latter view is in line with the observations that the early mammalian embryo is a highly regulative system, and that the body axes do not become fixed until the end of cleavage or early gastrulation.

EXPERIMENTAL MANIPULATIONS OF CLEAVING EMBRYOS

Much of the knowledge about the developmental properties of early mammalian embryos is the result of more recently devised techniques for experimentally manipulating them. Typically, the use of these techniques must be combined with other techniques that have been designed for in vitro fertilization, embryo culture, and embryo transfer (see Chapter 2).

Classic strategies for investigating the developmental properties of embryos are (1) removing a part and determining the way that the remainder of the embryo compensates for the loss (such experiments are called **deletion** or **ablation experiments**) and (2) adding a part and determining the way that the embryo integrates the added material into its overall body plan (such experiments are called **addition experiments**). Although some deletion experiments have been done, the strategy of addition experiments has proved to be more fruitful in elucidating mechanisms controlling mammalian embryogenesis.

Blastomere deletion and addition experiments (Fig. 3-10) have convincingly shown the regulative nature (i.e., the strong tendency for the system to be restored to wholeness) of early mammalian embryos. Such knowledge is important in understanding why the exposure of early human embryos to unfavorable environmental influences typically results in either death or a normal embryo.

One of the most powerful experimental techniques has been the injection of genetically or artificially labeled cells into the blastocyst cavity of a host embryo (see Fig. 3-10B). This technique has been used to show that the added cells become normally integrated into the body of the host embryo, providing additional evidence for embryonic regulation. An equally powerful use of this technique has been in the study of cell lineages in the early embryo. By identifying the progeny of the injected marked cells, investigators have been able to determine the developmental potency of the donor cells.

A technique that is providing great insight into the genetic control mechanisms of mammalian development is the production of **transgenic embryos**. Transgenic embryos (commonly mice) are produced by directly injecting foreign DNA into the pronuclei of zygotes (Fig. 3-11A). The DNA, usually recombinant DNA for a specific gene, can be fused with a different regulatory element that can be controlled by the investigator.

Transgenic mice are created by injecting the rat growth hormone gene coupled with a metallothionein promoter

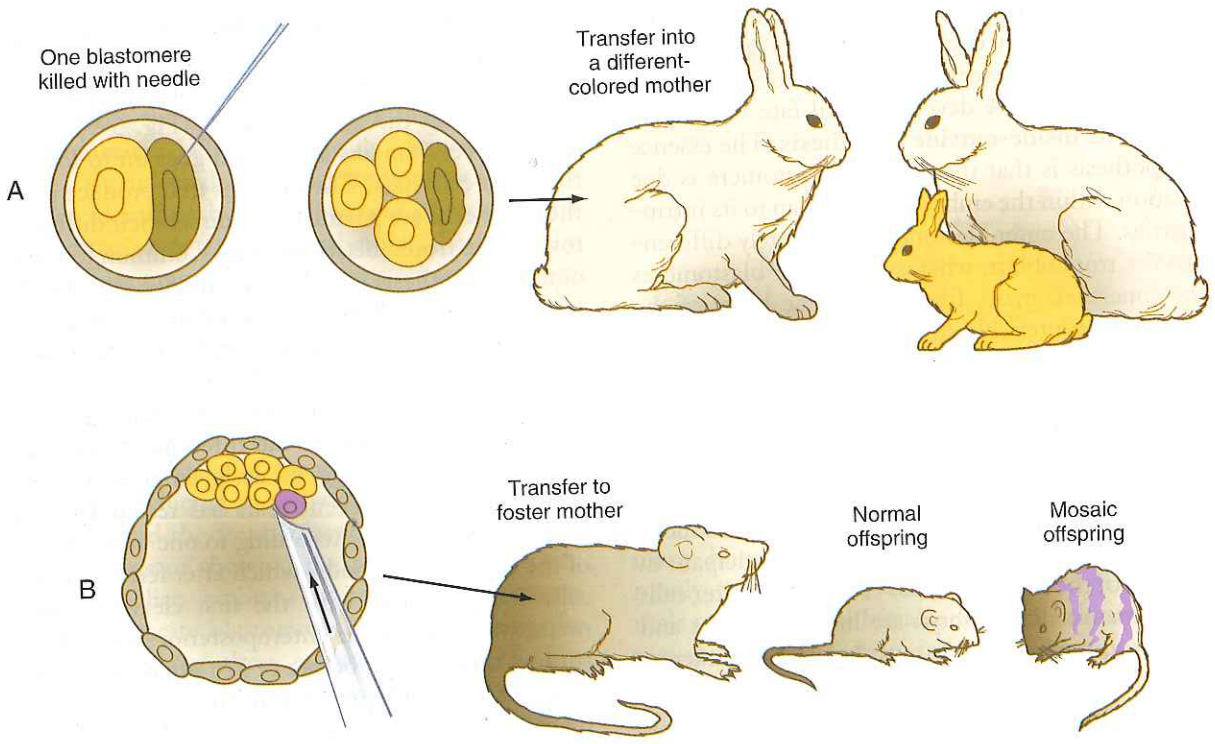

FIGURE 3-10. Blastomere addition and deletion experiments. **A,** If one blastomere is killed with a needle, and the embryo is transferred into a different-colored mother, a normal offspring of the color of the experimentally damaged embryo is produced. **B,** If a blastomere of a different strain is introduced into a blastocyst, a mosaic offspring with color markings characteristic of the strain of the introduced blastomere is produced.