The Structure of Eucaryotic Chromosomes

**Backgrounds**

Each human cell contains about 2 m of DNA; yet the cell nucleus is only 5 to 8 μm in diameter (the equivalent of trying to fold 40 km of extremely fine thread into a tennis ball).

In eukaryotic cells, enormously long double-stranded DNA molecules are packaged into chromosomes.

The complex task of packing DNA is accomplished by specialized proteins that bind to and fold the DNA.

Amazingly, the DNA is compacted in a way that allows it to remain accessible to all of the enzymes and other proteins that replicate it, repair it, and direct the expression of its genes.

Text p.179
Eucaryotic DNA is packed into multiple chromosomes

**Chromosomes:** The human genome contains about $3.2 \times 10^9$ (3.2 billion) nucleotides distributed over 24 chromosomes.

**Chromatin:** Each chromatin consists of a single, enormously long linear DNA molecules associated with proteins that fold and pack the fine thread of DNA into a more compact structure. Also associated with proteins in gene expression, DNA replication, and DNA repair.

**Homologous chromosomes:** Two copies of each chromosome, one inherited from the mother and one from the father.

**Sex chromosomes:** X and Y chromosome.

- **DNA hybridization:** the technique uses a set of DNA molecules coupled to fluorescent molecules to "paint" each chromosome a different color.

- **Human karyotype:** a display of the full set of 46 human chromosomes.

Unique banding patterns allow the identification of each human chromosome

- To stain the chromosomes with dyes that bind to certain types of DNA sequences.
- These dyes mainly distinguish between DNA that is rich in A-T nucleotide pairs and DNA that is G-C rich, and they produce a striking and reliable pattern of bands along each chromosome.
- Giemsa stain: produce dark bands in AT rich region.
Abnormal chromosomes are associated with some inherited genetic defects

(A) Inherited ataxia. The patient has one normal Chromosome 12 (left) and one aberrant chromosome 12
(B) Chromosome 4 DNA “painted” red and the parts corresponding to Chromosome 12 DNA painted blue.

Chromosomes contain long stings of genes

The most important function of chromosomes is to carry genes (the functional units of heredity)

Gene: a segment of DNA that contains the instructions for making a particular protein.
(cf. Some genes produce an RNA molecule)

Genes are arranged along the chromosomes

‘Junk DNA’: a large excess of interspersed DNA, the majority of which does not seem to carry critical information. This may be crucial for the long-term evolution. This extra DNA is highly conserved among related species.

In general, the more complex an organism is, the larger its genome. But, not always true. E.g., closely related species (see fig. 5-14). No simple relationship between gene number, chromosome number, and the total size.

E.g., Human vs (S. cerevisiae / plant / amoeba).
22 pairs + XY

Chinese muntjac

2 pairs + XYY

Indian muntjac

Figure 9.14. Essential Cell Biology 5/e © Garland Science 2013