question F:

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- G. All DNA polymerases discovered to date, whether from prokaryotes or eukaryotes, share several fundamental properties. List these properties, including a brief explanation. [One of these should be the enzymatic reaction (*i.e.*, chain elongation) catalyzed by DNA polymerases; include a drawing of this reaction mechanism.] You may continue on the top of the next page. (20 points)

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Continuation for question G:

- H. Explain how the drug AZT works to stop HIV from replicating. For full credit, include the structure of this drug. (5 points)