

# CHAPTER 19

## THE ORGANIZATION AND CONTROL OF EUKARYOTIC GENOMES

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### I. Introduction

- A. Gene expression in eukaryotes has two main differences from the same process in prokaryotes.
  - 1. First, the typical multicellular eukaryotic genome is much larger than that of a bacterium.
  - 2. Second, cell specialization limits the expression of many genes to specific cells.
- B. The estimated 35,000 genes in the human genome includes an enormous amount of DNA that does not program the synthesis of RNA or protein.
- C. This DNA is elaborately organized.
  - 1. Not only is the DNA associated with protein to form chromatin, but the chromatin is organized into higher organizational levels.
- D. Level of packing is one way that gene expression is regulated.
  - 1. Densely packed areas are inactivated.
  - 2. Loosely packed areas are being actively transcribed.

### II. Eukaryotic Chromatin Structure

- A. Chromatin structure is based on successive levels of DNA packing.
  - 1. While the single circular chromosome of bacteria is coiled and looped in a complex, but orderly manner, eukaryotic chromatin is far more complex.
  - 2. Eukaryotic DNA is precisely combined with large amounts of protein.
  - 3. During interphase of the cell cycle, chromatin fibers are usually highly extended within the nucleus.
  - 4. Eukaryotic chromosomes contain an enormous amount of DNA relative to their condensed length.
    - a) Each human chromosome averages about  $2 \times 10^8$  nucleotide pairs.
    - b) If extended, each DNA molecule would be about 6 cm long, thousands of times longer than the cell diameter.
    - c) This chromosome and 45 other human chromosomes fit into the nucleus.
    - d) This occurs through an elaborate, multilevel system of DNA packing.
  - 5. **Histone** proteins are responsible for the first level of DNA packaging.
    - a) Their positively charged amino acids bind tightly to negatively charged DNA.
    - b) The five types of histones are very similar from one eukaryote to another and are even present in bacteria.
  - 6. Unfolded chromatin has the appearance of beads on a string, a **nucleosome**, in which DNA winds around a core of histone proteins.
  - 7. The beaded string seems to remain essentially intact throughout the cell cycle.
  - 8. Histones leave the DNA only transiently during DNA replication.
  - 9. They stay with the DNA during transcription.
    - a) By changing shape and position, nucleosomes allow RNA-synthesizing polymerases to move along the DNA.
  - 10. As chromosomes enter mitosis the beaded string undergoes higher-order packing.
  - 11. The beaded string coils to form the 30-nm *chromatin fiber*.
  - 12. This fiber forms *looped domains* attached to a scaffold of nonhistone proteins.
  - 13. In a mitotic chromosome, the looped domains coil and fold to produce the characteristic metaphase chromosome.
  - 14. These packing steps are highly specific and precise with particular genes located in the same places.

# Modern Biology Chapter 10 Study Guide Answers

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