bohydrate for activity. Subsequent work of course might show similarities between the sugar residues of the casbene elicitor and those of the glucan elicitors.

The question of how the elicitors are recognised by the plant is of obvious importance. In both the castor bean (Stekoll & West), and in cultured soybean cells (Ebel *et al. Pl. Physiol.* **57**, 775; 1976) exposure of the plants to elicitor results in a large increase in the extractable activity of enzymes responsible for the synthesis of the relevant phytoalexin. In the soybean cells, the activity of phenylalanine ammonia lyase, a critical enzyme in the biosynthesis of phenylpropanoids, increased many fold within 20 hours of the addition of purified elicitor, although similar but smaller increases were observed with a commercially available fungal wall glucan, nigeran, obtained from *Aspergillus niger*. It seems that the recognition mechanism, for the glucan elicitors is not very specific, especially since glucan fractions from several races of *Phytophthora megasperma* var. *sojae* all induce glyceollin formation in soybean seedlings even though the seedlings exhibit differential resistance to the various fungal races.

It may be, therefore, that the elicitor-phytoalexin system is not responsible for the extreme specificity shown by many resistance mechanisms. On the other hand, the discovery of a proteinaceous elicitor, with its inherently much greater potential for specificity, raises the possibility that specific elicitor recognition mechanisms may exist. For several years, antigenic cross reactivity between antibodies derived from soluble extracts of compatible host-parasite pairs has been reported, with generally little cross-reactivity being observed between non-compatible species. Recent work (see for example Palmerley & Callow *Physiol. Pl. Path.* **12**, 241; 1978) tends to the conclusion that such relationships obtained from studies of whole cell antigens do not account for the extreme host-pathogen specificity which is known to occur. On the other hand, there are indications from symbiotic relationships, for example the *Rhizobium*-root nodule association (Dazzo & Hubbell *Appl. Microbiol.* **30**, 1017; 1975) that cell surface antigens are responsible for specificity. In this case, common surface antigens on the *Rhizobium* and clover root hair cells, were proposed to be linked by a multivalent lectin, thus providing both specificity of recognition, and a mechanism for achieving intimate cell-to-cell contact. Speculating along these lines, and bearing in mind the capacity of lectins to bind specifically to carbohydrate residues, the possibility of fungal surface elicitors being recognised by plant lectins seems feasible. A concentrated investigation of the antigenic relationships between fungal surface elicitors and plant surface proteins would seem to be a reasonable priority for future work. □

Fuel from magma

from Robert W. Cahn

SUCH modest amounts of geothermal energy as are currently extracted go to heat houses or make electricity, not very efficiently. The heat has of course to be used where it emerges. If a way could be found to store the heat chemically—to make a fuel—geothermal energy would at once become more widely useful. Such a way is proposed in a paper published from the Sandia Laboratories in New Mexico (Northrup *et al. Int. J. Hydrogen Energy* **3**, 1; 1978).

The Sandia proposals are based on the partial reduction of water vapour at temperatures in the range 600-1300 °C in basaltic magma, with the simultaneous partial oxidation of FeO to Fe_2O_3. Basaltic lava typically contains ~10% of ferrous oxide and 1–2% of ferric oxide, partly dissolved in a silicate melt and partly as constituents of suspended solid particles. It has been shown in the geological literature that the oxygen fugacity of such lava can be simulated by certain solid oxide mixtures, such as magnetite-wuestite or nickel-nickel oxide, and the known thermodynamic characteristics of these simulant solids can be used to predict the equilibria in the proposed reduction of steam by lava: different simulant mixtures correspond to slightly different oxygen fugacities. Such calculations have been performed for a pressure of 1 kbar and compared with experimental measurements on lava at 950 °C (slightly below its solidus temperature), and good agreement established for a realistic value of oxygen fugacity. Under these conditions, the emerging gas contains 1–3% of hydrogen. These measurements refer to reactions with a low steam/basalt ratio, so that the basalt in effect buffers the steam: only a small fraction of the ferrous oxide is oxidised, and this is a necessary condition if acceptable hydrogen yields are to be achieved.

Taking this into account, it is estimated that some 2 million tonnes of hydrogen could in principle be recovered from water interaction with 1 km³ of high-temperature magma. The thermal loss arising from the need to heat the requisite amount of steam to the temperature of the magma would only cool the magma by about 50 degrees C.

The efficiency of this process could be enhanced by adding biological material, such as seaweed or cellulose, to the reacting water. This has previously been proposed on the basis purely of the heat content of magma (Poole & Williams *Bull. Atomic Scient.* **32**, 48; 1976), but without taking into account the available reducing potential. According to the new calculations, the hydrogen content could be enhanced and useful quantities of methane or carbon monoxide generated, depending on the reaction temperature.

The authors go on to consider practicalities. Plainly such a process would need to be concentrated either at mid-oceanic ridges (it is rather quaintly pointed out that sargasso weed is available conveniently for the mid-Atlantic ridge!) or along island arcs or circum-oceanic volcanic belts. The basaltic magma below mid-ocean ridges has high FeO content and high temperature and is available at a shallow depth, and the authors cite geological evidence for the availability of large coherent bodies of magma: a session on the search for such bodies formed part of the 1976 Fall Meeting of the American Geophysical Union. The practical problems in tapping such bodies, assuring intimate contact of the reagents and recovering the reduced gas mixture are immense, and the authors outline a few of the needed lines of research. □

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Electric Universe

from P. C. W. Davies

GRAVITY is the force that controls the stars and galaxies. Although about forty powers of ten weaker than electricity, the cumulative effect of gravity in a massive body of astronomical size far outweighs electromagnetic forces, which tend to be self-neutralising. The reason for this is that all matter attracts gravitationally, but can both attract and repel electrically. Electrically charged matter therefore tends to accumulate charges of the opposite sign and achieve neutrality. This is the condition of ordinary matter.

Suppose, however, that a body is very hot, so that its atoms are dissociated into positive ions and electrons. Near thermal equilibrium the