hibitor in delaying the onset of diabetic cataracts. Besides the long experimental period required for cataract development, the time of appearance of the opacity varies considerably from animal to animal. We discovered that the degu (*Octodon degus*), a rodent native to the Andes of South America, develops nuclear opacity in 10 to 12 days after induction of diabetes. The rapid development of cataract appears to be related to a high aldose reductase activity in the lens of this animal. The enzyme activity in the degu lens was observed to be three to four times higher than that in the rat lens. Degus thus appeared to provide a more suitable model for testing the role of aldose reductase in the formation of diabetic cataracts. This report describes the effect of quercitrin treatment on the course of cataract development in experimentally diabetic degus. We recently reported that quercitrin, a flavonoid, is the most potent inhibitor of lens aldose reductase (5).

Degus weighing 90 to 100 g were used in this study, and before induction of diabetes they were segregated into two groups. One group received regular lab chow powder; the other group received the lab chow mixed with quercitrin (25 mg per gram of lab chow). In addition, the latter group was given orally a single dose of 70 mg per day of quercitrin in aqueous suspension. After 3 days on the above schedule both groups of degus were given streptozotocin intraperitoneally (dose, 10 mg per 100 g of body weight). On the third day after streptozotocin administration some animals were killed for determination of lens sugars and polyols; others were maintained longer for ophthalmoscopic examination. The data summarized in Table 1 show that the flavonoids are effective as aldose reductase inhibitors in vivo. Levels of sorbitol as well as of fructose, the two metabolites of the polyol pathway, were about 50 percent lower in the lenses of diabetic degus receiving quercitrin than in the lenses of controls. Glucose concentrations were approximately the same in lenses of the two groups, which probably is a reflection of the fact that blood sugar concentrations were similar.

The next phase of the study was to determine whether quercitrin could in fact delay the onset of cataracts. The control diabetic degus not receiving quercitrin developed a nuclear opacity by about the tenth day after the onset of hyperglycemia (Fig. 1). In contrast, the degus treated with quercitrin, although having a blood sugar concentration similar to that of the control group (approximately 380 mg/100 ml) did not develop cataracts even 25 days after the onset of diabetes, the time at which the experiment was terminated. The effect of quercitrin should, however, be viewed as a delay and not a prevention of cataract formation, since the lenses of the treated degus, although clear, did show vacuoles.

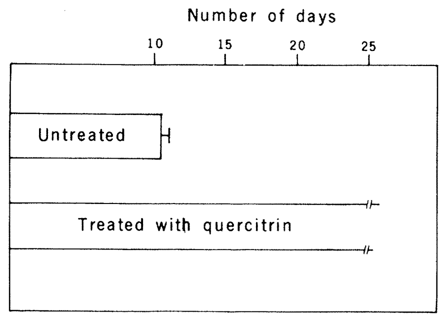

Fig. 1. The appearance of nuclear opacity in diabetic degus. There were 13 animals in each group. The average blood glucose of all animals was 385 ± 20 mg/100 ml. Experimental details have been described in the text.

Results provide strong support of the hypothesis that aldose reductase initiates the formation of cataracts in diabetes. This study reveals for the first time that inhibition of aldose reductase not only leads to a decrease in the sorbitol accumulation in the lens but also impedes the cataractous process. The cataract formation in diabetes may thus be at least delayed, if not prevented, by the in vivo use of an aldose reductase inhibitor. We have also examined other flavonoids for their ability to inhibit aldose reductase activity in the hope of finding even more potent derivatives than quercitrin (6). Possibly other flavonoids are effective in still lower doses and are more suitable therapeutically against the diabetic manifestations initiated by polyols.

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Ocean Thermal Gradients—A Practical Source of Energy?

In "Ocean thermal gradient hydraulic power plant," Beck (1) describes a scheme for extracting power from the ocean thermal gradients, a very important subject. He suggests introducing warm surface water through a restriction in the lower end of a vertical pipe, which leads to a closed, direct-contact spray condenser, cooled by water from lower ocean depths. Cavitation would occur in the restriction and steam bubbles would be formed, which would then travel up the vertical pipe, carrying water with them (as in the well-known air-lift pump) to a height of hundreds of feet.

There are a number of fallacies in this concept. Ignoring the energy required to pump the low-temperature subsurface water up to the condenser, the inefficiencies of direct-contact spray condensers, the energy required to remove air from the condenser, and the energy required to move water through the restriction, it should be noted that any vapor bubbles formed in the restriction would collapse immediately after entering the high-pressure zone just above the restriction, near the bottom of the vertical pipe. Vapor bubbles are, therefore, simply not available to provide pumping action as in the air-lift pump. Vapor bubbles would be created by boiling near the top of the vertical pipe as the warm water enters the condenser. These vapor bubbles would be available to lift the water, but then only a few inches, assuming reasonable driving temperatures such as 80°F for surface water and 40°F for subsurface water. This few inches of water, rather than a few hundred feet, is the only head available to drive a turbine to extract the energy.

One might suggest that entrained or absorbed air would be separated from the warm surface water by the cavitating restriction, and that it would provide the bubbles needed for an air-lift pump. Ignoring the fact that not enough air could be provided by this means, it should be noted that any air entering the system must be pumped from the condenser to maintain its pressure near that corresponding to the condensing steam temperature. The energy required to remove this air from the condenser is more than the potential energy stored in the water raised by the air-lift pump. Therefore, we cannot get something for nothing, using the air-lift principle.

In the report "Foam solar sea power plant," Zener and Fetkovich (*2*) propose a direct-contact spray condenser in a containment shell, which creates a low pressure that draws the warm surface water about 30 feet above sea level. At the low pressure, the warm water is said to "foam." The low-density foam elevates water to great heights, where foam breakers remove and collect it, and it then flows through a turbine. The assumption that a foam would be created and sustained during its vertical travel is questioned. It appears that the vapor bubbles formed would grow and break as they reach the liquid surface. Adding foaming agents would be impractical and polluting. A second problem with the concept is that the warm surface water, raised 30 feet above sea level, would cool as it vaporizes and would therefore require a circulation system to maintain its warm condition and allow the foaming process to continue. However, if this were the only problem, it would not be insurmountable. The real question is, how do you get water to foam rather than bubble?

Unfortunately, extracting useful energy from ocean thermal gradients still presents a series of gigantic conceptual problems.

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I should like to thank J. O. Henrie for his comments on the ocean thermal gradient hydraulic power plant (OTGHPP) scheme (*1, 2*), and particularly for his timing. A year ago many of his points would have been unanswerable.

Most of Henrie's predictions seem to be wrong according to my present understanding, some of which is incorporated into an unpublished report (*3*). Many of the engineering details are not reported in (*3*), having been developed later than the work reported, but I will attempt to provide some of that information here.

Considering Henrie's points, but not necessarily in his order, my present understanding is that the micronuclei inherent in dirty water would be activated by diffusion of dissolved air, in the first of two stages of bubble formation. Actual formation of steam bubbles occurs either very high in the cavitating venturi or, more probably, in the first part (in a fraction of an inch) of the pump tube proper through precipitous growth by evaporation. This is discussed in some detail in (*3*). While the notion that air in an air-lift pump or steam in a steam-lift pump carry water with them may be descriptive, it is more accurate to say that the water, containing most of the moving mass, is elevated to a useful height by buoyancy. While elevations of hundreds of feet are theoretically possible, a practical height of a floating system might be much less for stability reasons, as stated in (*1*). A height of perhaps 150 feet seems reasonable, but is undetermined at this time.

We cannot ignore the power required to bring the cooling water from ocean depths, but condensation should require an acceptable and fairly small portion of the power produced. The mass ratio of the water elevated in the steam-lift pump to the water used for condensing may be well over 200 to 1, because of the very large specific volume of the steam formed and so the relatively small amount of condensing water required to condense it. For effective operation of the OTGHPP, steam bubbles, wherever formed in the system, cannot be allowed to collapse, but the application of well-known design principles assures their nurture the full height of the steam-lift pump. Vapor bubbles must be available over the useful portion of the steam-lift pump tube to develop a low-density leg; vapor bubbles must be available for the system to work. But it *has* worked on a small scale, very convincingly (*3*). And the few inches of useful pumping head predicted by Henrie has been vastly exceeded, even in a small, high-friction system. The Civil Engineering Laboratory demonstration experiment (*3*) had a total height above water level of about 10 feet and a useful net working head of about 6 feet, boiling seawater from about 210°F.

Air leakage into the system is not seen as a problem in the large, simple system under consideration, which has few penetrations, no valves, and so on, in contrast with conventional vacuum systems in steam power plants. The few gasketed closures or sealed penetrations that will be used can all be protected with cold water seals. However, dissolved air is carried into the system by the water and at least partly released in the nucleation process. In fact, without dissolved air, the formation of steam bubbles is theoretically not feasible. This air would provide a trivial part of the buoyancy for lifting water, and a similar negative lift during its removal in a Taylor air compressor (*4*), where there would be a slight but finite reduction in the density of the water going to the hydraulic turbine.

I am not sure what Henrie means by "inefficiencies of direct-contact spray condensers," but available design information (*5*) predicts that with the crudest of approaches, effective condensing can be realized in simple equipment, and very close temperature approaches are possible if desired and economically justifiable. The friction in the nozzle-venturi-diffuser section is easily calculated and, in large diameters, is almost negligible. When compared with the uncertainties in the friction losses in the two-phase flow, it is trivial at this point in the refinement of the design equations.

In summary, the steam-lift pump, the completely new component in the OTGHPP (*2*), has been convincingly demonstrated on a small scale. Theoretical projections to the large sizes of potential interest in producing the large blocks of power needed are all optimistic. Nevertheless, we should not become overly euphoric until the scaled-up experiments have been done.

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Henrie is correct in identifying the foaming of seawater as the crucial process in our scheme for extracting power from the ocean thermal differences. As has been demonstrated by Abe (*1*), both natural and artificial seawater are quite foamable, in contrast to the essentially zero foamability of tap water. Whether seawater foam is sufficiently stable to operate our proposed solar sea power plant must, of course, be demonstrated. If experiments designed to settle this question are successful, we believe no further conceptual problem will block the economic extraction of power from the ocean thermal gradients.

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