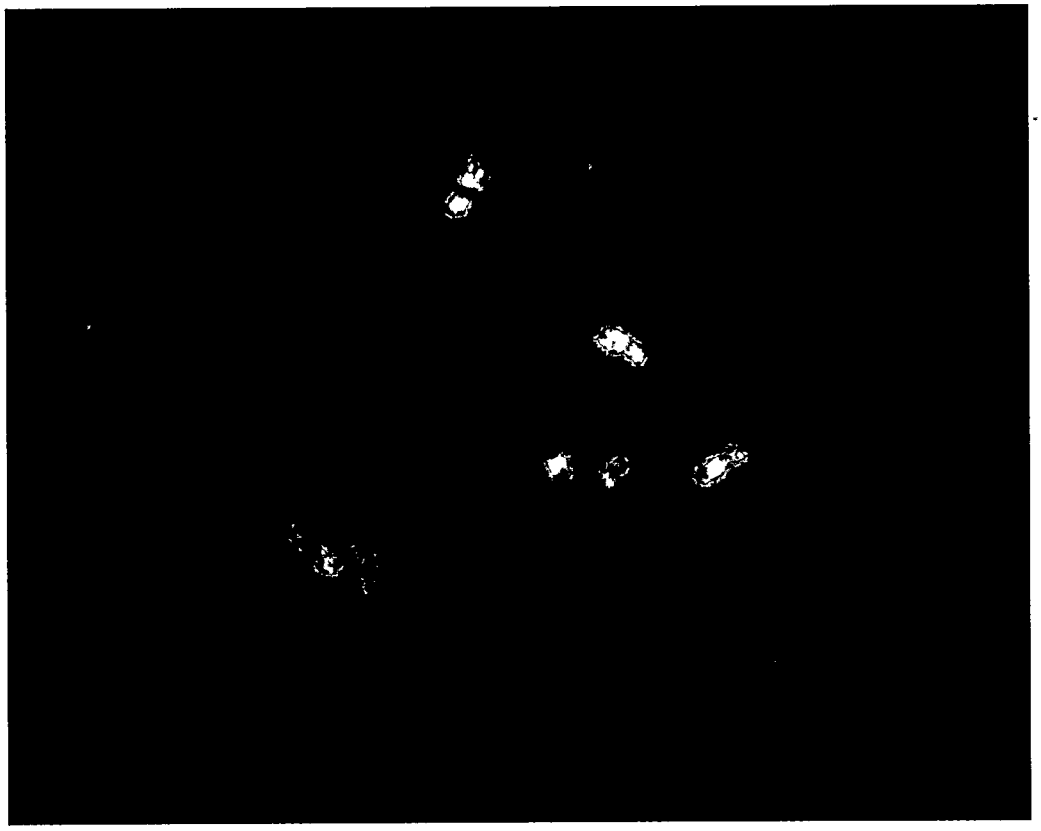

MIX AND MATCH Developed at Livermore in 1986, chromosome painting allows many genetic events, natural and otherwise, to be readily observed. In this image, human chromosomes 1, 2, and 4 (two of each) have been stained orange, chromosomes 3, 5, and 6 green. Along with the normal chromosomes, two can be seen that are part orange, part green, a result of chromosomal exchange.

that mimic those found in human patients, thus paving the way to new diagnostic and therapeutic techniques. Diseases being studied in such mice include sickle-cell disease, polycystic kidney disease, and leukemia.

Also recent are breakthroughs in a field called molecular cytogenetics. In 1986, as part of the biodosimetry effort at Livermore, Joe Gray developed a technique for "chromosome painting" whereby the different human chromosomes can be uniformly tagged with fluorescent dyes of diagnostic colors. Major genetic changes—the swapping of pieces of chromosome, for example—are thus easily seen, whether the product of natural mutational events or exposure to mutagenic agents. Thus the obvious application to biodosimetry (see page 14). Chromosome painting has also been used to illuminate the incremental genetic changes that accompany the transformation of normal to malignant cells in a number of human cancers, including those of the breast, colon, and prostate.

Efforts launched in the immediate postwar years to ensure the public safety thus produced not only today's radiation safety standards, short-term assays such as the Ames test, and advances in dosimetry, but also the bright prospects of the Human Genome Project. Another thrust, though, had medical advances as its goal from the start—not the protection of human health, but its dramatic enhancement through nuclear medicine—the theme of the next chapter in the history of biological research in the Atomic Age.

1989 Los Alamos scientists isolated and characterized the ends (or telomeres) of human chromosomes. The telomeres are involved in cell maintenance and longevity, since they are shortened during normal cell replication. "Immortal" cancer cells somehow escape the restraint of telomeric shortening.

1992 The gene for myotonic dystrophy was discovered by a consortium that included Livermore scientists, leading to a diagnostic tool for a late-onset disease that affects one out of every eight thousand people.

1993 Using hybrid fish as their model systems, Brookhaven scientists showed that UVA wavelengths are more important than UVB wavelengths in the induction of malignant melanoma.

1994 Livermore and Los Alamos announced high-resolution physical maps of human chromosomes 19 and 16, respectively.

1997 OBER formed the Joint Genome Institute to integrate the high-throughput production efforts of the genome centers at Berkeley, Livermore, and Los Alamos.