tigators do have some evidence that the system of blood vessels that carries hypothalamic hormones to the pituitary can also carry pituitary hormones to the brain. Kastin, for example, has found MSH in certain parts of the brain. Some investigators have suggested that the effects of the hormones are pharmacological rather than physiological because relatively large doses must be administered in order to produce an effect. The existence of the blood-brain barrier and the fact that the hormones are rapidly broken down in blood help to account for this need to inject large quantities of the peptides.

In any event, the evidence accumulated thus far has raised the possibility that MSH and ACTH 4-10 may be of use in treatment of conditions in which learning or memory is impaired. These include the memory problems that may accompany old age, the temporary amnesia following electric shock treatments for mental disorders such as depression, and the reduced attention span of children suffering from minimal brain dysfunction or hyperactivity. De Wied has found, for example, that ACTH 4-10 and vasopressin can alleviate the amnesia induced in rats when they are subjected to concentrations of carbon dioxide that cause respiratory arrest. This amnesia is a model for that caused by electric shock.

At present, trials of ACTH 4-10 for therapy of the first two conditions are under way, but it is still too early to judge the effectiveness of the agent. One thing in favor of its use is that no side effects have yet been detected. So far there has been little discussion, publicly at least, of the possibility of using these agents to improve the memories of normal people but it is an idea that cannot help but occur to anyone who has ever forgotten anything.

—JEAN L. MARX

Geothermal Resources: A New Look

A new assessment of U.S. geothermal resources underlines the limited utilization being made of this form of energy compared to its potential. The assessment is contained in a report* prepared by the Geological Survey on the basis of new knowledge about geothermal systems and a tabulation of all known systems. The report concludes that at least 12,000 megawatts of electric generating capacity, more than 15 times the current U.S. geothermal output, could probably be achieved at present prices and with current technology. Nearly 10 times that resource, the report estimates, either remains to be discovered or is known but awaits marginally higher energy prices or improved technology. Large quantities of heat at temperatures too low for power generation but adequate for space heating and some industrial uses are also identified, as are the more speculative but large geopressured resources—including heat, high pressure, and methane—underlying parts of the Gulf Coast.

The estimates appear to be conservative. They do not, for example, include any resources below 3 kilometers, the depth to which geothermal wells have already been drilled. The hot and in some cases still molten rocks below that depth, although they constitute an immense store of heat, were considered as beyond the pale of present technology. Nor do the estimates include the large geothermal deposits in Yellowstone, Mt. Lassen, and other national parks, where exploitation would probably destroy the recreational attractions. Additional reasons for believing that the near-term geothermal potential is at least as large as the Survey estimates can be found in the intense interest in these resources in the private economic sector. A virtual explosion of geothermal exploration and drilling activity by oil companies and others has taken place in the past 2 years, despite a host of delays for drilling permits, a hopelessly snarled program for leasing federal lands, and the lack of tax incentives comparable to those available for oil exploration and production.

Despite the future potential of deep, hot igneous rocks and geopressured zones, the main interest at present is in geothermal deposits in which the heat is transferred by hydrothermal convection. The Survey report lists 290 deposits of this type within the United States, about one-fifth of which appear to have subsurface temperatures above 150°C, high enough to be considered for generation of electricity. Subsurface temperatures are estimated on the basis of silicon dioxide and sodium, potassium, and calcium content in water samples from each deposit; these concentrations are thought to serve as chemical geothermometers that in most instances give minimum estimates of the reservoir temperature. Crude estimates were also made of reservoir volume.

As with mineral resources, much of the geothermal heat seems to be concentrated in a few large deposits. Six deposits (five in California and one in New Mexico), each containing more than 10^{19} calories, constitute a large part of the known high-temperature resource. One extended region, the Bruneau-Grandview area of Idaho, contains by itself a staggering 2.6×10^{20} calories (estimated), more than two-thirds of the known intermediate-temperature resource. Reevaluation of intermediate-temperature deposits with newly developed models that take into account the mixing of cooler surface waters and geothermal waters may uncover more deposits of economic interest, the report suggests.

The ultimate source of the heat in hydrothermal systems is thought by many investigators to be a geologically recent magma chamber, but estimates of the number of such chambers and their heat content is more speculative. The report suggests, nonetheless, that perhaps 2.5×10^{22} calories are stored in such chambers in the United States above 10 kilometers depth. Of this total, about half is probably in molten or partially molten form, with temperatures around 650°C. Tapping this energy, however, will involve drilling into the magma chamber and hence, the report concludes, a considerable advance in drilling technology.

Also uncertain is a quite different type of geothermal resource, the geopressured zones found in sedimentary rocks in an area extending from Texas to Louisiana, both onshore and offshore. Geopressured deposits contain hot water at abnormally high pressures, and, in addition, often contain significant amounts of dissolved natural gas. Thus recovery of heat, of mechanical energy (from the high pressures), and of natural gas is potentially possible. Although the area in which these deposits occur has been extensively explored for oil and gas, drilling into geopressured zones has been avoided because of the difficulty in controlling a high-pressure well. The potential resource, however, is large, capable of sustaining an electric generating capacity of 30,000 to 115,000 megawatts and of producing methane of perhaps equal value. The report concludes that this resource is for the most part economically marginal at present energy prices. Taken in combination, however, U.S. geothermal resources are far from contributing at their true potential.—ALLEN L. HAMMOND

*D. E. White and D. L. Williams, Eds., *Assessment of Geothermal Resources of the United States—1975*, Geological Survey Circular 726, Washington, D.C., 1975.