○ EUKARYOTIC CHROMOSOMES:

DNA is the genetic material, and it exists with protein in the form of chromosomes in eukaryotic cells. During most of the life of a cell, chromosomes are in a highly dispersed state called chromatin. During these times, units of inheritance called **genes** (Gr. genos, race) may actively participate in the formation of protein. When a cell is dividing, however, chromosomes exist in a highly folded and condensed state that allows them to be distributed between new cells being produced. The structure of these chromosomes will be described in more detail in the discussion of cell division that follows.

Chromatin consists of DNA and histone proteins. This association of DNA and protein helps with the complex jobs of packing DNA into chromosomes and regulating DNA activity.

There are five different histone proteins. Some of these proteins form a core particle. DNA wraps in a coil around the proteins, a combination called a **nucleosome** . The fifth histone, sometimes called the linker protein, is not needed to form the nucleosome but may help anchor the DNA to the core and promote the winding of the chain of nucleosomes into a cylinder. Further folding and the addition of protective proteins result in the formation of chromosomes during mitosis and meiosis.

Not all chromatin is equally active. Some human genes, for example, are active only after adolescence. In other cases, entire chromosomes may not function in particular cells. Inactive portions of chromosomes produce dark banding patterns with certain staining procedures and thus are called **heterochromatic regions**, whereas active portions of chromosomes are called **euchromatic regions.**

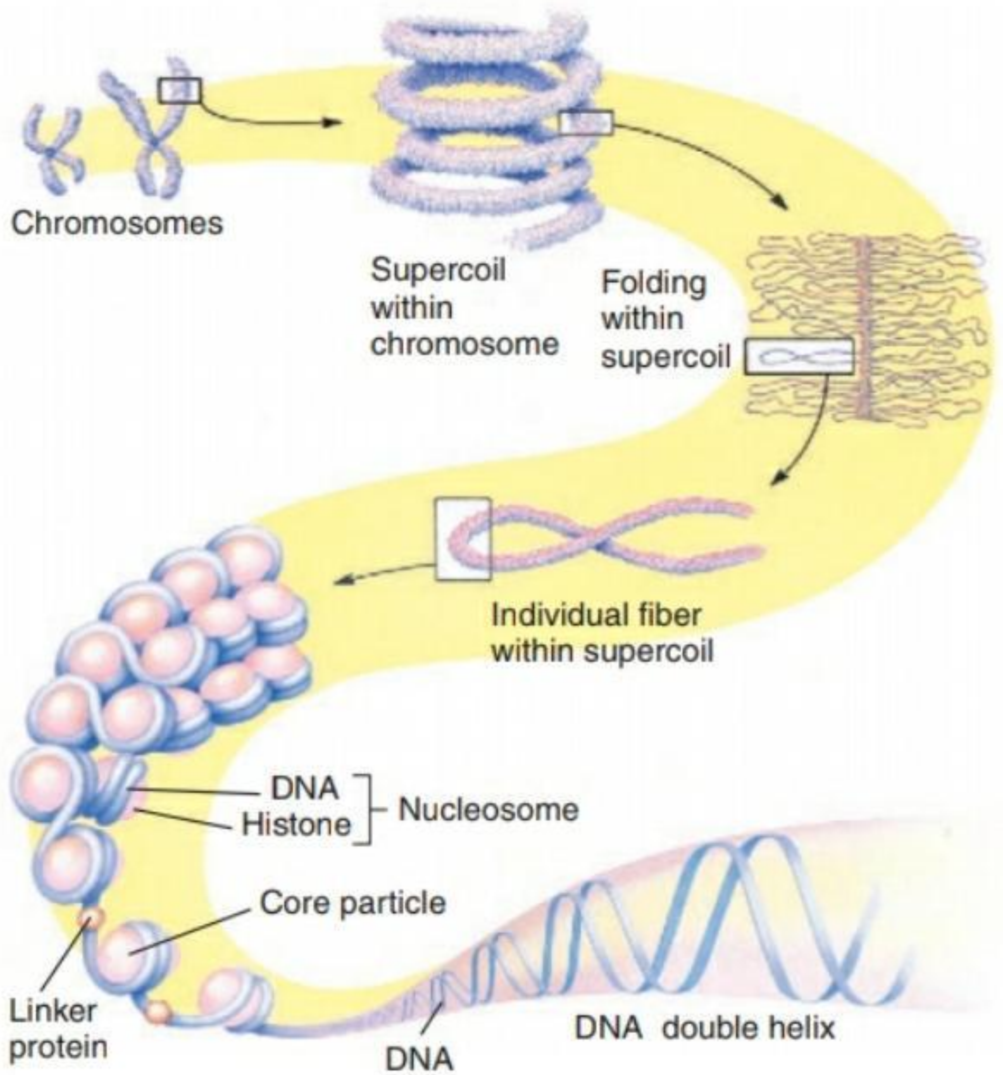

FIGURE 3.1

Organization of Eukaryotic Chromosomes. Chromosomes consist of a supercoil of highly folded chromatin. Chromatin is a chain of nucleosomes. Each nucleosome is comprised of histone proteins wound by a strand of DNA. Linker histone proteins are associated with DNA between adjacent nucleosomes.

- ## **SEX CHROMOSOMES AND AUTOSOMES:**

In the early 1900s, attention turned to the cell to find a chromosomal explanation for the determination of maleness or femaleness. Some of the evidence for a chromosomal basis for sex determination came from work with the insect Protenor. One darkly staining chromosome of Protenor, called the X chromosome, is represented differently in males and females. All somatic (body) cells of males have one X chromosome (XO), and all somatic cells of females have two X chromosomes (XX).

Similarly, half of all sperm contain a single X, and half contain no X, while all female gametes contain a single X. This pattern suggests that fertilization involving an X-bearing sperm will result in a female offspring and that fertilization involving a sperm with no X chromosome will result in a male offspring. As figure 3.2 illustrates, this sex determination system explains the approximately 50:50 ratio of females to males in this insect species. Chromosomes that are represented differently in females than in males and function in sex determination are **sex chromosomes.** Chromosomes that are alike and not involved in determining sex are **autosomes** (Gr. autus, self +soma, body). The system of sex determination described for **Protenor** is called the X-O system. It is the simplest system for determining sex because it involves only one kind of chromosome. Many other animals (e.g., humans and fruit flies) have an X-Y system of sex determination. In the X-Y system, males and females have an equal number of chromosomes, but the male is usually XY, and the female is XX. (In birds, the sex chromosomes are designated Z and W, and the female is ZW.) This mode of sex determination also results in approximately equal numbers of male and female offspring:

	Sperm	
	X	Y
Egg X	XY	XX

1male: 1female

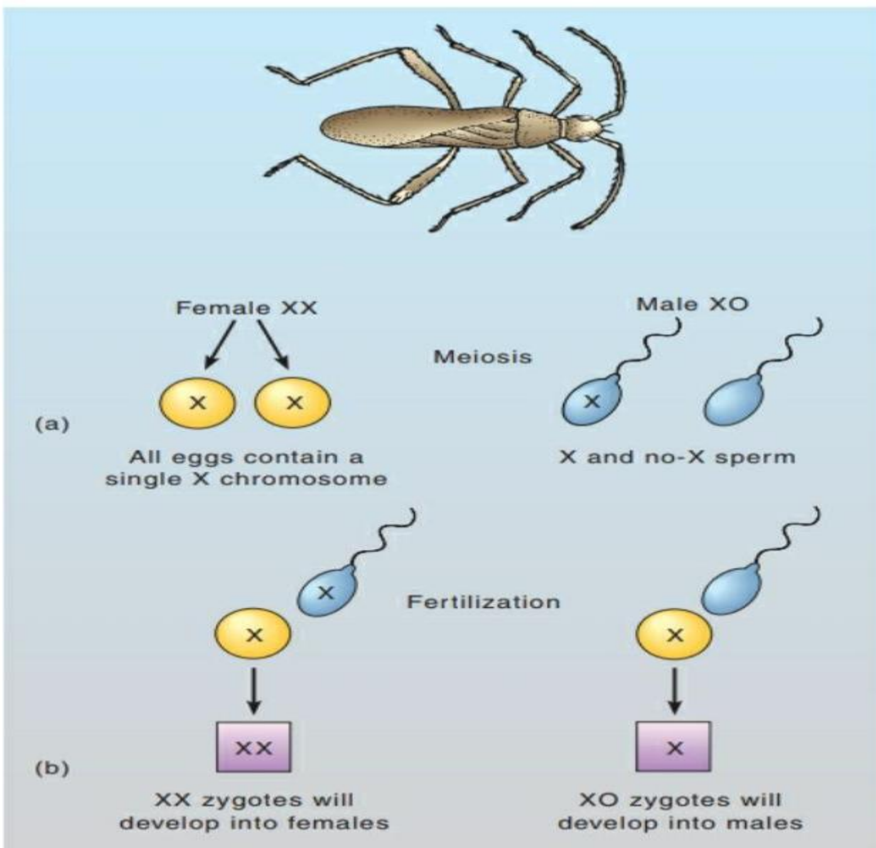

FIGURE 3.2

XO-System of Sex Determination for the Insect Protenor. (*a*) In females, all cells except gametes possess two X chromosomes. During meiosis, homologous X chromosomes segregate, and all eggs contain one X chromosome. Males possess one X chromosome per cell. Meiosis results in half of all sperm cells having one X, and half of all sperm cells having no X. (*b*) Fertilization results in half of all offspring having one X chromosome (males), and half of all offspring having two X chromosomes (females).

o NUMBER OF CHROMOSOMES:

Even though the number of chromosomes is constant within a species, chromosome number varies greatly among species.

Chromosomes are present in sets, with the number in a set being characteristic of each kind of animal and expressed as “N.” N identifies the number of different kinds of chromosomes. Most animals have two sets, or 2N chromosomes. This is the diploid (Gr. di, two + eoides, doubled) condition. Some animals have only one set, or N chromosomes (like gametes) and are haploid (Gr. hapl, single) (e.g., male honeybees and some rotifers).

Very few animals (e.g., brine shrimp, snout beetles, some flatworms, and some sow bugs) have more than the diploid number of chromosomes, a condition called polyploidy
(Gr. polys, more). The upset in numbers of sex chromosomes apparently interferes with reproductive success. Asexual reproduction often accompanies polyploidy.