and 19 GeV per beam. For perspective, the J/psi particle mass is about 3.1 GeV, requiring 1.55 GeV per beam in a storage ring. A recently discovered particle, the upsilon, is similar to the J/psi but which contains a heavier quark has a mass of almost 9.5 GeV, just reachable by DORIS. And some theorists speculate that a third particle with an even heavier quark in it may have a mass near 30 GeV, accessible by PETRA and PEP.

Among other details, PETRA is octagonal in shape with a circumference of 2.3 kilometers. Although there are eight possible beam intersection regions, only four will be used at first, and two others will be activated if the "physics" looks interesting enough. PEP is hexagonal, with a slightly smaller circumference of 2.2 kilometers. Five of its six intersection regions are scheduled for major experiments. If either machine ever is operated at the maximum beam energy, the total electrical power consumed will be about 15 to 20 megawatts, which is about that needed for a town of 20,000 inhabitants.

Both machines will receive electrons and positrons from accelerators already existing on site, but there is a significant difference in how this is accomplished in the two rings. SLAC has the advantage of its 2-mile-long linear electron accelerator, which is capable of injecting both electrons and positrons into PEP at any energy that the storage ring can handle. DESY has a 7.5-GeV electron synchrotron that, in combination with other machines also located at the laboratory, squirts these particles into PETRA. Thus, PETRA must be able to accelerate both electrons and positrons to the operating energy, as well as to store the particles.

Carrying out the ambitious experimental program planned for the new storage rings is well beyond the capability of the in-house staff of the institutions respon-

Successful Transplant of a Functioning Mammalian Gene

Someday, perhaps, advances in recombinant DNA research will be so commonplace that they are no longer news. That day has not yet arrived, however. The latest development to attract attention in the press is the successful transplant of a rabbit gene into monkey cells, which was achieved by Paul Berg and his colleagues, Richard Mulligan and Bruce Howard, at Stanford University.

The DNA segment they transplanted codes for one of the polypeptide chains (called the β chain) comprising hemoglobin, the oxygen-carrying protein of red blood cells. All mammals (and birds) produce hemoglobin, but the structures of the molecules differ somewhat from species to species. As a result of the gene transfer, the monkey cells began producing the rabbit form of the β chain.

The experiment became public as a result of remarks Berg made in response to reporters' questions at a press conference preceding his address on recombinant DNA research to the clinical congress of the American College of Surgeons on October 18. Berg thought he had made it clear that his comments on the ongoing research in his laboratory were off the record, but they were reported in several newspapers.

Although the investigator is unwilling to describe the details of the gene transfer because they have not yet been published in a scientific journal, he confirms that the transfer was accomplished by inserting the rabbit gene into the DNA of the virus SV-40 to form a recombinant molecule. Berg and his colleagues then infected a cultured line of African green monkey cells with the altered virus, which is able to take over the cell's synthetic machinery to make viral nucleic acids and proteins, including, in this case, the rabbit hemoglobin chain. The monkey cells, which are derived from the kidney, do not ordinarily produce hemoglobin and certainly do not produce rabbit hemoglobin.

Introduction of the functioning rabbit gene into monkey cells is another accomplishment in a series of successful transplants of mammalian genes into cells of other species. For example, within the last year or so, investigators have transferred genes for the mammalian hormones insulin and somatostatin into bacterial cells which consequently acquired the ability to produce the hormones.

But the current development is the first example of the use of recombinant DNA technology to transfer a functioning gene from one mammalian species to another, although it is not the first time this feat ever has been accomplished. About 5 years ago, O. Wesley McBride of the National Cancer Institute and Harvey Ozer, now at the Worcester Foundation for Experimental Biology, showed that mouse cells, when incubated with chromosomes from hamster cells, acquired the ability to synthesize a hamster enzyme. Presumably the hamster gene entered the mouse cells on a piece of chromosome. Several investigators are now using chromosome-mediated gene transfer for genetic studies such as the mapping of gene arrangements on chromosomes. Moreover, formation of hybrids by fusing cells from two different species is a common technique that achieves a form of gene transfer. Recombinant methods have the advantage of being more specific, however; procedures are now available for isolating and copying individual genes for insertion into a suitable transfer vehicle, whereas selection of a particular gene for transfer by the other methods is more difficult.

An obvious implication of the Stanford work is that a similar procedure might one day be used for genetic engineering, such as the replacement of defective or missing genes. Sickle cell anemia, for example, is caused by the gene for the β chain of hemoglobin being defective. Because SV-40 causes tumors in some animals, although not in humans as far as is known, the virus would not be a suitable vehicle for gene replacement therapy. In fact, an early (1973) experiment in Berg's laboratory, which involved the insertion of a bacterial gene into SV-40, helped to alert investigators and ultimately the public to the possibility that production of recombinant DNA molecules might have hazardous as well as beneficial effects. Although no hazards have materialized, the guidelines for recombinant DNA research that were adopted by the National Institutes of Health require that experiments using SV-40 for the introduction of new genes into cultured mammalian cells be carried out in at least P3 laboratories. (P3 is the second highest level of physical containment specified by the guidelines.)

But, in any event, the gene transfer procedure developed at Stanford should greatly facilitate the study of such fundamental problems in molecular biology as the control of gene expression in mammalian cells.—J.L.M.