

## **BIOS 390 - Molecular Biology Week 2 Quiz Study Guide**

### **Question Set 1**

(TCO 3) DNA replication is said to be semiconservative because

Each daughter DNA molecule consists of one strand from the parent DNA molecule and one new strand.

(TCO 3) DNA synthesis occurs in

The 5' to 3' direction.

(TCO 3) Which of the following statements is correct?

The growth and development or healing of wound in an organism require new cells. The new cells in organism come from division of preexisting cells. DNA is the material in body which has all structural and functional information for body. Therefore each cell needs a full instruction in the form of DNA to work properly. So before cell division the DNA need to be replicate into two and transfer to new cell as a source of information.

The DNA replication occur before cell division in S-phase of cell cycle. The DNA replication occur in nucleus of eukaryotic cell while prokaryotic cells do not have nucleus and their cell division occur in cytoplasm.

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### **Question Set 2**

(TCO 3) During DNA replication, DNA ligase is most active on the lagging strand.

This is because

The lagging strands contain more short DNA segments than the leading strand, and these short segments are ligated together with DNA ligase

(TCO 3) Phosphodiester bonds are formed between adjacent Okazaki fragments by

DNA ligase. DNA polymerase is the enzyme that carries in the daughter nucleotides, and DNA helicase is the one that unwinds the double helix to open the replication fork.

(TCO 3) Which of the following activities are unique for DNA polymerase I?

DNA polymerase I has 2 enzymatic function.

1. Polymerase activity

5' to 3' DNA dependent and RNA dependent polymerization.

## 2. Exonuclease activity

5' to 3' exonuclease during nick translation

3' to 5' exonuclease in proof reading.

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### Question Set 3

(TCO 3) Once bound to an origin of replication, the origin replication complex (ORC) recruits

The first proteins to bind the DNA are said to “recruit” the other proteins. Two copies of an enzyme called helicase are among the proteins recruited to the origin. Each helicase unwinds and separates the DNA helix into single-stranded DNA. As the DNA opens up, Y-shaped structures called replication forks are formed.

(TCO 3) Positive supercoils ahead of the replication fork are resolved by DNA gyrase.

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### Question Set 4

(TCO 3) Replication licensing ensures that

Control of DNA replication licensing in a cell cycle. To maintain genome integrity in eukaryotes, DNA must be duplicated precisely once before cell division occurs. A process called replication licensing ensures that chromosomes are replicated only once per cell cycle.

(TCO 3) Pre-replication complex assembly

- a. Assembly of the pre-replication complex only occurs when cyclin-dependent kinase (CDK) activity is low during late M phase and early G1 phase of the cell cycle. Assembly of pre-initiation complex, on origin recognition is facilitated by Dna A (a protein that activates initiation of replication) in prokaryotes or OriC in eukaryotes. Cyclin dependent kinase are the kinase proteins which are involved in the regulation of cell cycle (regulating transcription and mRNA processing). Whereas high cyclin-dependent kinase (CDK) activity, inhibits (regulates) the replication.

(TCO 3) Find the incorrect statement. (Describe the replication processes.)

DNA replication starts with the enzyme gyrase (topoisomerase) which acts on the DNA molecule by removing the negative super coiling of the molecule. Once the negative super coiling is done, the enzyme helicase acts on DNA thus separating the double stranded molecule thereby enabling the DNA polymerase to attach and start its polymerization effect.

The double stranded DNA molecule is separated by an enzyme polymerase which initiates polymerization reaction by adding nucleotides to the already attached primer (small DNA fragment). The DNA polymerase acts on the nucleotides in the 3' end of the newly growing strand. DNA polymerase acts in the 5'-3' direction. This enzyme adds nucleotides towards 5'-3' in the leading strand. The replication fork moves throughout the length of the DNA molecule by the synthesis of the DNA fragments which are dis-continuous and termed as okazaki fragments. The discontinuous okazaki fragments would be joined by the action of ligase enzyme.

Thus once the replication fork traverses throughout the DNA molecule two copies of the genetic material would be formed.

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### Question Set 5

(TCO 3) Nucleotide selectivity and proofreading by DNA polymerase depends on

When an incorrect base pair is recognized, DNA polymerase reverses its direction by one base pair of DNA and excises the mismatched base. ... In eukaryotes only the polymerases that deal with the elongation (delta and epsilon) have proofreading ability (3' → 5' exonuclease activity).

(TCO 3) Chromatin assembly factor 1 (CAF-1) is thought to aid replication by

Chromatin assembly factors facilitate the process of depositing nucleosomes on daughter DNAs. CAF-I free H3H4 tetramers and then is recruited to newly replicated DNA by interactions with DNA sliding clamps. These sliding clamps (PCNA) are ring-shaped replication factors that encircle the DNA. It is released from the replication machinery as the replication fork moves. NAP-I free H2AH2B dimers.

(TCO 3) Telomerase is a ribonucleoprotein complex. The RNA component of the complex

Telomerase RNA component, also known as TERC, is an ncRNA found in eukaryotes, that is a component of telomerase - The enzyme used to extend telomeres. TERC serves as a template for telomere replication (reverse transcription) by telomerase.

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### Question Set 6

(TCO 4) A nonsense mutation is one in which the mutant protein is shorter than normal.

**Non-sense Mutation-** It is a point mutation (single nucleotide substitution) that generates an additional (other than the one naturally present in the wild type transcript) stop codon in the mRNA transcript. As a result, the process of translation terminates at the new stop codon, giving a partially synthesized polypeptide. Due to premature termination, the length of the mutated polypeptide is also smaller than the wild type normal protein.

(TCO 4) A silent mutation is one in which the amino acid sequence is not altered. A silent mutation is a point mutation that doesn't lead to an amino acid change in the protein product.

(TCO 4) A missense mutation is one in which A missense mutation is a type of a point mutation. In missense mutation, a single nucleotides changes in a codon which codes for different amino acid during translation and form a non-functional protein. It is a nonsynonymous type of substitution. Missense mutation causes epidermolysis bullosa, sickle-cell disease, and SOD1 mediated ALS.

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### Question Set 7

(TCO 4) Which statement is not true about the deamination of cytosine? (Describe the deamination of cytosine.)

Deamination describes the loss of an amine group from a molecule (replaced by a carbonyl group). Cytosine can spontaneously turn into uracil, through a process called hydrolytic deamination. When this happens, the guanine that was initially bound to that cytosine molecule is left opposite uracil instead (remember that uracil normally binds to adenine). When the cell next replicates its DNA, the position opposite this uracil molecule would be taken up by an adenine instead of the guanine that should be there, altering the message that this section of DNA encodes. This process of cytosine deamination is one of the most common types of DNA damage, but is normally corrected effectively.

(TCO 4) The most frequent ultraviolet (UV) light-induced lesions of DNA are

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### Question Set 8

(TCO 4) In human cells, pyrimidine dimers can be repaired by Photoreactivation which is a photochemical repair process induced by photolyase enzymes, acts as the repair system in human cells.

(TCO 4) In humans DNA, replication errors are repaired by

(TCO 4) In humans, double strand DNA damage is repaired by

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### Question Set 9

(TCO 4) Translesion synthesis is mediated by

(TCO 4) In the mismatch repair pathway, DNA damage is recognized by

(TCO 4) Base excision repair is initiated by

The base excision repair pathway is an organism's primary defense against mutations induced by oxidative, alkylating, and other DNA-damaging agents. This pathway is initiated by DNA glycosylases that excise the damaged base by cleavage of the glycosidic bond between the base and the DNA sugar-phosphate backbone.

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### Question Set 10

(TCO 3) Outline the steps of nuclear chromosome replication in eukaryotes, starting from origin firing and ending with telomere replication.

(TCO 3) Define the term “replication licensing” and its importance in DNA replication. Explain how this is achieved in a cell.

(TCO 3) Describe the “end replication problem.” Discuss the role of telomeres as a solution to the end replication problem and also in aging of a cell.

Each time a cell divides, 25-200 bases are lost from the ends of the telomeres on each chromosomes.

Two main factors contribute to telomere shortening during cell division.

1. The “end replication problem during DNA replication accounts for the loss of about 20 base pairs per cell division.

2. Oxidative stress accounts for the loss of between 50-100 base pair per cell division. The amount of oxidative stress in the body is thought to be affected by lifestyle factors such as diet, smoking and stress.

When the telomere becomes too short, the chromosome reaches a 'critical length' and can no longer be replicated.

Telomeres play 3 major purposes:

1. They help to organize each of our 46 chromosomes in the nucleus of our cells.

2. They protect the ends of chromosomes by forming a cap, much like the plastic tip on shoelaces. If the telomeres were not there, chromosomes may end up sticking to other chromosomes.

3. They allow the chromosomes to be replicated properly during cell division.

An older cell will necessarily have shorter telomeres than a younger one.

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### Question Set 11

(TCO 3) Why do humans need telomeres and bacteria don't?

Most of the bacterial chromosomes are circular and therefore they do not face the end replication problem and their ends do not suffer the problem of premature termination of replication.

But the eukaryotic chromosomes are linear and the DNA replication enzymes are unable to replicate the sequences present at the ends of the chromosomes and if these end sequences are not replicated then the information carried by them may get lost. Telomerase enzymes solves this end replication problem in eukaryotes and protect the terminal ends of the chromosomes.

(TCO 3) Describe an example of "polymerase switching."

(TCO 3) Why are RNA primers required during DNA replication?

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### Question Set 12

(TCO 3) Compare and contrast the three major classes of DNA damage.

1. single base changes - or "conversion," affects the DNA sequence but has only a minor effect on overall structure.
2. structural distortion - Structural distortion may impede transcription and replication by blocking the movement of polymerases.
3. DNA backbone damage - includes the formation of abasic sites—loss of the nitrogenous base from a nucleotide—and double-strand DNA breaks.

(TCO 3) Describe the process of translesion synthesis and explain why it is not truly a repair system.

(TCO 3) What two enzymes catalyze direct reversal of DNA damage? Briefly explain the mechanisms they use. Are both repair pathways present in human cells?

**DNA photolyase and DNA methyltransferase.**

During photoreactivation, the enzyme DNA photolyase uses energy from near-UV to blue light to break the covalent bonds holding the two adjacent pyrimidines together. Structural studies have revealed that DNA photolyases are globular proteins with two buried cofactors. One of these cofactors is a pigment that absorbs blue/near-UV light; the other is flavin adenine dinucleotide in its fully reduced state (FADH<sup>-</sup>). Photolyases are considered one of the most ancient and efficient means of repairing UV-damaged DNA. Surprisingly, however, placental mammals, including humans, do not have a photoreactivation pathway. Unlike the DNA photolyases, methyltransferases are present in all organisms ranging from *E. coli* to humans. These highly selective enzymes catalyze removal of the methyl group from the damaged guanine. The enzyme binds to the minor groove of the DNA double helix. Upon binding of the enzyme, the minor groove widens and the DNA bends approximately 15° away from the protein. This change in the structure of the double helix allows the damaged nucleotide to flip out from the major groove into the active site. A sulfhydryl group of a cysteine residue in the active site then accepts the methyl group from guanine. Although a very effective process, repair comes with a cost. Once the methyltransferase accepts the methyl group from guanine, the enzyme cannot be used again.

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### Question Set 13

(TCO 4) Give example of a single base change and suggest how that change, if not repaired, will be detrimental to the host.

(TCO 4) Of the three classes of DNA damage, which is the most detrimental, and why?

Double-strand breaks can be induced by ionizing radiation (e.g. X-rays, radioactive materials) and a wide range of chemical compounds. Ionizing radiation can attack the deoxyribose sugar in the DNA backbone directly or indirectly by generating reactive oxygen species. Since both strands of the DNA are disrupted, double-strand breaks are considered the most severe type of DNA damage.

(TCO 4) How can a point mutation have a range of effects—from being undetected to very fatal