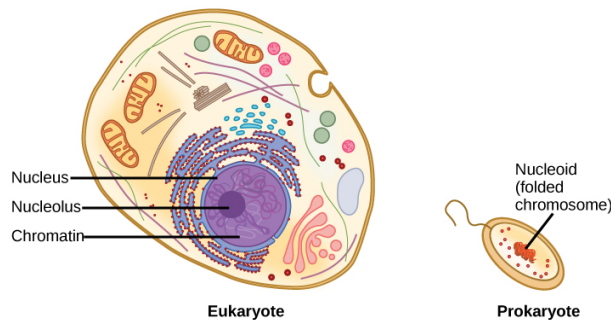


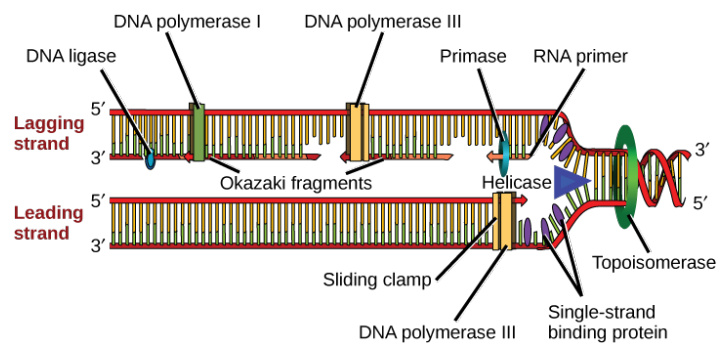
**Biology 2e**Unit 3: **Genetics**Chapter 14: **DNA Structure and Function****Visual Connection Questions**

1. In eukaryotic cells, DNA and RNA synthesis occur in a separate compartment from protein synthesis. In prokaryotic cells, both processes occur together. What advantages might there be to separating the processes? What advantages might there be to having them occur together?



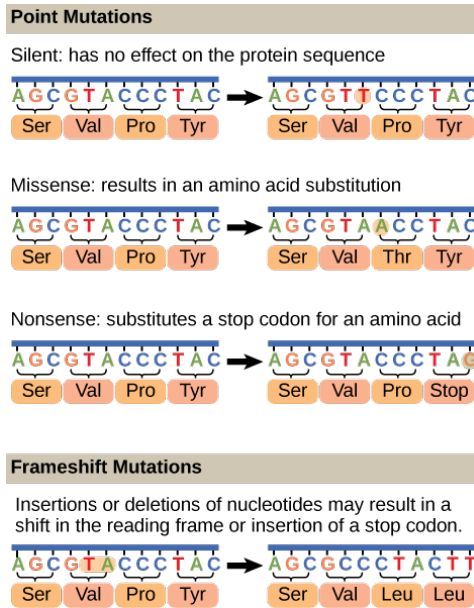
Compartmentalization enables a eukaryotic cell to divide processes into discrete steps so it can build more complex protein and RNA products. But there is an advantage to having a single compartment as well: RNA and protein synthesis occurs much more quickly in a prokaryotic cell.

2. You isolate a cell strain in which the joining together of Okazaki fragments is impaired and suspect that a mutation has occurred in an enzyme found at the replication fork. Which enzyme is most likely to be mutated?



DNA ligase, as this enzyme joins together Okazaki fragments.

3. A frameshift mutation that results in the insertion of three nucleotides is often less deleterious than a mutation that results in the insertion of one nucleotide. Why?



If three nucleotides are added, one additional amino acid will be incorporated into the protein chain, but the reading frame won't shift.

## Review Questions

4. If DNA of a particular species was analyzed and it was found that it contains 27 percent A, what would be the percentage of C?

c. 23 percent

5. The experiments by Hershey and Chase helped confirm that DNA was the hereditary material on the basis of the finding that:

d. radioactive phosphorus was found in the cell

6. Bacterial transformation is a major concern in many medical settings. Why might health care providers be concerned?

d. All of the above.

7. DNA double helix does not have which of the following?

d. uracil

8. In eukaryotes, what is the DNA wrapped around?

d. histones

9. Meselson and Stahl's experiments proved that DNA replicates by which mode?

b. semi-conservative

**10.** If the sequence of the 5'-3' strand is AATGCTAC, then the complementary sequence has the following sequence:

c. 3'-TTACGATG-5'

**11.** How did Meselson and Stahl support Watson and Crick's double-helix model?

a. They demonstrated that each strand serves as a template for synthesizing a new strand of DNA.

**12.** Which of the following components is not involved during the formation of the replication fork?

d. ligase

**13.** Which of the following does the enzyme primase synthesize?

b. RNA primer

**14.** In which direction does DNA replication take place?

a. 5'-3'

**15.** A scientist randomly mutates the DNA of a bacterium. She then sequences the bacterium's daughter cells, and finds that the daughters have many errors in their replicated DNA. The parent bacterium likely acquired a mutation in which enzyme?

b. DNA pol II

**16.** The ends of the linear chromosomes are maintained by

d. telomerase

**17.** Which of the following is not a true statement comparing prokaryotic and eukaryotic DNA replication?

c. DNA replication always occurs in the nucleus.

**18.** During proofreading, which of the following enzymes reads the DNA?

c. DNA pol

**19.** The initial mechanism for repairing nucleotide errors in DNA is \_\_\_\_\_.

b. DNA polymerase proofreading

**20.** A scientist creates fruit fly larvae with a mutation that eliminates the exonuclease function of DNA pol. Which prediction about the mutational load in the adult fruit flies is most likely to be correct?

b. The adults with the DNA pol mutation will have slightly more mutations than average.

**Critical Thinking Questions**

**21.** Explain Griffith's transformation experiments. What did he conclude from them?

Live R cells acquired genetic information from the heat-killed S cells that “transformed” the R cells into S cells.

**22.** Why were radioactive sulfur and phosphorous used to label bacteriophage in Hershey and Chase's experiments?

Sulfur is an element found in proteins and phosphorus is a component of nucleic acids.

**23.** When Chargaff was performing his experiments, the tetranucleotide hypothesis, which stated that DNA was composed of GACT nucleotide repeats, was the most widely accepted view of DNA's composition. How did Chargaff disprove this hypothesis?

If the tetranucleotide hypothesis were true, then DNA would have to contain equal amounts of all four nucleotides (A=T=G=C). However, Chargaff demonstrated that A=T and G=C, but that the four nucleotides are not present in equal amounts.

**24.** Provide a brief summary of the Sanger sequencing method.

The template DNA strand is mixed with a DNA polymerase, a primer, the 4 deoxynucleotides, and a limiting concentration of 4 dideoxynucleotides. DNA polymerase synthesizes a strand complementary to the template. Incorporation of ddNTPs at different locations results in DNA fragments that have terminated at every possible base in the template. These fragments are separated by gel electrophoresis and visualized by a laser detector to determine the sequence of bases.

**25.** Describe the structure and complementary base pairing of DNA.

DNA has two strands in anti-parallel orientation. The sugar-phosphate linkages form a backbone on the outside, and the bases are paired on the inside: A with T, and G with C, like rungs on a spiral ladder

**26.** Prokaryotes have a single circular chromosome while eukaryotes have linear chromosomes. Describe one advantage and one disadvantage to the eukaryotic genome packaging compared to the prokaryotes.

Advantage: The linear arrangement of the eukaryotic chromosome allows more DNA to be packed by tightly winding it around histones. More genetic material means that the organism can encode more information into a single cell. This eventually allowed some eukaryotes to develop into multicellular organisms with cell specialization.

Disadvantage: Maintaining more genetic material requires more energy, and introduces the possibility for more errors (more complexity).

**27.** How did the scientific community learn that DNA replication takes place in a semi-conservative fashion?

Meselson's experiments with *E. coli* grown in  $^{15}\text{N}$  deduced this finding.

**28.** Imagine the Meselson and Stahl experiments had supported conservative replication instead of semi-conservative replication. What results would you predict to observe after two rounds of replication? Be specific regarding percent distributions of DNA incorporating  $^{15}\text{N}$  and  $^{14}\text{N}$  in the gradient.

Following two rounds of conservative replication, two bands would be detected after ultracentrifugation. A lower (heavier) band would be at the  $^{15}\text{N}$  density, and would comprise 25% of the total DNA. A second, higher (lighter) band would be at the  $^{14}\text{N}$  density, and would contain 75% of the total DNA.

**29.** DNA replication is bidirectional and discontinuous; explain your understanding of those concepts.

At an origin of replication, two replication forks are formed that are extended in two directions. On the lagging strand, Okazaki fragments are formed in a discontinuous manner.

**30.** What are Okazaki fragments and how they are formed?

Short DNA fragments are formed on the lagging strand synthesized in a direction away from the replication fork. These are synthesized by DNA pol.

**31.** If the rate of replication in a particular prokaryote is 900 nucleotides per second, how long would it take 1.2 million base pair genomes to make two copies?

1333 seconds or 22.2 minutes.

**32.** Explain the events taking place at the replication fork. If the gene for helicase is mutated, what part of replication will be affected?

At the replication fork, the events taking place are helicase action, binding of single-strand binding proteins, primer synthesis, and synthesis of new strands. If there is a mutated helicase gene, the replication fork will not be extended.

**33.** What is the role of a primer in DNA replication? What would happen if you forgot to add a primer in a tube containing the reaction mix for a DNA sequencing reaction?

Primer provides a 3'-OH group for DNA pol to start adding nucleotides. There would be no reaction in the tube without a primer, and no bands would be visible on the electrophoresis.

**34.** Quinolone antibiotics treat bacterial infections by blocking the activity of topoisomerase. Why does this treatment work? Explain what occurs at the molecular level.

Bacteria treated with quinolones will no longer be able to replicate their DNA. Topoisomerase relieves the excess DNA supercoiling that occurs ahead of the replication fork as DNA is unwound for replication. If topoisomerase is inhibited, DNA helicase will only be able to unwind the DNA for a short stretch before the supercoiling becomes too overwound for replication to continue.

**35.** How do the linear chromosomes in eukaryotes ensure that its ends are replicated completely?

Telomerase has an inbuilt RNA template that extends the 3' end, so primer is synthesized and extended. Thus, the ends are protected.

**36.** What is the consequence of mutation of a mismatch repair enzyme? How will this affect the function of a gene?

Mutations are not repaired, as in the case of xeroderma pigmentosa. Gene function may be affected or it may not be expressed.

**37.** An adult with a history of tanning has his genome sequenced. The beginning of a protein-coding region of his DNA reads ATGGGGATATGGCAT. If the protein-coding region of a healthy adult reads ATGGGGATATGAGCAT, identify the site and type of mutation.

This is a frameshift mutation with a deletion of an "A" in the 12<sup>th</sup> position of the coding region.

Patient:           ATGGGGATATGGCAT

Normal:           ATGGGGATATGAGCAT