has been relatively easy to obtain with vaccines. However, HIV-1 replicates to very high levels in humans early after infection and, therefore, the most useful animal models for HIV-1 vaccine trials are likely to be those in which similar intense early viral replication is seen. Many primary HIV-1 isolates that establish nonpathogenic infections in chimpanzees do not replicate particularly well in those animals. Studies of these infections are, therefore, not likely to predict vaccine efficacy in humans. For this reason, vaccine trials with an HIV-1 isolate that replicates to high levels and induces AIDS in chimpanzees could prove very useful in assessing vaccine strategies.

A number of the vaccine strategies that have been assessed in animal models are unlikely to elicit sterilizing immunity to a diversity of HIV-1 isolates. However, some of these approaches may decrease the intensity of viremia during primary infection, lower the set-point of viral replication during chronic infection, and, accordingly, prolong survival in individuals who become infected with HIV-1 after vaccination. With lower viral loads, these infected individuals may transmit HIV-1 inefficiently, decreasing the spread of the virus in a population. A vaccine that could accomplish this, while not ideal, would certainly be beneficial in areas of the world with high rates of HIV-1 transmission and limited access to antiretroviral therapies. Preclinical evidence that an HIV-1 vaccine might be efficacious in these ways can best be ascertained in a pathogenic HIV-1/chimpanzee model.

Many investigators, like Prince and Andrus, say that the decision to use chimpanzees in experiments that may lead to their death is not warranted. With 40 million humans already infected with HIV-1 and the prediction of further dramatic spread of this virus in human populations, developing an HIV-1 vaccine is viewed as an absolute priority. However, all possible vaccine strategies for preventing HIV-1 infection cannot be tested for efficacy in human populations. The use of nonhuman primate species for HIV-1 vaccine evaluation will continue to present a difficult ethical dilemma for our entire society as it grapples with the AIDS epidemic.

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Hydrogen Chemistry of Basalt Aquifers

In their report "Evidence against hydrogen-based microbial ecosystems in basalt aquifers" (14 Aug., p. 976), Robert T. Anderson *et al.* found that they could produce only very small quantities of hydrogen gas (H_2) from chemical reaction of water and basalt rock (temperature unspecified), and then only under acidic conditions (pH = 6). In nature, however, reaction of water and mafic rocks commonly yields alkaline ground water, and can produce significant quantities of H_2. The Semail ophiolite in Oman presents an extreme case (*1*); there, rainwater has reacted with rock rich in olivine and serpentine at 20° to 50°C to yield highly alkaline ground water (pH to 12.1) and gas seeps of up to 99% (molar) H_2.

Thermochemically, the production of hydrogen gas from water can be driven by oxidation of ferrous to ferric iron (*2*). We have replicated this result in equilibrium computer modeling of basalt alteration (*3*); for instance, reaction of basalt glass and liquid water in a closed system (25°C; mass ratio of 1 to 5) yields a mineral assemblage dominated by serpentine and smectite clay, water of pH = 11.9 with 186 milligrams of dissolved H_2 per kilogram, and a H_2 fugacity of 135 bars.

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References and Notes

1. C. Neal and G. Stanger, *Earth Planet. Sci. Lett.* **66**, 315 (1983).
2. R. Garrels and C. Christ, *Solutions, Minerals, and Equilibria* (Harper & Row, New York, 1965).
3. C. Bethke, *Geochemical Reaction Modeling* (Oxford Univ. Press, New York, 1996); J. Laul, *Geochim. Cosmochim. Acta* **50**, 909 (1986).

Response

Treiman and Wallendahl suggest, on the basis of a geochemical model, that when subsurface basalt and water are combined in a closed system, a significant amount of hydrogen gas should be produced. However, as we reported, when basalt and ground water are actually mixed together, hydrogen is not produced to any appreciable extent. Furthermore, their model predicts a pH of 11.9, whereas the pH in the real ground water (8.0) is much lower. We believe that the reason for these differences between reality and the predictions of the model are that the model contains faulty parameters. For example, Treiman and Wallendahl consider a basalt glass in their model, whereas the basalts in the aquifer material were crystalline. When it is necessary to chose between theoretical results from a model and direct experimental results, it seems prudent to base conclusions on the real data.

In contrast to the assertion of Treiman and Wallendahl, the study by Neal and Stanger did not demonstrate that the rocks in the Oman system produced hydrogen by reacting with water. This was only inferred from isotopic measurements and several assumptions about isotope equilibrium and exchange. Direct experimental measurements of rock-water interaction with materials from this site are required in order to prove the source of hydrogen in this system. It is also important to note that the study by Neal and Stanger has little relevance to our study because the rocks in the Oman system have a significantly different mineralogy from that of the basalt in the aquifer in question in our study. We specifically stated that our results do not rule out the possibility that hydrogen can be abiotically produced under some natural conditions. However, as detailed in our report, our studies and the results of others strongly suggest that hydrogen produced by basalt–ground-water interactions is not the primary energy source for the microbial community in the Columbia River Basalt aquifer.

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CORRECTIONS AND CLARIFICATIONS

The figure accompanying the Perspective "A glimpse of the Holy Grail?" by Herman J. C. Berensen (*Science*'s Compass, 23 Oct., p. 642) was printed incorrectly, with parts A through C reversed. The correct figure appears below.