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 x 10· 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.