

Mendel's work went unappreciated for 35 years, by which time Mendel had died. Other biologists just weren't convinced that numbers had anything to do with biology. But during that 35-year period (1865–1900), great improvements were made in microscope lenses, and improved techniques for cell study (Plates 27 and 29) were developed. These advances led to the discovery of chromatin (Plate 30), so named because of the deep stain it takes from the appropriate dyes (Greek: *chromos*, "color"). In cell division the chromatin was seen to coil up into compact bundles called chromosomes as cells prepare to divide. In 1882 Walther Fleming worked out the details of the most common type of cell division, which is called mitosis (Greek: *mitos*, "thread") because of the threadlike appearance of the chromatin.

Although cell division is a continuous process, it is customary to divide it into four phases to make discussion easier. The period between divisions, when the cell is growing or just carrying out its life functions, is called interphase.

**Color the heading Interphase at the upper right. Then color the headings Cell and Nucleus and titles A, D, E, and F. Color the cell beside the "Interphase" heading.**

During interphase, the nucleus is surrounded by the nuclear envelope, and the *chromatin* is in the form of numerous loose threads. In cells of animals and primitive plants, a pair of *centrioles* is located in the cytoplasm just outside the nucleus. This plate illustrates division of such a centriole-containing cell.

**Color the heading Prophase, all remaining titles, and the two prophase cells, one above and one below the Prophase heading.**

Mitosis begins with prophase, in which the chromatin coils up and condenses into compact structures called *chromosomes*. Two prophase cells are shown, one early and one late, to emphasize the continuous nature of the process. As the chromosomes become shorter and thicker, it becomes clear that each one is made up of two subunits, which we call *chromatids*. If centrioles are present, a second pair of centrioles is synthesized during interphase, and a starlike array of microtubules called an *aster* forms around the centrioles. As prophase proceeds, the two pairs of centrioles move toward opposite sides of the cell, each with its own aster. During this migration, numerous addi-

tional microtubules are assembled between the centrioles to form the *spindle apparatus*, which is so named because of its similarity to the spindle of a spinning wheel. Many microfilaments of actin (one of the muscle proteins) become associated with the microtubules in the spindle. Any nucleoli present gradually become smaller and disappear. Eventually the asters arrive at opposite ends of the cell, and the spindle apparatus extends along one side of the nucleus. The nuclear envelope then disintegrates, marking the generally accepted end of prophase. (Cells without centrioles do not form asters but do form a very similar spindle, which is known as an *anastral spindle*, Latin: *an*, "without.")

**Color the heading Metaphase and the structures in the two metaphase cells, one above and one below the heading.**

In the portion of mitosis designated as metaphase, the spindle apparatus moves into the area of the nucleus. As it does so, the chromosomes move to the center of the spindle. Each chromosome attaches by a specialized portion (*centromere*) to a different bundle of spindle microtubules. In animals and seed plants, virtually all the cells have their chromosomes in homologous ("same-proportioned") pairs. This is referred to as the "diploid" condition. As you will see in the next plate, gametes are "haploid" (Greek: *haplos*, "single"), having only one chromosome of each pair. (Haploid cells can also divide by mitosis in some organisms but not in animals.) The number, size, and shape of the chromosomes is constant for any given species. Humans have 23 pairs of chromosomes; other species have chromosome numbers ranging from one pair to more than 200 pairs.

**Color the headings Anaphase and Telophase and the corresponding cell structures. Then color the two daughter cells in the upper left corner.**

In anaphase, the chromatids of each chromosome separate to form two daughter chromosomes. The spindle tubules pull these daughter chromosomes to opposite sides of the cell so that each end of the daughter cells has an identical set. In telophase, the spindle dissolves, the chromosomes uncoil and become a diffuse chromatin network again, and the nucleolus and nuclear envelope reappear. In most cells, the cytoplasm is then divided to form two separate cells, each surrounded by its own membrane, as illustrated at the upper left.

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