one, led to a high level of protection in monkeys. In their work on humans[2], Patarroyo *et al.* synthesized a 45-amino-acid peptide (SPf-66) containing these three peptides and polymerized it into a high-molecular-weight protein. Patarroyo *et al.* find that this polymer in alum induces protective immunity in human volunteers. It is worrying that one of the peptides used in this vaccine has two different amino acids in one of four isolates of *P. falciparum* sequenced[12], because vaccination of a population could rapidly select variants that are unaffected by immunity induced to the vaccine.

When it comes to testing a human vaccine against *P. falciparum*, there is a particular difficulty of evaluation. The asexual erythrocyte parasite develops in 48 hours from a young parasite, the ring form, to a mature parasite that can infect ten other erythrocytes. Because mature parasitized erythrocytes are sequestered along vascular endothelium, only erythrocytes containing ring forms are seen in the peripheral blood. After the parasitaemia reaches 0.5 per cent ring forms, for example, it decreases as the parasitized erythrocytes are sequestered or as a result of immunity. There is no way of knowing if the parasitaemia will jump, 48 hours later, to 5 per cent, a dangerously high level, or if immunity has controlled parasite development. Thus, no study of the efficacy of an asexual erythrocyte vaccine is without some risk.

The authors, aware of this dilemma, chose to treat patients at 0.5 per cent parasitaemia. But in the case of four volunteers, treatment was not initiated promptly, resulting in one of the volunteers (J.D.) reaching a parasitaemia of 4.26 per cent. The failure strictly to follow the protocol placed some volunteers at excessive risk. Had the level of parasitaemia for initiating therapy been set lower, for example, 0.25 per cent as I would have preferred, only one volunteer (W.B.) would have been protected. This illuminates a problem that will be faced in testing vaccines to control asexual parasitaemia. This contrasts with trials of sporozoite vaccines where volunteers are at minimal risk, as they are treated as soon as a parasite is observed in the blood.

What is the next step now that the first human trial of an asexual erythrocyte vaccine is completed? The top priority is the need to confirm the monkey trials in other laboratories and with other isolates of *P. falciparum*. When confirmed, the trials should be extended to include other proteins or peptides (such as the recombinant protein of RESA/Pf155)[13] to be tested in monkeys. Better adjuvants or delivery by a living organism (such as BCG or attenuated *Salmonella*) may be required. There still remains the indeterminacy of when a vaccine will be available for developing countries.

The main concern now is the selection of mutant parasites that are resistant to a vaccine. Inclusion of a vaccine against the sexual stages of the parasite can block the transmission of mutant parasites in vaccinated people. Because of the indeterminacy, countries in the developing world must continue to devise methods within their means to control malaria and to limit disease, and the research base must remain broad, including research on chemotherapy and on the mosquito vector. DDT was said to have eliminated malariologists in the 1950s because it appeared so promising. Why did scientists at that time leave malaria research for other fields although Africa was largely untouched by insecticides? This type of short-sightedness should not now dominate research priorities. □

1. Greenwood, B. M. *et al. Trans. R. Soc. trop. Med. Hyg.* **81**, 478–486 (1987).
2. Patarroyo, M. E. *et al. Nature* **332**, 158–161 (1988).
3. Miller, L. H. *et al. Science* **234**, 1349–1356 (1986).
4. Kemp, D. J. *et al. Proc. natn. Acad. Sci. U.S.A.* **80**, 3787–3791 (1983).
5. Good, M. F. *et al. Proc. natn. Acad. Sci. U.S.A.* **85**, 1199–1203 (1988).
6. Brown, K. N. & Brown, I. N. *Nature* **208**, 1286 (1965).
7. Hommel, M., David, P. H. & Oligino, L. D. *J. exp. Med.* **157**, 1137–1148 (1983).
8. Hadley, T. J. *et al. J. clin. Invest.* **80**, 1190–1193 (1987).
9. Klotz, F. W., Hudson, D. & Miller, L. H. *J. exp. Med.* **165**, 359–367 (1987).
10. Patarroyo, M. E. *et al. Nature* **328**, 629–632 (1987).
11. Patarroyo, M. E. *et al.* in *Modern Approaches to New Vaccines: Prevention of AIDS and other Viral, Bacterial, and Parasitic Diseases* (eds Chanock, R. M. *et al*). 117–124 (Cold Spring Harbor, New York, 1987).
12. Mackay, M. *et al. EMBO J.* **4**, 3823–3829 (1985).
13. Collins, W. E. *et al. Nature* **323**, 259–262 (1986).

Louis H. Miller is in the Malarial Section, Laboratory of Parasitic Diseases, National Institute of Allergy and Infectious Diseases, National Institutes of Health, Bethesda, Maryland 20892, USA.

I. I. Rabi (1898–1988)

For the last decade of his life, I.I. Rabi was the acknowledged dean of physics in the United States. He died on 11 January and with his passing goes a man of vision — the moral conscience of physics since the Second World War.

After completing his PhD at Columbia University in 1926, Rabi went to Europe to learn the new physics, studying briefly with Schrödinger, Sommerfeld, Bohr, Pauli and Heisenberg. But his work with Otto Stern during 1928 determined the course of his physical research. He returned to the United States and Columbia University in 1929. After two years of uninspired attempts to continue his theoretical work on solids, Rabi decided to go back to molecular-beam studies.

In 1931, three years after Dirac's seminal work on the quantum theory of the electron, the basic physics of the atom seemed well understood. It was the atomic nucleus that provided the questions at the frontier of physics. With the Breit–Rabi theory, developed in 1931, molecular-beam methods could be used to study the magnetic properties of the atomic nucleus — even though nuclear magnetic moments are 2,000 times smaller than those of the atom.

Rabi started with the basic Stern–Gerlach method and, through the 1930s, he added successive magnetic fields, each of which worked its influence on the tiny nuclear magnetic moments of the passing beam particles. By 1938, he had developed the magnetic resonance method, the precursor to both nuclear magnetic resonance in bulk matter and magnetic imaging. Many atoms coursed through his molecular-beam apparatus, but hydrogen was the one that captured Rabi's imagination. "Here you have a system you could understand", said Rabi. "There were no complications. Anything I couldn't understand was because there was something to be discovered."

Rabi's measured values of the proton's magnetic moment reduced the experimental uncertainties from 10 to 5 to 0.7 per cent. As a finale, he discovered, with J.M.B. Kellogg, N.F. Ramsey and J. Zacharias, the quadrupole moment of the deuteron. In 1944 Rabi won the Nobel prize for physics.

The Second World War brought a sudden halt to Rabi's research. With the cavity magnetron invented at the University of Birmingham as the centrepiece, the radar project began at the Massachusetts Institute of Technology where Rabi was the associate director of the radiation laboratory. Later, along with Bohr, Rabi served as senior advisor to J. R. Oppenheimer on the Manhattan Project.

After the war, Rabi became a statesman of science. He believed that science could be used to break through barriers that separated nations and he put this belief to practice. Rabi was instrumental in founding the Brookhaven National Laboratory in the United States and, with that as a model, he proposed to the fifth general assembly of UNESCO, in 1950, the establishment of a European nuclear research laboratory. Eighteen months later, eleven European nations signed the document establishing CERN. In 1955, Rabi saw another of the products of his efforts come to fruition: the first international conference on the peaceful uses of atomic energy, which was held in Geneva in Switzerland.

Rabi's interest in physics remained acute to the very end of his life. Each time I visited him, he wanted to talk about "the subject". Shortly before he died, Rabi said to me, "I'm going for 90". He missed by 6 months, an experimental error he would have loathed. John S. Rigden

John S. Rigden is Editor of the American Journal of Physics, 353 East 45th Street, New York, New York 10017, USA.