cial and cultural factors in each country.

One can easily point, for instance, to a number of obvious proximate causes of tropical deforestation: the burning of forests to make farmlands; use of increasing amounts of land for raising cattle; and the overcutting trees to obtain wood fuel. Just beneath the surface, however, lurks a tangle of difficult deeper causes: poverty, population growth, administrative failures and lack of expertise, technology and manpower.

With each passing year, the enormity of these problems is adding pressure on the developed world—where capital and technological expertise is concentrated—to help find a fresh and effective approach to avert massive tropical deforestation. Japan recognizes that until the root causes of deforestation are properly addressed, it will prove all the more difficult to find such a successful approach.

In May 1990, the director general of the Forestry Agency received an interim report from an advisory body that called on Japan to formulate a bold new initiative on the tropical forest issue. The report proposed that this initiative be based on the ideas of "sustainable development" and "keeping the earth green," so that the present generation may pass on a healthy planet to the not-so-distant generations of the 21st century.

The specific recommendations of the report included proposals that Japan: (1) hold a conference of senior forestry officials from around the world; (2) promote forestry aimed at maintaining the earth's environment; (3) promote proper utilization and control of existing tropical forests; (4) appeal to the world for the need to quickly establish a 10-year emergency international "Green Preservation" program to protect endangered plant and animal species; (5) help to establish a system to promote this emergency program.

The Forestry Agency is taking the lead in implementing Japan's international forestry cooperation programs, which are based on the interim report's recommendations. The agency has many decades of experience through its 10 million hectares of domestic forestation, and also has long experience of cooperation in overseas forestry programs. It now faces the challenge of putting this expertise to good use in Japan's international cooperative projects designed to help protect the world's endangered tropical forests.

Satoru Shimazaki is assistant director for Planning and Policy, International Forestry Cooperation Office, at the Forestry Agency.

Efforts to Cut CO_2

By Hidefusa Miyama

The greenhouse effect. Scientists have spoken of it for years, but never before with such urgency. Today there is a growing consensus that global warming is a reality, with potentially traumatic effects on the global climate, ecosystems and human civilization itself.

The theory is straightforward. Suspended in the atmosphere, various gases and particulate matter form a huge barrier analogous to greenhouse glass, thus producing a global warming effect. The gases include carbon dioxide (CO_2), methane, chlorofluorocarbons (CFCs) and nitrous oxide (N_2O). CO_2 is believed to be the chief villain, blamed for some 55% of the warming effect. CFCs cause some 24% of the warming, but are also eroding the ozone layer that shields the earth from solar radiation. For this reason, the various CFCs now in commercial use are being phased out, with the final deadline set for the year 2000.

Resolving the global warming problem will require efforts to reduce the far more widespread CO_2 emissions. The first practical measure is energy saving, including increasing the use of renewable natural energy sources. However, as long as humankind continues industrial activity, it will be difficult to substantially reduce CO_2 generation.

It therefore becomes necessary to capture and recover CO_2 after it has been generated, from exhaust gas. Today Japan, as with flue-gas desulfurization and denitrification in the recent past, has become one of the first countries to begin research for this new goal.

Most present research is being conducted by government-run institutions, such as the National Research Institute for Pollution and Resources, the National Chemical Laboratory for Industry and the Fermentation Research Institute—all controlled by the Agency of Industrial Science and Technology. Other public research institutions include the University of Tokyo, the Tokyo Institute of Technology, Kyoto University, Osaka University and other schools. The Central Research Institute of the Electric Power Industry, the research arm of Japan's electric power companies, is also engaged in research, as are other industries.

Particularly noteworthy projects are being promoted by a new nonprofit organization, the Research Institute of Innovative Technology for the Earth (RITE). RITE, only established in July 1990, launched several unique projects late last year, some of which make innovative use of biotechnology to fix CO_2. These projects are described below:

Fixing CO_2 with microorganisms:

RITE's biotechnology-based CO_2 fixation scheme begins with a search for plant plankton or bacteria capable of active photosynthesis. Once such microorganisms are found, researchers will try breeding them to improve their capability, and

will determine the optimal conditions for artificial culture to build a system for mass culturing these natural CO_2 "sweepers." The mass-cultured microorganisms hopefully will be utilized for extracting useful substances and as feeds, as well as a source of biomass energy. They could eventually help reduce forest destruction and replace fossil fuels.

The University of Tokyo is cooperating with RITE in this 10-year project, budgeted at ¥14 billion.

Fixing and producing chemicals:

Another 10-year RITE project seeks to fix CO_2 gas with catalytic hydrogenation technology. Scientists will work on processes designed to synthesize useful chemicals. High concentrations of CO_2 gas from such stationary gas sources as industrial facilities will be continuously separated by membranes to be synthesized into, with the addition of hydrogen, such useful chemicals as methanol.

The project hinges on the development of high-quality membranes and catalysts for hydrogenation.

RITE has chosen the Agency of Industrial Science and Technology as its partner for the ¥10 billion project.

Bacteria turning out chemicals:

A third RITE project calls for developing biotechnology to efficiently produce feedstocks for making plastics. What makes the effort unique is the planned use of a certain specific kind of bacteria to produce plastics raw materials. The bacteria should consume CO_2 as a source of carbon and take in hydrogen for energy. RITE puts the cost of the four-year project cooperating with private companies at ¥230 million.

Other RITE development projects include joint R&D with private companies on ultra-compact heat-resistant oxygen sensors made of ceramics. RITE plans to continue to sponsor basic-research projects in the field of CO_2 reduction, soliciting proposals from scientists around the world.

Hidefusa Miyama is senior researcher and director of the Research Institute of Innovative Technology for the Earth (RITE), Tokyo Office.

An Example of the Biotechnology Based CO_2 Fixation