

CHAPTER 19

THE ORGANIZATION AND CONTROL OF EUKARYOTIC GENOMES

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 2×10^8 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.

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