**Chapter 24 Genes and Chromosomes**

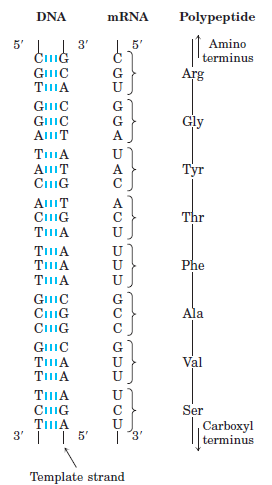
* The size of DNA molecules presents an interesting biological puzzle.
* These molecules are generally much longer than the cells or viral particles.
* How do they fit into their cellular or viral packages?
* Answer is the tertiary packaging of DNA into **chromosomes**.

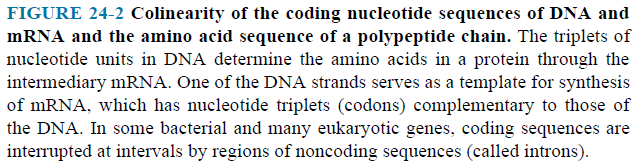
**24.1 Chromosomal Elements**

* There are the different types of DNA sequences and structural elements within chromosomes.

**Genes Are Segments of DNA That Code for Polypeptide Chains and RNAs**

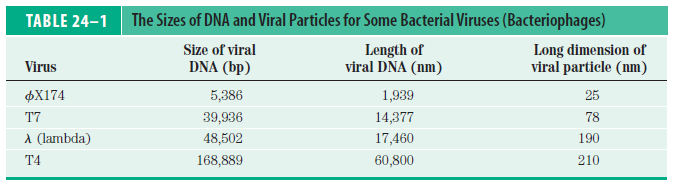
* A **gene** is encodes the primary sequence of some final gene product, which can be either a polypeptide or an RNA with a structural or catalytic function.
* DNA also contains other segments or sequences that have a regulatory function.
* **Regulatory sequences** provide signals that may denote the beginning or the end of genes, or influence the transcription of genes, or function as initiation points for replication or recombination.
* Some genes can be expressed in different ways to generate multiple gene products from a single segment of DNA.
* Each amino acid of a polypeptide chain is coded for by a sequence of three consecutive nucleotides in a single strand of DNA called as **codons (Fig. 24–2)**.



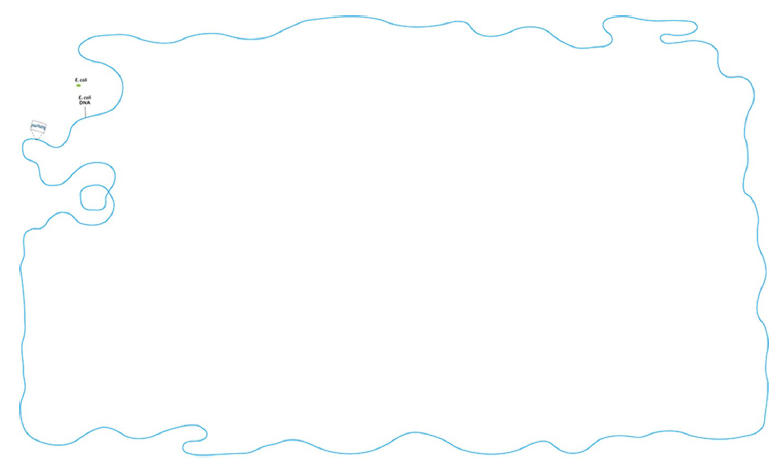


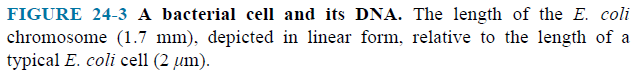
**DNA Molecules Are Much Longer Than the Cellular or Viral Packages That Contain Them**

* The genomes of DNA viruses vary greatly in size **(Table 24–1)**.

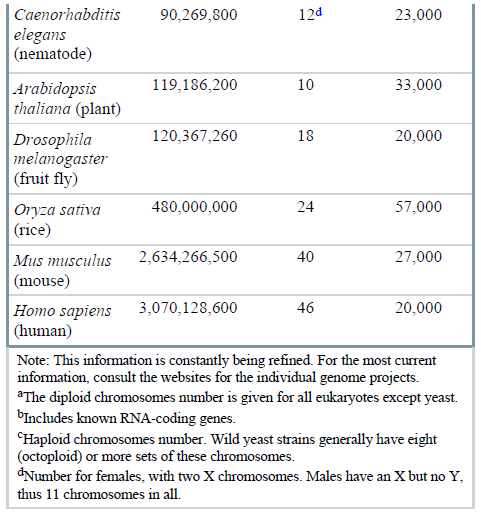
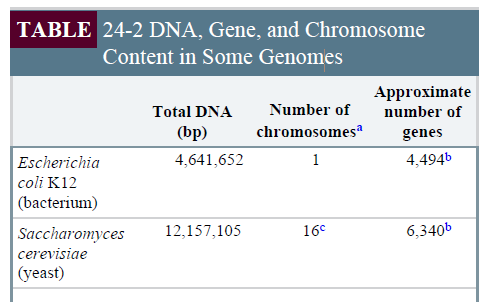


* The chromosome of an *E. coli* cell is a single, double-stranded circular DNA molecule. Its 4,641,652 bp have a contour length of about 1.7 mm, some 850 times the length of the *E. coli* cell **(Fig. 24–3)**.

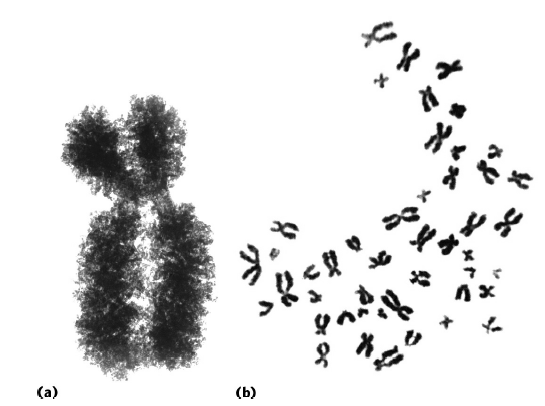


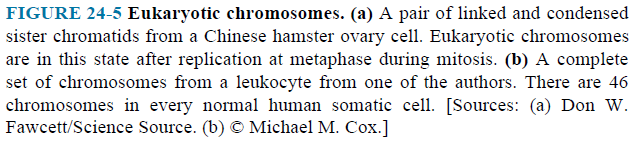


* Each type of chromosome in eukaryotes carries a characteristic set of genes **(Table 24–2)**.



* A human cell has 46 chromosomes **(Fig.24-5)**.

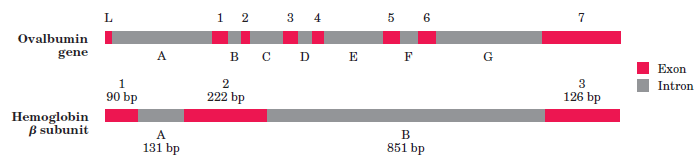


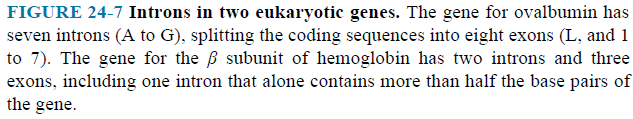


* The DNA molecules in the 24 different types of human chromosomes (22 matching pairs plus the X and Y sex chromosomes) vary in length.
* Most human cells are diploid and each cell contains a total of 2 m of DNA, some 20,000 times the length of the humancell (100 m).
* An adult human body contains approximately 1014 cells and thus a total DNA length of 2 x 1011 km.
* Compare this with the circumference of the earth (4 x 104 km), (5 million times), or the distance between the earth and the sun (1.5 x 108 km), (650 times roundtrip)—a dramatic illustration of the extraordinary degree of DNA compaction in our cells.
* Eukaryotic cells also have organelles (mitochondria and chloroplasts) that contain DNA.
* Mitochondrial DNA (mtDNA) molecules are much smaller than the nuclear chromosomes.
* In animal cells, mtDNA contains fewer than 20,000 bp (16,569 bp in human mtDNA) and is a circular duplex. Plant cell mtDNA ranges in size from 200,000 to 2,500,000 bp.
* Chloroplast DNA (cpDNA) also exists as circular duplexes and ranges in size from 120,000 to 160,000 bp.
* Mitochondrial DNA codes for the mitochondrial tRNAs and rRNAs and for a few mitochondrial proteins. More than 95% of mitochondrial proteins are encoded by nuclear DNA.

**Eukaryotic Genes and Chromosomes Are Very Complex**

* Their nucleotide sequences contain one or more intervening segments of DNA that do not code for the amino acid sequence of the polypeptide product.
* Nontranslated DNA segments in genes are called **intervening sequences** or **introns**, and the coding segments are called **exons**.
* Few bacterial genes contain introns.
* In higher eukaryotes, the typical gene has much more intron sequence than exon sequence **(Fig. 24–7)**.

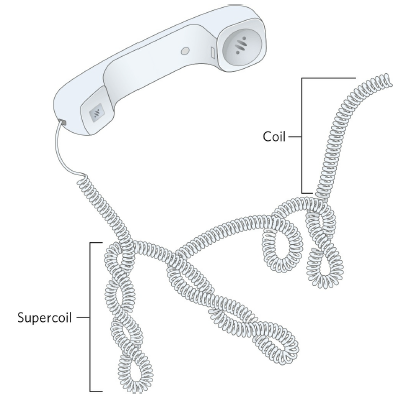


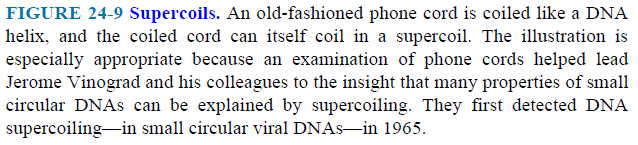


* The function of introns is not clear.
* In total, only about 1.5% of human DNA is “coding” or exon DNA, carrying information for protein or RNA products.

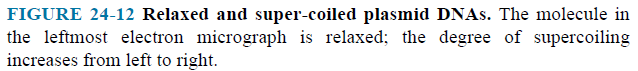
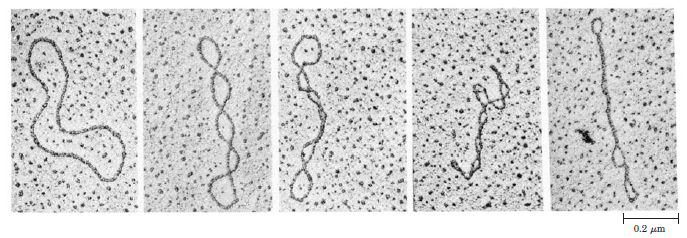
**24.2 DNA Supercoiling**

* Cellular DNA is extremely compacted.
* Supercoiling means the coiling of a coil.
* A typical phone cord is coiled like a DNA helix **(Fig. 24–9)**.

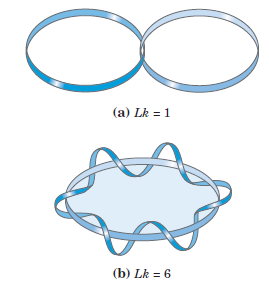


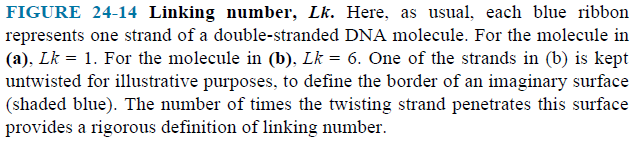


* + The coiled cord can itself coil in a supercoil.
* Replication and transcription of DNA are affected by supercoiling.
  + Both processes require a separation of DNA strands.
* Topological properties are changed only by breakage and rejoining of the backbone of one or both DNA strands.
* Small circular DNA can be relaxed or supercoiled **(Fig. 24–12)**.



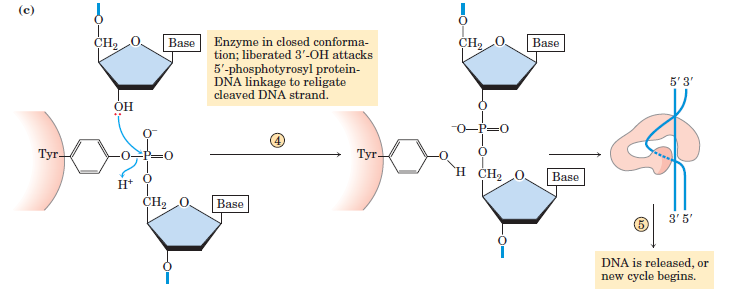
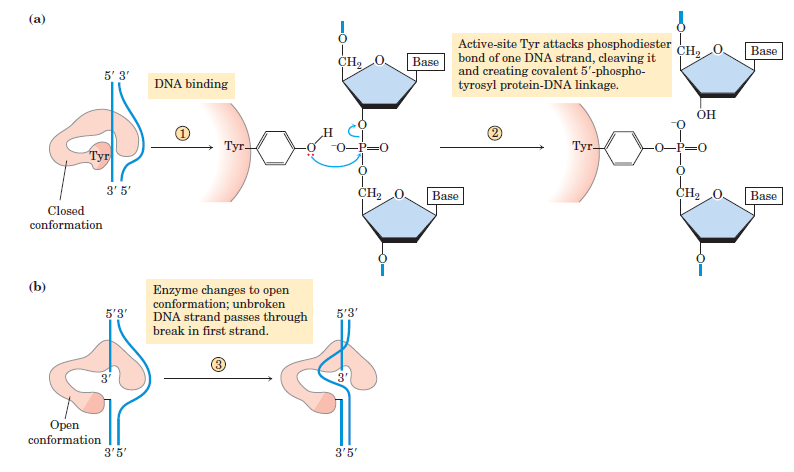
* DNA underwinding is defined by topological linking number.
* Linking number is a topological property of double-stranded DNA **(Fig. 24–14)**.

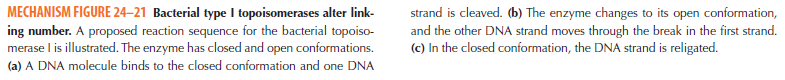


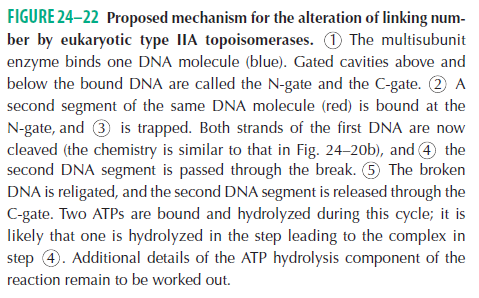
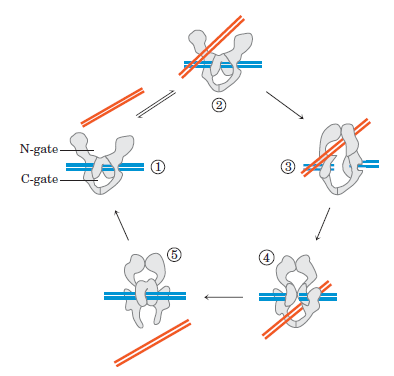


**Topoisomerases Catalyze Changes in the Linking Number of DNA**

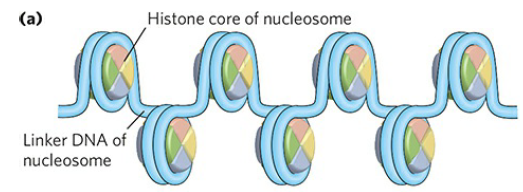
* Every cell has enzymes with the function of underwinding and/or relaxing DNA.
* Topoisomerases increase or decrease the extent of DNA underwinding.
* These enzymes play an important role in processes of replication and DNA packaging.
* There are two classes of topoisomerases.
* **Type I topoisomerases** act by breaking one of the two DNA strands, passing the unbroken strand through the break and rejoining the broken ends.
* **Type II topoisomerases** cleave both strands of a DNA molecule and pass another duplex through the break.
* Type I and II topoisomerases generally relax DNA by removing supercoils **(Fig. 24–20** and **21)**.



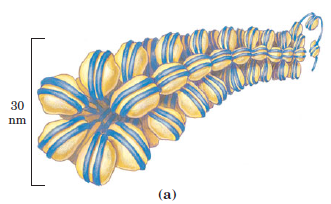
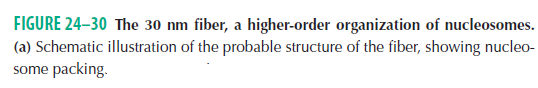




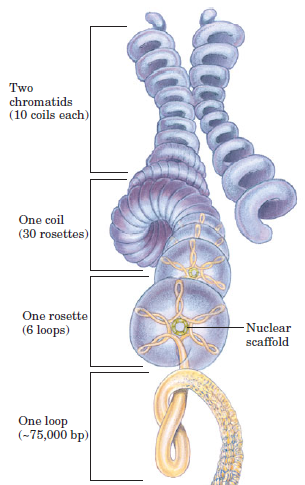
* 1. **The Structure of Chromosomes**
* The eukaryotic cell cycle produces remarkable changes in the structure of chromosomes.
* **Chromosome** isa single large DNA molecule and its associated proteins, containing many genes; stores and transmits genetic information (Each chromosome producing two sister chromosomes called sister **chromatids**).
* **Chromatin** is a filamentous complex of DNA, histones, and other proteins, constituting the eukaryotic chromosome.
* The DNA in the chromatin is associated with proteins called **histones**.
* Histones are small, basic proteins (the basic amino acids arginine and lysine).
* Histones package and order the DNA into structural units called **nucleosomes (Fig. 24–24)**.

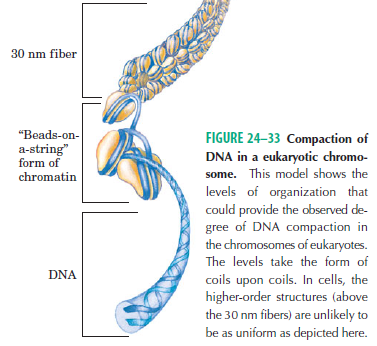
 

* Nucleosomes are the fundamental organizational units of chromatin.
* The compaction of a DNA molecule involves several levels of highly organized folding.
* Nucleosomes are packed into higher-order structures.
* Nucleosome cores seem to be organized into a structure called the **30 nm fiber (Fig. 24–30).**

* The 30 nm fiber—a second level of chromatin organization—provides an approximately 100-fold compaction of the DNA **(Fig. 24–33).**





* DNA compaction in eukaryotic chromosomes is likely to involve coils upon coils upon coils…..

**Bacterial DNA Is Also Highly Organized**

* Bacterial DNA is compacted in a structure called the **nucleoid**.
* Bacterial DNA does not seem to have any structure comparable to the local organization provided by nucleosomes in eukaryotes.
* Histonelike proteins are abundant in *E. coli*.
* But these proteins bind and dissociate within minutes, and no regular, stable DNA-histone structure has been found.