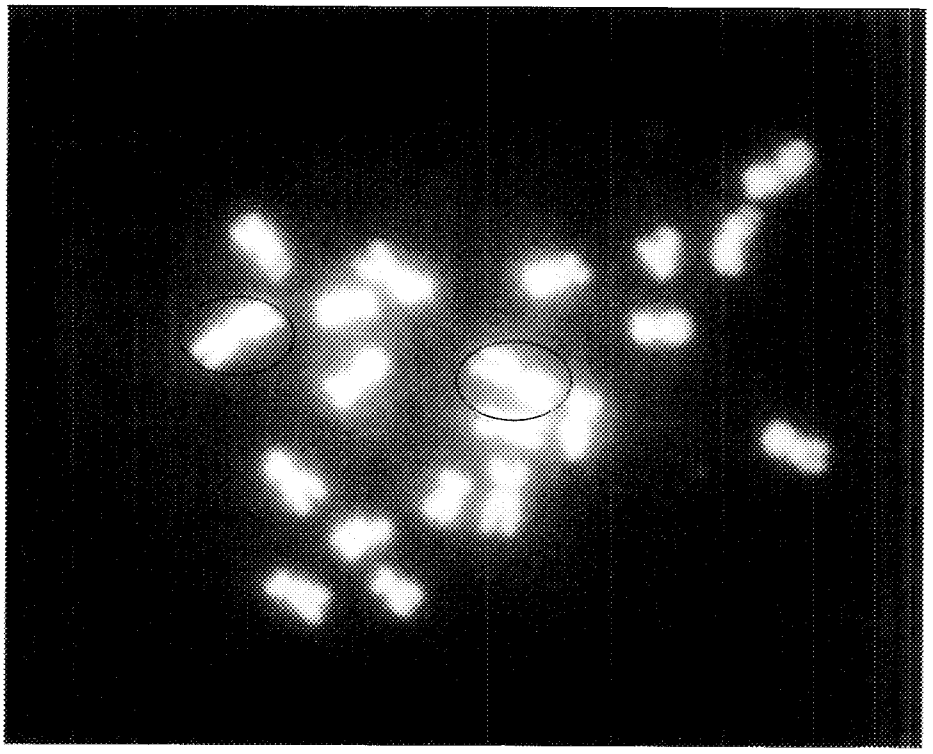
CHROMOSOMES: the sites of hereditary information

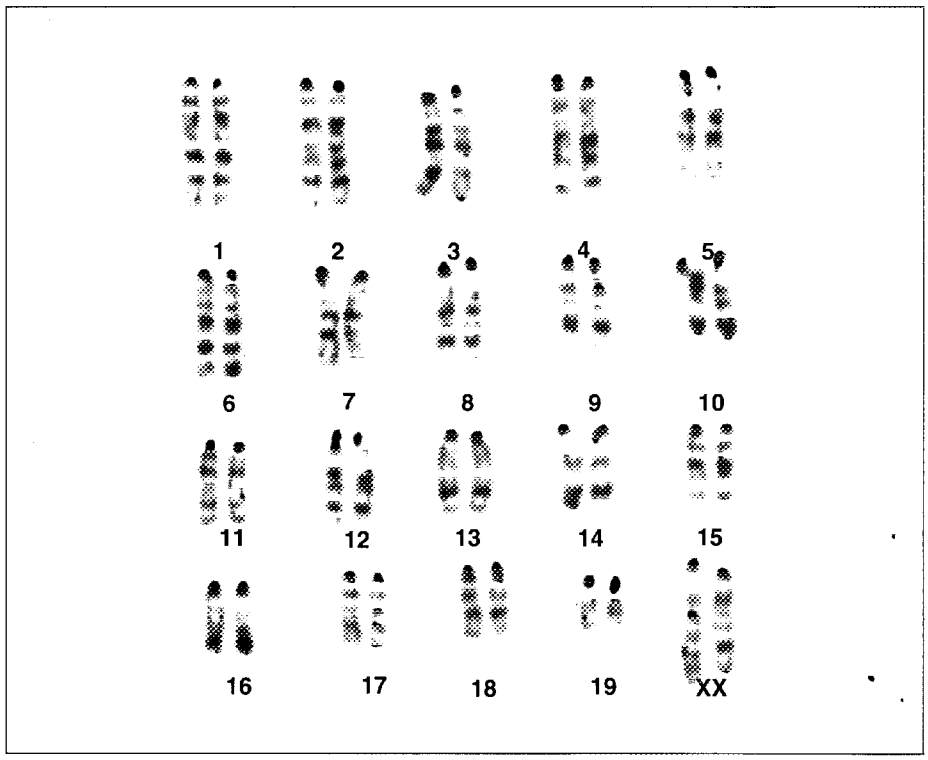
Within the nucleus of each cell of a eukaryotic organism are a number of chromosomes, each composed of a single molecule of DNA (see "DNA: Its Structure and Components") and a roughly equal mass of proteins (primarily the proteins called histones). The DNA molecule carries hereditary information; the proteins help effect the ordered condensation, or compaction, of the very long, very thin DNA molecule. During most of a cell's life, its chromosomes are too decondensed to be visible with an optical microscope. However, during metaphase, a phase preparatory to cell division (see "Mitosis" and "Meiosis"), the chromosomes become highly condensed and hence easily visible. Most studies of chromosomes are therefore carried out on chromosomes extracted from cells arrested at metaphase. Each such "metaphase chromosome" consists in reality of two duplicates of a single chromosome bound together along a somewhat constricted region called a centromere. The three micrographs of metaphase chromosomes shown here illustrate some general facts about chromosomes.



× about 550

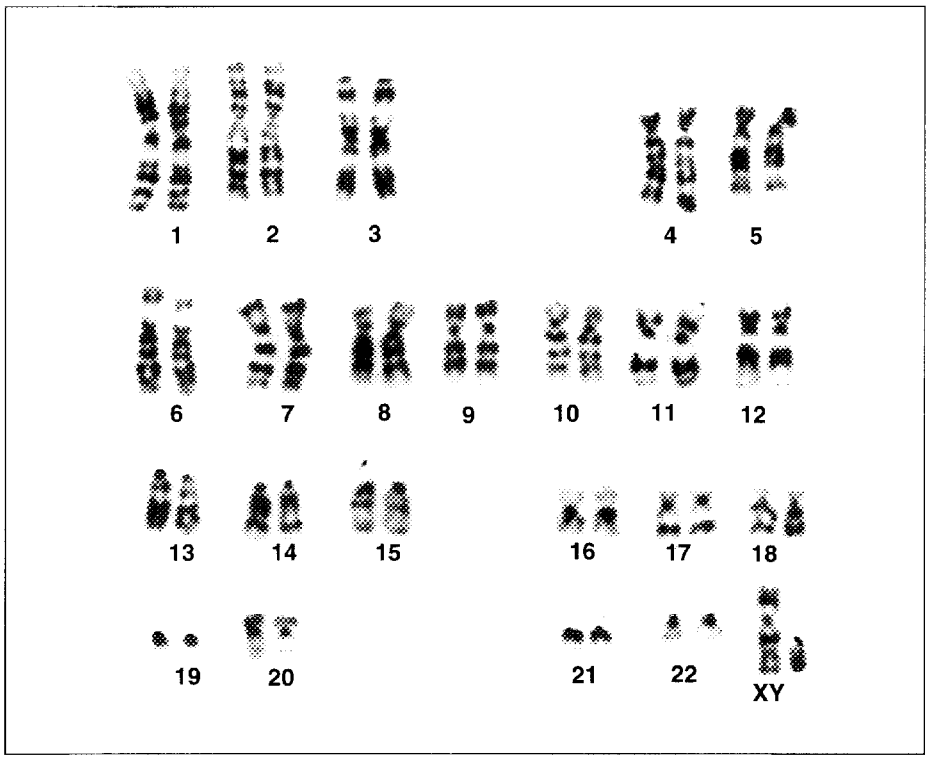
Shown above are the metaphase chromosomes extracted from a root-tip cell of maize (*Zea mays*). The chromosomes were stained with a fluorescent dye and photographed through an optical microscope while being illuminated by a laser that excites the dye's fluorescence. (The chromosomes could have been stained instead with a nonfluorescent dye.) A total of twenty metaphase chromosomes is visible in the micrograph, and any somatic cell (any cell other than an egg or a sperm) of any *Zea mays* plant possesses that same number of metaphase chromosomes. In general, all the somatic cells of all the members of a species possess the same even number of metaphase chromosomes, called the diploid chromosome number. The diploid chromosome number varies erratically from species to species: the known values range from 2 to many hundreds. (Note that the diploid chromosome number is not a measure of a species' evolutionary status.) The twenty metaphase chromosomes of *Zea mays* obviously exhibit different morphologies, that is, different sizes and centromere positions. However, even the untrained observer might notice that the two highlighted metaphase chromosomes look very much alike. In fact, the twenty metaphase chromosomes of *Zea mays* can be grouped into ten homologous, or morphologically indistinguishable, pairs. The metaphase chromosomes of all eukaryotic species occur as homologous pairs, and that general fact is due to the occurrence of chromosomes themselves as homologous pairs. Furthermore, the homology of a pair of chromosomes is due to a high degree of similarity between the base sequences of their constituent DNA molecules. (Micrograph courtesy of Paul Jackson and Jérôme Conia.)

Shown at right are the metaphase chromosomes extracted from a somatic cell of a house mouse (*Mus musculus*). To help identify homologous pairs, the chromosomes were stained with a dye called Giemsa that produces a pattern of dark and light bands, a pattern that varies from one homologous pair to another. The chromosome images have been grouped in homologous pairs and arranged in order of decreasing size. Such a display of metaphase chromosomes is called a karyotype. The last entry in the karyotype is the pair of chromosomes that are involved in determining sex. Because this particular mouse cell posseses two *homologous* sex chromosomes, it is a cell from a female mouse. Cells of a male mouse possess two nonhomologous sex chromosomes, one X chromosome and a smaller Y chromosome.



× about 750

× about 650



Shown at left is the karyotype of a human prepared from the Giemsa-stained metaphase chromosomes of a lymphocyte. Note the twenty-two homologous pairs of autosomes (chromosomes other than sex chromosomes) and the two nonhomologous sex chromosomes. The nonhomology of the sex chromosomes indicates that this is the karyotype of a male human, namely of the well-known cytogeneticist T. C. Hsu of the University of Texas System Cancer Center. (Both of the karyotypes on this page were provided by T. C. Hsu.)