March,† Karl Illmensee of the University of Geneva, Switzerland, reported that the human insulin gene appeared to remain intact in two mouse embryos that had developed from eggs injected with DNA carrying that gene. Illmensee's experiments were performed in collaboration with Axel Ullrich of Genentech, Incorporated, of San Francisco.

Mintz, Wagner, and Stewart found significant quantities of HSV thymidine kinase activity in one of the five fetuses that carried the intact *tk* gene. A second fetus may have had small amounts of the viral enzyme. According to Mintz, "One of the five animals was producing the herpes enzyme as well as its own. A second case is a pretty good candidate for gene function."

The presence of HSV thymidine kinase in one fetus was independently confirmed by an immunological assay performed in the laboratory of Saul Silverstein at Columbia University. Not enough tissue was available to perform this assay for the second fetus.

Showing that foreign DNA is maintained in a functional form in the animals that develop from injected eggs is a significant achievement, but it is only one requirement that must be met if investigators are to study gene control in living animals. The DNA must be incorporated into the host cell chromosomes and transmitted through the egg and sperm to future generations of animals. Breeding is the only way to generate sufficient numbers of animals carrying the foreign gene to do the desired developmental studies.

According to Mintz, the evidence, although not ironclad, strongly supports the idea that the viral *tk* and human β-globin genes were integrated in the mouse chromosomes. Meanwhile, Ruddle and Gordon have determined that injected DNA, even though it is rearranged, can be integrated and transmitted through the germ cells to a second generation of mice.

The Yale workers allowed some of the animals that developed from injected eggs to grow to adulthood and then surgically removed their spleens to test for the presence of the foreign DNA. Gordon says, "Some of the foreign DNA was retained without integration into the recipient cell DNA. But in three other animals there was clear evidence for integration; gene sequences of the host DNA were attached to the transferred gene."

† The symposium, Developmental Biology Using Purified Genes, was sponsored by ICN Pharmaceuticals and the University of California at Los Angeles and held in Keystone, Colorado, on 15 to 20 March.

Starship Capricorn

The starship Enterprise may have had a 5-year mission to explore strange new worlds, but little was ever said about the arrangements for sanitation and garbage disposal.

Hoping to help fill this gap in the literature, a team of scientists headed by Cornell University chemical engineer Michael L. Shuler has done a computer simulation study of regenerative life support systems for long space voyages. In their report to the Intersociety Conference on Environmental Systems, held on 15 July in San Francisco, they concluded that the systems should be optimized by including a pair of goats.

The simulation was for a 10-year mission with a crew of 24 people. Certain foods would be stored in dried form, but grains, fruits, and vegetables would be grown hydroponically. Inedible plant material and human wastes would be decomposed in aerobic bacterial digesters, which produce a nitrogen-rich liquid suitable for fertilizer in the hydroponic gardens and a sludge that could be stored in the emptied food bins.

The goats would fine-tune the system. Since they are ruminants "with very nonfastidious feed requirements," according to the study team, their digestive systems could do the initial decomposing of stems, stalks, and roots, thus making it faster and easier for bacteria to complete the job. They would also consume a small part of the sludge as a nitrogen supplement.

An additional advantage, according to the study team, is that the goats would reduce the need for stored food supplements by providing meat and "large quantities of milk per unit body weight."—M. MITCHELL WALDROP

One of the three animals was a female, and she has now been bred several times. Six of the ten progeny tested thus far carried the foreign DNA in the same form as the mother. Gordon concludes, "It appears that we have integrated material in the chromosome; it was transmitted to about half the progeny, which is about what you would expect from normal patterns of inheritance."

The Mintz group also has adult mice that developed from some of their injected eggs. The results of studies of these animals are not yet available.

Why intact genes are transferred in some cases but not in others is not known. Ruddle and Gordon had originally hypothesized that maintenance of an intact viral *tk* gene and its expression might prove harmful to normal development, in which case they might never see the viral enzyme in any of the mice that survived the fetal period. Gordon explains, "The *tk* gene product generates some of the subunits for making DNA. If you alter the activity of enzymes crucial for this pathway you could disrupt development."

The Yale workers examined only newborn or older mice whereas the Mintz group and Illmensee and Ullrich studied fetuses, which might have eventually succumbed to the deleterious effects of viral thymidine kinase production. Militating against this possibility, however, is the fact that all the fetuses studied by the Mintz group appeared normal just before the end of gestation, when many cell divisions had already occurred. Mintz notes, incidentally, that the total amount of thymidine kinase activity in the mouse fetus that was producing both viral and murine enzyme was the same as in the other fetuses. This suggests that the animal may have been regulating the two genes in a coordinate fashion with the result that the total enzyme activity was not excessive.

A second, and perhaps more likely, explanation of why the integrity of transferred genes was maintained in some cases but not others is that plasmid composition, which differed among the three laboratories, might influence the manner in which DNA is maintained in the cell. Not much information is available on how the plasmid might affect gene transfer, although there is preliminary evidence that some plasmid sequences are not tolerated by the cell. As a result they may have to be rearranged if they are to be retained at all. Other DNA carried by the plasmid might be altered at the same time. More work is clearly required to clarify the role of the plasmid.

In any event, all the steps necessary for studying gene expression in the living animal have now been taken, even if not in the same laboratory. It should be only a matter of time before investigators can breed mice that carry functional foreign genes.—JEAN L. MARX

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