a boron separation plant that can collect about 1 gram of boron-10 per day. This isotope is of interest as a neutron absorber for control purposes in reactors. The laser isotope separation project at Los Alamos, headed by Robinson and Reed Jensen, has also become the principal competitor in infrared photodissociation research to the Soviet group.

As of this date, in addition to isotopes of boron and sulfur, researchers at several institutions have demonstrated selective excitation and separation of isotopes of hydrogen, carbon, silicon, chlorine, osmium, and molybdenum contained in various organic and inorganic compounds. The molybdenum experiments are especially interesting because, as compared to that of SF_6, the spectrum of molybdenum hexafluoride, a heavy molecule, is more like that of uranium hexafluoride. Researchers at Los Alamos have obtained about 15 percent enrichment of molybdenum-92 with respect to molybdenum-98.

In the case of SF_6, the Soviet researchers have shown that irradiating with several hundred laser pulses can increase the ratio of sulfur-34 to sulfur-32 in naturally occurring sulfur by several hundredfold. The Los Alamos group has reported lower enrichment ratios, but they also used a different experimental geometry. Exact enrichment ratios depend on such variables as the laser frequency, the pulse energy, the length of the pulse, the number of pulses, and the gas pressure in the reaction cell. The latter factor is especially important because of the increasing probability of collisions as the pressure rises, and the best results for SF_6 are obtained for pressures of 1 torr or less.

Although laser intensities were about 10^9 watts per square centimeter in the original experiments, recently investigators have found that the apparent threshold for laser dissociation of SF_6 could be orders of magnitude smaller. For example, Dennis Keefer and Willis Person of the University of Florida have found a threshold as low as 21×10^6 watts per square centimeter when the pulse length was 200 nanoseconds and 6×10^6 watts per square centimeter when the pulse length was 3 microseconds. The threshold also increased with the gas pressure.

At Moscow's Institute of Spectroscopy, Letokhov, Ambartsumian, and their associates recently reported another and, to many theorists, somewhat puzzling result. Using two lasers, the first having a low power and being tuned to a particular vibrational absorption frequency and the second having a much higher power but not being tuned to any resonant frequency, the investigators were able to obtain even higher separation yields than previously. And the

Speaking of Science

The Petroleum Plant: Perhaps We Can Grow Gasoline

The notion of obtaining fuels and energy from plants grown for that purpose has not yet won many converts among either federal energy officials or industrial scientists. But investigators who believe in the concept have not been deterred; they have kept studying sugar cane, kelp, trees, and other high-yield plants. Now a new candidate, shrubs that produce a hydrocarbon substance very much like gasoline, has been proposed by Nobel laureate Melvin Calvin of the University of California at Berkeley The shrubs, members of the genus *Euphorbia*, produce significant quantities of a milklike sap—called latex—that is actually an emulsion of hydrocarbons in water. These hydrocarbons are similar to those produced by the rubber tree, but are much lower in molecular weight. Their size distribution is similar to that of hydrocarbons in petroleum, Calvin says, and the crude hydrocarbon produced by the plants could probably be used directly in existing refineries after it has been separated from the water.

Calvin told the recent Centennial Meeting of the American Chemical Society that he has high hopes for two species in particular: *Euphorbia lathyrus*, also known as the gopher plant, a small bush that grows wild in northern California; and *Euphorbia tirucalli*, a much larger bush that is used as a hedge in Brazil, but which should grow well in southern California. A major advantage of these plants, he argues, is that they should grow well in dry regions on land that is not suitable for growing food. He estimates that the plants might be capable of producing between 10 and 50 barrels of oil per acre per year.

After the plants reach the proper height, he says, they would simply be cut near the ground and run through a crushing mill in much the same fashion as is done with sugar cane. Hydrocarbons would be obtained from the resultant sap with technology that is already available for separating emulsions of oil and water. The plants themselves would regrow from the stumps, so replanting might be necessary only once every 20 years or so. Calvin optimistically estimates that the cost of crude hydrocarbons obtained in this manner would be somewhere between $3 and $10 ber barrel. The oil, furthermore, would be practically free of sulfur and other contaminants.

As might be guessed from the skepticism with which Calvin's estimates have been met, the concept is still very tentative and there are few hard facts from which to draw any conclusions about its potential viability. More facts will be available in a couple of years, though. Calvin has already begun experimental planting of *E. lathyrus* on his ranch in northern California, and he is negotiating with the University of California at Davis for a test planting of *E. tirucalli* there. He has also discussed this concept with energy and agricultural officials in Brazil, and the Brazilian national petroleum company, Petrobras, is now investigating the shrubs. Calvin's first goals are to obtain information about the plant's requirements for water and care and to determine the potential yields. Only with this information will it be possible to say anything about the feasibility of the project.

Substantial quantities of land might be required to implement Calvin's proposal. He estimates, assuming a yield of 40 barrels per acre, that an area the size of Arizona would be necessary to meet current requirements for gasoline. It would obviously also require a substantial initial investment to get the project going. But the investment might be a sound one. Even if cheaper sources of energy for transportation and heating are eventually found, *Euphorbia* might well turn out to be an enduring and stable source of raw materials for the petrochemical industry. —T.H.M.