

# Bio 102 Practice Problems

## Chromosomes and DNA Replication

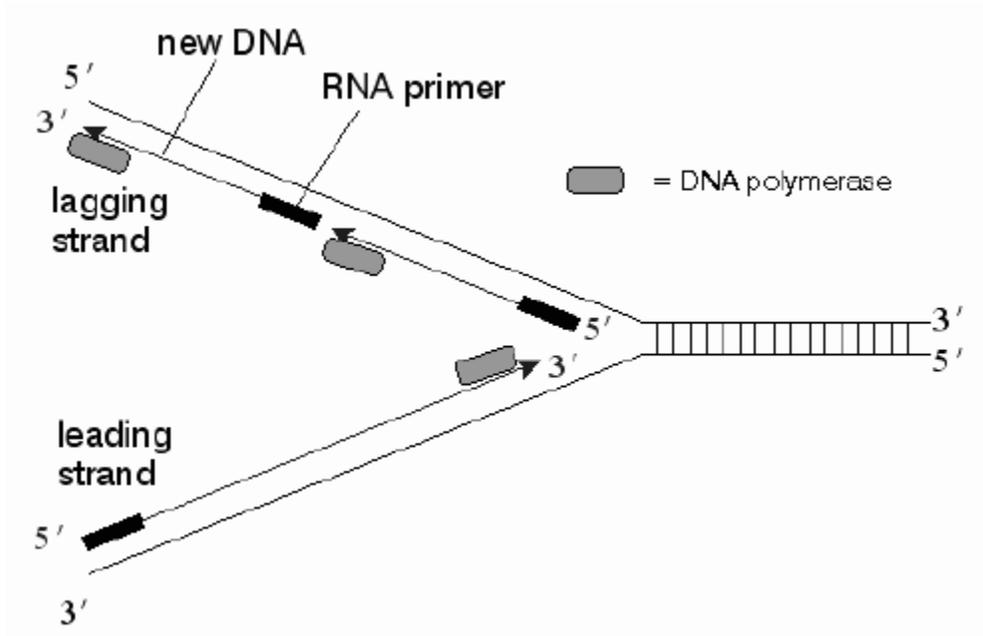
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**Multiple choice: Unless otherwise directed, circle the one best answer:**

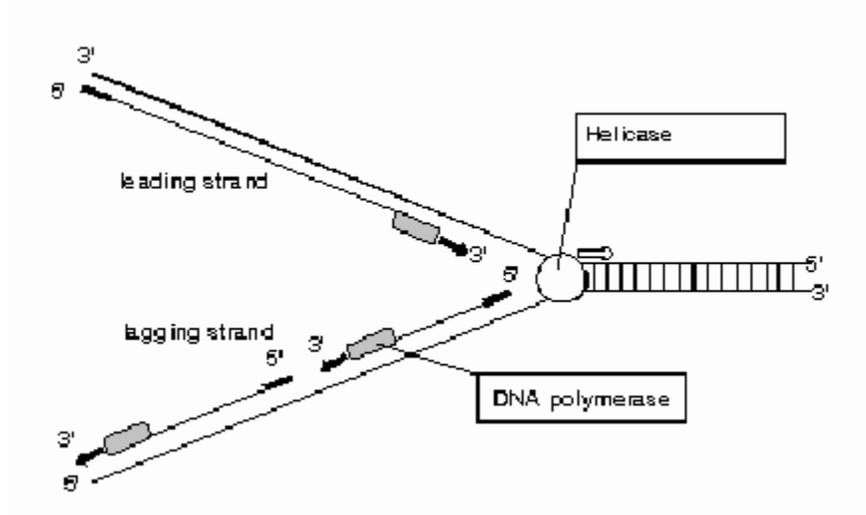
- Which one of the following enzymes is NOT a key player in the process of DNA replication?
  - Topoisomerase
  - Helicase
  - Primase
  - DNA polymerase
  - RNA polymerase
  - Ligase
- Gyrase (or topoisomerase):
  - Separates the DNA strands at the origin
  - Keeps the single-stranded DNA regions from coming back together
  - Re-coils the DNA into a helix after replication is complete
  - Breaks and rejoins the DNA backbone to remove tension produced by the helicase
  - Breaks hydrogen bonds between DNA and the RNA primers
- The enzyme that removes RNA primers during DNA replication is:
  - RNA polymerase I
  - RNA polymerase II
  - RNA polymerase III
  - DNA polymerase I
  - DNA polymerase III
- All of the following are enzymes that participate in DNA replication EXCEPT:
  - RNA primer
  - Helicase
  - DNA polymerase III
  - DNA polymerase I
  - Ligase

**Short answer (show your work or thinking to get partial credit):**

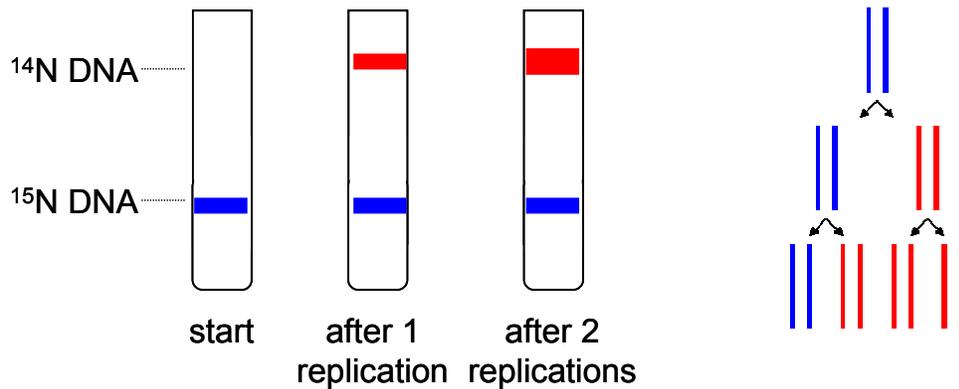
- Below is a replication fork (one side of an origin): a double-stranded DNA partially opened up to provide single-stranded regions where replication can occur. Draw and label the following: RNA primers (label 3' and 5' ends), leading-strand DNA polymerase and new DNA (label 3' and 5' ends and show direction of synthesis with an arrow), 2 lagging-strand DNA polymerases and new DNA (label ends and show direction of synthesis).



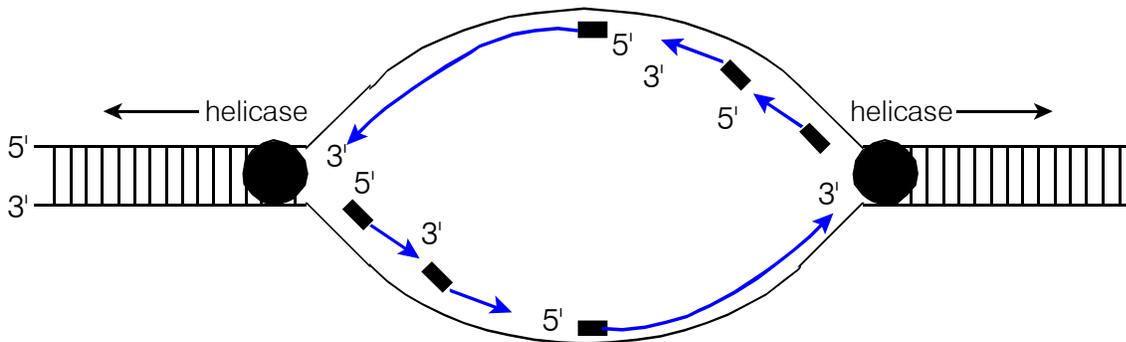
- Below is a drawing of a replication fork. (1) Label the 3' and 5' ends of each nucleic acid strand shown. (2) Label the leading and lagging strands. (3) Two enzymes are shown in the drawing: one represented by a rounded rectangle and one by a white circle. Place the names of these enzymes in the boxes provided.



3. You have just isolated the first bacterium from Mars. It has DNA much like earthly organisms, but replicates its DNA conservatively, instead of semiconservatively. Show the DNA bands you would expect to see if you carried out the Meselson-Stahl experiment for this organism. Remember, it will initially be grown on  $^{15}\text{N}$  and then switched to  $^{14}\text{N}$ .



4. The drawing below shows an origin of DNA replication. Show how the new strands would be synthesized, using rectangles to represent RNA primers and arrows to represent new DNA being made. Label your 3' and 5' ends.



5. Shown below are two DNA molecules that are partially single-stranded and partially double-stranded. We put these two DNA molecules in a test tube with DNA polymerase and nucleotides and allow a little time for a reaction to happen.



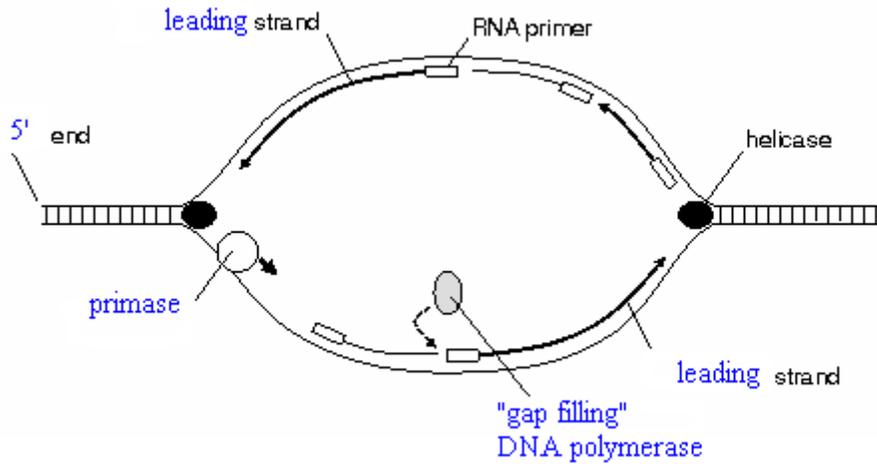
If a reaction happens, add bases to the above molecule(s) to show the product(s). If no reaction will happen, explain why not.

DNA polymerase requires a single-stranded template, a primer and nucleotides and can only add nucleotides to an existing 3' end.

In the left molecule, there are two 3' ends that DNA polymerase could add to by reading the single-stranded segments. So DNA polymerase could add nucleotides until it reached the end of the template, as shown in blue above.

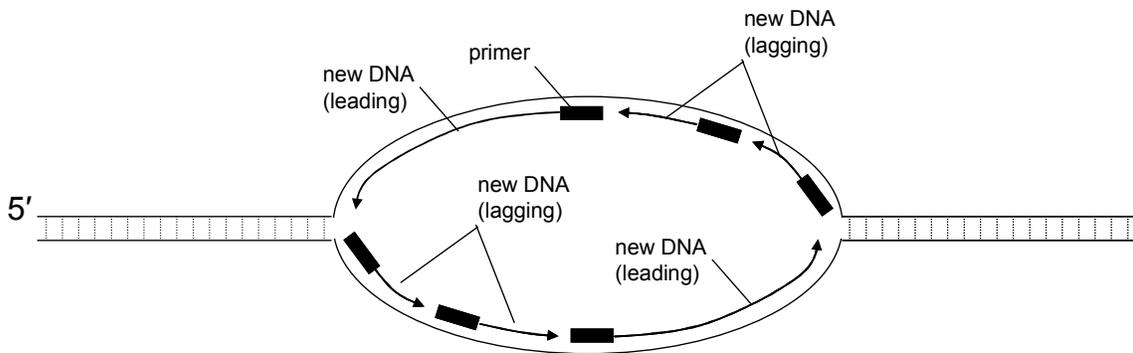
In the right molecule, there are 3' ends but no template next to them, so DNA polymerase can do nothing.

6. The diagram below shows a DNA molecule in the process of replication. Arrows show the direction of new DNA synthesis.

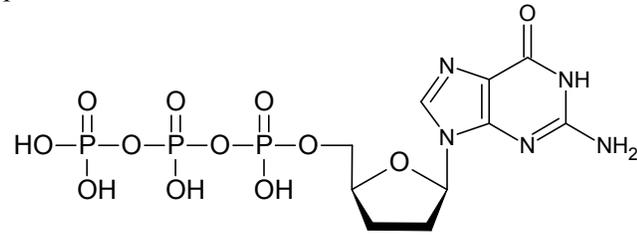


- Some of the enzymes and features are labeled, but some labels are incomplete or have been omitted. Fill in the boxes with the appropriate labels.
- What enzyme that is not shown in the picture is necessary in order for the helicases to keep moving forward and unwinding the DNA? [topoisomerase](#)

7. A replication bubble is shown below. Assume that DNA replication is occurring in this area, but RNA primers have not yet been removed. Draw and label the RNA primers and the new DNA strands that have been synthesized. Use arrows to show the direction of synthesis for the new DNA strands. Label the leading and lagging strands.



8. Below is the structure of a dideoxy nucleotide, which as you can see resembles a normal DNA nucleotide except that it has no  $-OH$  group on its 3' carbon.



- a. Is this dideoxy nucleotide a purine or a pyrimidine? How do you know? (2 points)  
Purine (two-ring structure of base)
- b. Assuming that it would base-pair correctly, could DNA polymerase add this nucleotide to a DNA strand that it was synthesizing during DNA replication? Explain. (2 points)  
Yes. It has three phosphates on its 5' end, which is all that DNA polymerase needs to attach it to the 3' end of another nucleotide.
- c. If DNA polymerase did add this nucleotide to a new DNA strand, could it then add another nucleotide onto the chain? Explain. (2 points)  
No. DNA polymerase can only attach a new nucleotide to a 3' OH on an existing chain, and since there's no 3' OH here, nothing can be added to it. This would stop synthesis.

**True or False? Read carefully: a question is false unless it is completely true!**

- T**  **F**  1. Meselson and Stahl provided experimental evidence supporting the idea that DNA replicates semiconservatively, with each strand serving as the template for synthesis of a new strand.
- T**  **F**  2. DNA polymerase cannot start synthesis without a primer; because of this limitation, a cell's DNA actually contains some short stretches of RNA.
- T**  **F**  3. Watson and Crick's DNA structure was especially convincing because it immediately suggested a hypothesis for how a nucleotide sequence could be translated into protein.
- T**  **F**  4. The DNA strand that is referred to as the lagging strand on one side of the replication "bubble" will be the leading strand on the other side of the bubble.

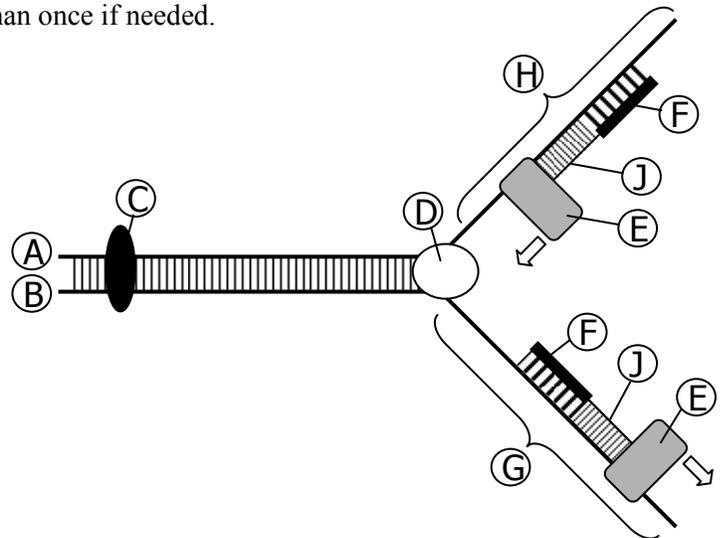
**Matching:**

1. Match the enzymes on the right with their roles in DNA replication on the left.

- |                                                                                                               |                   |
|---------------------------------------------------------------------------------------------------------------|-------------------|
| <u>  </u> <b>B</b> Can only add nucleotides to an existing 3' OH end                                          | a. Ligase         |
| <u>  </u> <b>E</b> Actually a specialized form of RNA polymerase                                              | b. DNA polymerase |
| <u>  </u> <b>A</b> Can't add nucleotides to a chain, but can make covalent bonds between adjacent nucleotides | c. Phosphatase    |
| <u>  </u> <b>D</b> Disrupts hydrogen bonds between DNA bases                                                  | d. Helicase       |
|                                                                                                               | e. Primase        |

2. Match each statement below with the appropriate letter from the replication fork diagram on the right. One letter per blank, but you may use the letters more than once if needed.

- |                                                                        |
|------------------------------------------------------------------------|
| <u>  </u> <b>F</b> Removed by DNA polymerase                           |
| <u>  </u> <b>A</b> 5' end of template DNA                              |
| <u>  </u> <b>D</b> Activity of this enzyme creates supercoils          |
| <u>  </u> <b>G</b> Lagging strand                                      |
| <u>  </u> <b>E</b> This enzyme catalyzes phosphodiester bond formation |



3. The chart below lists several enzymes important in DNA replication. Put the numbers in the blanks to indicate the order in which these enzymes work during replication. If an enzyme is not involved in replication, put a zero in its blank.

<u>3</u>	Main DNA polymerase
<u>4</u>	Gap-filling DNA polymerase
<u>2</u>	Primase
<u>1</u>	Helicase
<u>0</u>	RNA polymerase
<u>5</u>	Ligase

**Fill in the blanks:**

Several different enzymes are required in the complex process of DNA replication. The functions of some of these enzymes are described below; fill in each blank with the name of the appropriate enzyme.

1. **DNA ligase** is required to make phosphodiester bonds between two adjacent Okazaki fragments.
2. **Topoisomerase** prevents the “knotted rope” problem by breaking and rejoining DNA strands to remove tension generated by unwinding of the helix.
3. **Helicase** moves outward from the origin and breaks hydrogen bonds between DNA nucleotides.
4. **DNA polymerase** requires both a template and an appropriately placed 3' end to synthesize a nucleic acid.
5. **Primase** is the first enzyme to synthesize a nucleic acid at a replication fork.