philic portions on both sides (Fig. 4). The phospholipid bilayer, once formed, is impermeable to ionic molecules, but these proteins are synthesized on one side of an already existing bilayer, and some of their ionic amino acid side chains have to pass through the bilayer to reach the other side. The current status of work on this problem has been reviewed (45). A similar question can be asked with reference to the entry of nucleic acids into cells, such as occurs on infection by viruses, and to the transfer of newly synthesized phospholipid molecules to the external half of a bilayer (46).

It is noteworthy that these questions do not arise in relation to an unexpected failure to attain an equilibrium state. On the contrary, they seek to explain the existence of a state close to equilibrium where there are known physical constraints that would be expected to block the approach to equilibrium.

References and Notes

- 1. J. W. Gibbs, Trans. Conn. Acad. 3, 108 (1876);
- *ibid.* 3, 343 (1878).2. Enthusiasm for the use of chemical potentials has not always been universal. For instance, in G. N. Lewis and M. Randall [*Thermodynamics* and Free Energy of Chemical Substances (McGraw-Hill, New York, 1923)] there is only one reference to chemical potentials (p. 158), in
- R. W. Gurney, *Ionic Processes in Solution* (McGraw-Hill, New York, 1953; Dover, New York, 1962), p. 90.
 J. H. Hildebrand et al., *Regular and Related*
- Solutions: The Solubility of Gases, Liquids, and Solids (Van Nostrand Reinhold, New York, 1970), chap. 5. The data given in this reference and results from my own laboratory suggest that dominishing from ideal minimum belowing when and results from my own laboratory suggest that deviations from ideal mixing behavior, as when molecules of different sizes and shapes are mixed, are small where solvent-solute interactions are weak. Only the extreme case of high polymers would constitute an exception.
 5. C. Tanford, *The Hydrophobic Effect: Formation of Micelles and Biological Membranes* (Wiley, New York, 1973).
 6. C. McAuliffo, *I. Bhys. Chem.* **70**, 1267 (1066).

- New York, 1973).
 C. McAuliffe, J. Phys. Chem. 70, 1267 (1966).
 S. S. Davis, T. Higuchi, J. H. Rytting, J. Pharm. Pharmacol. 24 (Suppl.), 30P (1972).
 R. Smith and C. Tanford, Proc. Natl. Acad. Sci. U.S.A. 70, 289 (1973).

- 9. D. B. Gilbert, C. Tanford, J. A. Reynolds, Biochemistry 14, 444 (197 10.
- J. A. Reynolds, D. B. Gilbert, C. Tanford, *Proc.* Natl. Acad. Sci. U.S.A. 71, 2925 (1974).
 R. B. Hermann, J. Phys. Chem. 76, 2754 (1972).
- 12 M. J. Harris, T. Higuchi, J. H. Rytting, ibid. 77, 2694 (1973)
- 13.
- C. Chothia, Nature (London) 254, 304 (1975).
 G. S. Hartley, Aqueous Solutions of Paraffin-Chain Salts (Hermann, Paris, 1936), chap. 7.
 H. S. Frank and M. W. Evans, J. Chem. Phys. 13, 507 (1945). 15.
- 16
- 13, 507 (1945). W. Kauzmann, Adv. Protein Chem. 14, 1 (1959). For example, see J. H. Hildebrand [J. Phys. Chem. 72, 1841 (1969)]. Arguments against the concept that invoke the vapor state [for ex-ample, R. Wolfenden and C. A. Lewis, Jr., J. Theor. Biol. 59, 231 (1976)] neglect the cohesive energy gain that is involved in forming any con-densed state. In effect, they compare no envi-ronment with an aqueous environment. A
- 18. Direct evidence for one system is given by A. A. Ribeiro and E. A. Dennis, J. Phys. Chem. 81, 957 (1977)
- C. Tanford, *ibid.* **76**, 3020 (1972); *ibid.* **78**, 2469 (1974). 19. 20.
- P. J. Flory, Statistical Mechanics of Chain Molecules (Wiley, New York, 1969), chap. 5. R. J. Robson and E. A. Dennis, *J. Phys. Chem.* 81, 1075 (1977). 21.
- Tanford, Y. Nozaki, M. F. Rohde, *ibid.*, p. 22. C 1555
- 23.
- 1555. C. Tanford, in *Micellization, Solubilization and Microemulsions*, K. Mittal, Ed. (Plenum, New York, 1977), p, 119. The optimal area depends on the strength of repulsive interaction relative to the hydrophobic free energy. Optimal areas are different for different head groups and do not remain exactly the same for a particular head group when the size of the hydrophobic mojety is changed. The 24. the same for a particular head group when the size of the hydrophobic moiety is changed. The argument in the text, based on a universal optimal range of 60 to 65 Å², is not intended to be the basis for quantitative calculations. C. Huang, *Biochemistry* **8**, 344 (1969). S. Batzri and E. D. Korn, *Biochim. Biophys. Acta* **298**, 1015 (1973).
- 26.
- 27. J. Brunner, P. Skrabal, H. Hauser, ibid. 455, 322
- C. B. Anfinsen, Science 181, 223 (1973).
 M. Levitt and A. Warshel, Nature (London), 253, 694 (1975). 29.
- M.
- C. Tanford, J. Am. Chem. Soc. 84, 4260 (1962).
 Cold Spring Harbor Symp. Quant. Biol. 36 (1971).
 This entire volume is devoted to the structures of proteins and viruses.
 D. E. Green, Ann. N.Y. Acad. Sci. 195, 150 (1972). 31.
- 32. (1972). S. J. Singer and G. L. Nicolson, *Science* 175,
- 33. 34.
- S. J. Singer and G. L. Nicolson, Science 175, 720 (1972). C. Tanford and J. A. Reynolds, *Biochim. Biophys. Acta* 457, 133 (1976). The two sides of a membrane in vivo are dis-35. tinct, and proteins that traverse the membrane (Fig. 4, B to D) are always found inserted in the same direction. This means that each surface
 - domain is at equilibrium with respect to location in an aqueous or hydrocarbon environment, but the hydrophilic domains on the two sides are

an honors graduate with distinction,

stood insisting that "heavy objects hit

the ground first because they are heavi-

er." Another scene in another country:

the student now before us was an under-

presumably not at equilibrium, there being ordi-narily no reason for a thermodynamic prefer-ence for either part to be on one side rather than the other. Sidedness is no longer present in detergent solution, and in at least some cases pref-erence for one direction over the other is lost when previously solubilized proteins are rein-serted into vesicles. See, for example, L. Pack-er, C. W. Mehard, G. Meissner, W. L. Zahler, er, C. W. Mehard, G. Meissner, w. L. Zamer, S. Fleischer, Biochim. Biophys. Acta 363, 159

- Y. Nakashima and W. Konigsberg, J. Mol. Biol. 36. 88, 598 (1974)

- Yanamara and Y. Rolngsterley, J. Mol. Biol. 88, 598 (1974).
 B. K. Chamberlain, Y. Nozaki, C. Tanford, R. E. Webster, in preparation.
 L. Spatz and P. Strittmatter, Proc. Natl. Acad. Sci. U.S.A. 68, 1042 (1971).
 L. Visser, N. C. Robinson, C. Tanford, Bio-chemistry 14, 1194 (1975).
 D. Corcoran and P. Strittmatter, Fed. Proc. Fed. Am. Soc. Exp. Biol. 36, 897 (1977).
 The model shown is based on a model suggested by Inouye (42) for a bacterial lipoprotein [V. Braun, Biochim. Biophys. Acta 415, 335 (1975)] of known sequence. The ratios of hydrophilic to hydrophobic amino acids are, however, re-
- M. Known sequence: The factors of hydrophille to hydrophobic amino acids are, however, re-versed.
 M. Inouye, *Proc. Natl. Acad. Sci. U.S.A.* 71, 2396 (1974).
 Bacteriorhodopsin occurs in the purple mem-42.
- 43.
- Bacteriorhodopsin occurs in the purple mem-brane of *Halobacter halobium* in a two-dimen-sional crystalline array, and its structure, con-taining seven transmembrane helices per mole-cule, has been determined to a resolution of 7 Å [R. Henderson and P. N. T. Unwin, *Nature* (London) 257, 28 (1975)]. The amino acid se-quence is not known. A. Klug and A. C. H. Durham, in (31), p. 449; A. Kellenberger, *Ciba Found. Symp.* 7, 189 (1972). J. E. Rothman and J. Lenard, *Science* 195, 743 (1977). The mechanism has to be vectorial be
- 44.
- 45. (1977). The mechanism has to be vectorial because transmembrane proteins are always in-serted in a unique direction (35), and it appears to be effective only at the actual time of biosynthesis of a polypeptide chain. A more subtle problem that has not been active-
- 46 ly pursued has to do with differences in acyl chain composition of lipids from different mem-branes. About half of them are generally unsaturated, which serves to prevent crystallization of the hydrocarbon core of the bilayer and keep it fluid. But no known purpose is served by such deviations from the norm as the presence of docosohexanoyl chains (six unconjugated double bonds) as the predominant unsaturated chains in retinal rod outer segment membranes. Similarly, there is no obvious functional need for the pres-ence of cholesterol in the membranes of eukarvotic cells.
- Abreviations: Ala, alanine; Glu, glutamic acid; Gly, glycine; Asp, aspartic acid; Pro, proline; Lys, lysine; Phe, phenylalanine; Ser, serine; Leu, leucine; Gln, glutamine; Thr, threonine; Tyr, tyrosine; Ilc, isoleucine; Trp, tryptophan; Met, methionine; and Val, valine. 47.
- I am grateful to J. A. Reynolds for numerous helpful suggestions in the preparation of this ar-ticle, and to the National Science Foundation 48 for research support.

graduate, but older than most. He knew and understood well much of what is taught in an American graduate physics curriculum; he had taught himself physics while in hiding during the 1970-1972 Bangladesh war. The student had few formal qualifications, but he was very good.

This was the Physics Interviewing Project (1). The incidents indicate the nonuniformity and sometimes unreliability of degrees, honors, and rankings. And they point up the value of a personal interview, which is why there is a Physics Interviewing Project. The Project, organized about a decade ago by M. J. Moravcsik of the University of Oregon, aids foreign students seeking admission and support from Western graduate physics

A Tour of Interviews in Asia Earl Callen and Michael Scadron

The Physics Interviewing Project:

The American professor stood on a rickety laboratory stool, a 1-rupee coin in one extended hand, an iron pendulum bob in the other. The Asian physics student, a Master of Science candidate and

0036-8075/78/0602-1018\$01.25/0 Copyright © 1978 AAAS

departments, and assists those departments in selecting promising foreign students. A major purpose of this article is to encourage other disciplines to emulate an activity which, it seems to us, has served physics and developing countries well.

The Project operates by sending one or two physicists on an interviewing tour about once every 2 years. To date there have been five trips to Asia and one each to Latin America and Africa. Before each trip U.S. and other Western graduate physics departments are invited to support the Project. Most of our sponsors are in the United States, but British, Australian, and Canadian schools have also joined us. Travel costs of the trip currently \$350 per school—are borne by recommendation on their behalf, sometimes 2 or 3 years after the interview. This we do critically on the basis of many comparative records. Through our program, excellent students who would otherwise have been lost to science have completed higher degrees and are returning as practicing scientists to jobs in Malaysia, Indonesia, and Sri Lanka, where they are needed (2).

The Physics Interviewing Project has been described in detail elsewhere (1). In this article we wish to record some personal observations that seem to us to be invariant from trip to trip, in the hope that our comments will stimulate others to a more active participation in aiding science in the Third World. There is good work to be done here and a real need, but

Summary. The Physics Interviewing Project assists graduate physics departments in evaluating foreign applicants. Supported by some 20 universities, two interviewers, both working scientists, travel abroad and interview students individually for about 1 hour each. Prospective teaching assistants are rated on physics knowledge, problemsolving ability, and English language proficiency. Ratings on all interviewees are sent to all supporting schools and other schools as requested. The Project aids able students from countries that have no physics Ph.D. programs (Indonesia, Malaysia, Thailand) to obtain assistantships and Ph.D.'s abroad, assists in the technological development of those countries, and helps U.S. schools in selecting the most promising foreign candidates. A similar program should be beneficial in other sciences.

the sponsors. There are no profits, no salaries, and very little overhead.

Each trip lasts for 1 month, during which we visit about 20 schools in ten countries, and interview a half-dozen or so of the best students at each school. Interviews are 1 hour in length, one student at a time, and are often conducted by the two interviewers together. After the interview we write up an evaluation of the student—his (or her) English language proficiency, his knowledge of physics, basic and advanced, and what we deem to be his promise as a scientist; more specifically, we try to see if he can earn support as a graduate teaching assistant.

On our return home these graded evaluations are sent to the sponsoring schools. After our last trip each of 19 sponsors received evaluations of 129 students. It is then up to the schools and students, but we do offer further assistance in bringing them together. After a month or so, we also send, at no charge, an evaluation to any nonsponsoring school requested by the student or, with the permission of the student, to any school that asks it of us. We are often requested by students to write letters of one must begin by understanding some of the problems faced by science in developing nations. We write here only of our experience in Asia.

Asian Students

One observation, not original here but sufficiently important to justify repetition, is the unscientific attitude of many members of the Asian scientific community (1, 3). Rather than a methodology for problem-solving, science is embraced as an orthodoxy; it is learned by rote and recited back as catechism (4). This may be due in part to the insecurity of the often-underqualified faculty and the absence of an active, evolving scientific and technical milieu. As Moravcsik and Ziman (3) have written, "Practice shows, however, that without the benefit of continued personal involvement in scientific research, such people not only quickly fall behind the fast-growing content of the sciences but also become divorced from the spirit of science as the art of problem solving. Evidence of this is unfortunately all too obvious on the Indian subcontinent, where the stifling system of rote learning and regurgitation for examinations is closely connected with these ubiquitous shortcomings in the science instructors."

One regularly encounters B.Sc. and M.Sc. students manipulating advanced and esoteric formalisms-Young tableaux and the renormalization groupunder faculty whose Ph.D. and research niche have been acquired in the West. The rules of the game have been imported but the context left behind. One of us sat in on a junior-level course and heard the instructor recite more or less verbatim an article by Feynman on the theory of positrons (5). Berated by us later because they could not describe the motion of a ball dropped into an imaginary hole drilled through the earth, students argued that those were last year's problems; this year Feynman graphs mattered. On each trip we encountered honors students who could not, even with prodding, calculate the height to which a ball, thrown up with a given velocity, would rise. In another country a student of magnetism was manipulating the formalism of temperature-dependent, twotime Green's functions under his Oxfordtrained professor, but he seemed to have formed no image of what his Green's functions represented. He could not calculate the quantum mechanical reflection coefficient of a one-dimensional square step, or figure out with what velocity a mass constrained by a string to rotate in a vertical plane must move at the bottom of its orbit so as to just get over the top without falling. This student is intelligent; he simply has not done enough problems or been trained to think like a physicist.

The contribution an exchange scientist can bring to Asia, more important than a demonstration of tripping the latest light fantastic of the pace-setters, is to teach undergraduate science courses with a recitation section and a heavy dose of homework problems. Physics students need to walk with Halliday and Resnick (6) before flying with Feynman.

That being said, we must stress that many brilliant physicists have come from Asia and some have received their higher degrees in the West. Of the 600 students interviewed on our four trips to Asia, about 5 percent seemed to us to be outstanding, 10 percent able to succeed at the best U.S. graduate schools, and fully another one-third seemed as gualified as the entering graduate students of most schools here. The geographic distribution of better students is almost uniform and random throughout Asia. Nor do the best students always come from the "top" schools or from the more technologically advanced nations. On the most recent trip it was our judgment that the most promising student was from central Java.

Of course, we tend to see the best stu-

Earl Callen is a professor in the Department of Physics, American University, Washington, D.C. 20016, and Michael Scadron is a professor in the Department of Physics, University of Arizona, Tucson 87721.

dents, and the best are at the point of a pyramid-one, however, not built solely on merit. In Hong Kong of the 150,000 children who are graduated from the sixth grade each year, most are finished with schooling at age 12, beginning a lifetime of serious work at age 14 because child labor laws forbid heavy labor below that age. Of the 15,000 who are graduated annually from the high schools, 2000 are admitted to the two public universities, the University of Hong Kong and the Chinese University (the total enrollment at college level is 6000). Hong Kong is rich and advanced. In poorer Asian nations the screening process and dropout rate are far more severe. (We exclude China, Taiwan, and Japan from this discussion.)

A major barrier facing the Asian student is cultural. Self-assertion and aggressive self-promotion are not admired traits in Asia. The better student is often reluctant to push for admission, support, or travel funds, leaving it instead to the system, to fate, or to the will of the gods. In our experience it is often the mediocre but more aggressive or better-connected students who manage to find their way to foreign graduate schools. The best Indonesian students on each of our past three trips had a difficult time obtaining travel funds, after being admitted with support to sometimes more than one of the graduate schools supporting the interviewing trips. These students received no encouragement from their government, but they would have been content to wait another year, or to accept passively the dictates of an unresponsive system, had we not urged them to pursue their studies in a determined manner.

The English Language

Communication across the cultural and language barrier is a major impediment to evaluating the foreign student's technical competence. [Fortunately, other measures-rankings, GRE's (Graduate Record Examinations), grades, and recommendations-are variously available.] We interviewed only in English, which is less chauvinistic than it sounds because fluency in English, sometimes inaccurately assayed by the TOEFL (Test of English as a Foreign Language) test (1), is necessary if the student is not only to attend lectures in the United States but to serve as a teaching assistant.

In states newly formed or liberated (of the nine countries we last visited, six have recently changed their status) nationalism runs strong, and there is a powerful urge to revert to a native language. It is ironic, and surely must be galling, that the only common tongue, the unifying language in which members of polyglot indigenous groups within the nation communicate, is the imposed language. English plays such a role in India, Sri Lanka, Bangladesh, Pakistan, and Malaysia. Many of these countries, asserting their nationalism, revert to the tongue of a dominant group to the disadvantage of the many minority groups who do not speak that language or dialect. In this respect it is remarkable that Indonesia, a country composed of a multitude of islands and supporting a myriad of languages, is now unified under a common Malay language, Bahasa Indonesia. From the narrow perspective of science, the displacement of English, the international language of science, while understandable in a nation promoting its newly rediscovered identity, can be disruptive of technological development.

Consider the case of Sri Lanka. During the late 1950's and early 1960's the Bandaranaike government, purifying Ceylon of foreign influences, attempted to impose the indigenous and majority tongue, Sinhalese, on the minority onethird of the population, mostly Tamilspeaking south Indians. Sinhalese was decreed the language of the civil service and of the upper levels of the school system. Today, English is the medium of communication between the Sinhalese and Tamil communities. Although there is an effort to have some subjects taught in Sinhalese, English has remained the language of science.

India, with its almost 200 languages and dialects, is another country in which the government has retrenched on its language policy. Emergency Rule notwithstanding, former Prime Minister Indira Gandhi did not force Hindi on the civil service or the schools. In recent years there have been few language riots, but a decade ago they were rampant. English remains the common link between the northern Hindi, southern Tamil, and eastern Bengali communities, and most Indian science students are trained with English textbooks.

Malaysia is going the other way. When Singapore (80 percent Chinese) and Malaysia parted company, Muslims gained a thin political edge in Malaysia—42 percent Malay Muslim, 38 percent Chinese, and about 10 percent Tamil Indian, plus others. The edge may be narrow, but it is firmly held. Malay is sternly enforced as the national language, and Islam is the national religion. Malaysia has its own brand of affirmative action, "Malay privilege." To help Malays achieve parity with the more successful Chinese, civil service jobs, scholarships, and the better industrial jobs are reserved for Malays. At the University of Malaya, where most of the faculty and students are Chinese, the first-year courses, in 1975, had to be taught in Malay, and now Malay is also required in second-year courses. So far there are few intermediate or higherlevel science books translated into Malay. Over the years we have watched the quality of physics improve at the University of Malaya, which is now on a par with the best Asian schools, but the language policy is impeding further progress. At Kebangsaan University, the new Malay language school, all students are of Malay stock. Here the English language facility is poor, presumably from lack of usage, and the physics is weaker, probably because of the lack of Malay language physics textbooks.

The contrast between Malaysia and Indonesia is interesting. The impact of the small Chinese community on the Indonesian universities is much less than that in Malaysia. Javanese Malays make up the bulk of the faculty and student body at the three Javanese universities, probably because of their strong intellectual tradition (and also in part because of the anti-Communist, anti-Chinese suppression a decade ago). This is reflected in the quality of the Malay students of Java compared with those of Malaysia. In fact, on three interviewing trips we have seen one excellent Ph.D. prospect at the University of Indonesia in Jakarta, four at the Bandung Institute of Technology, and two at Gadjah Mada University, Jogyakarta (probably as high a ratio of top students to the student population as anywhere in the Third World). Some faculty members at Kebangsaan University in Malaysia are in fact Malays recuited from Indonesia.

Asian Universities

It is refreshing to discover that there are still countries in which scientists are in demand. The rapidly developing nations, such as Iran, Malaysia, and to some extent Indonesia, need technically trained people, and these are astonishingly scarce in industry, in the government, and even in the universities. In Malaysia there is a good job awaiting every technically trained Malay. Even in Sri Lanka and Nepal, without expanding economies, university positions are occasionally promised and held for students obtaining a higher degree abroad. In Indonesia, with 120 million inhabitants, there are at most 30 Ph.D. physicists (who recently began an Indonesian Physical Society), which means that the ratio of physicists to the population at large is roughly 1000 times smaller than in the West. Iran is buying 15 nuclear reactors, laying down an electrification grid, installing computers, building up a vast military force with sophisticated electronic weaponry, and buying turnkey factories. In Iran there are 65 doctoral-level physicists.

In recent years the emphasis of graduate study in the West has shifted from theoretical science toward applied fields. There seem to be two schools of thought about what the proper emphasis is in an underdeveloped nation. One school holds that role models are needed to nucleate cultural change. An internationally famous scientist, a Nobel Laureate, stimulates interest in science and technology. Particle theorists and cosmologists are particularly favored because the subjects are "glamorous"-and theoreticians are cheap. The other school maintains that a poor nation should focus its limited scientific resources on its short-term material needs-mechanization, agriculture, housing, health, energy, water, mineral and fuel resources, and defense. Climates vary and the pendulum swings, but today Indonesia is following the "practical" swing of the West.

In a letter inviting the Physics Interviewing Project, Tjia May-On of the Bandung Institute of Technology stated that "the manpower market here has undergone considerable changes lately. Physics graduates are no longer being let alone by the industries. Many of our would-be graduates are either committed by contracts to big companies or have other plans of their own. It will take something really convincing to get them interested in further academic work." Tjia suggested that the Project best serves the current interests of Indonesian students when it assists their placements in applied physics programs. Of the 20 Indonesian students recently interviewed, seven indicated interest in geophysics and only five wanted to pursue modern theoretical physics. One of the outstanding Indonesian students interviewed on the 1971 trip, and one who could soar with Feynman, recently returned to Bandung from the United States with a straight A average and a higher degree in geophysics.

In spite of the great need, the Indonesian government has done little to 2 JUNE 1978

promote technical education. Universities are badly underfunded, school laboratories are poorly equipped, libraries have almost no journal subscriptions (one university has a single subscription to the Physical Review, another several hundred miles away receives Physical Review Letters, neither gets much else in physics). Faculty salaries are extremely low. Teachers are civil servants, paid according to the very low Indonesian civil service pay scale. To make ends meet, junior faculty must moonlight at other iobs. The Indonesian scientists who teach at Kebangsaan University in Malaysia earn ten times as much as their colleagues back home. There is little government money for technical training abroad. Bright students now tend to go into economics, business, and government. Nonetheless, over the years we have met many dedicated young student scientists whom we considered good enough to succeed at any U.S. graduate school.

Malaysia, Hong Kong, Singapore, and Iran, in contrast to Indonesia, support education handsomely. Faculty salaries and sabbatical leave supplements are excellent, surpassing Western standards when the cost of living is taken into account. Malaysia has well-equipped laboratories and a scholarship program for training Malays (only) abroad. The undergraduate laboratories at the four universities in Hong Kong and Singapore are equal to those at the best U.S. universities. The college graduate from Singapore has performed x-ray spectroscopy and electron spin resonance experiments and has put together transitor circuitry. But in Singapore the government of Lee Kuan Yew, following the lead of South Korea, requires male citizens to spend a number of years in the military before university training.

Iran is rapidly opening new universities, some, such as Arva Mehr, with technical emphasis. The governmentsponsored faculty development program is so well funded and accessible that faculty complained to us that mediocre students are being offered faculty contracts by new universities and sent abroad for training. The criticism could not be fairly leveled at Arya Mehr, where one feels the excitement of research, but it has a familiar enough ring in rapidly developing countries. One hopes that the Iranian schools do not make that common mistake of new installations of saturating quickly and permanently with an inferior staff. We did note that the students we interviewed in rich Iran were less keen than their much-neglected counterparts

in Bangladesh, Sri Lanka, and Indonesia. Experience in Asia suggests that this is not so much a matter of intrinsic or cultural differences as financial ones. The government of Iran provides ample opportunities to study abroad; hence, the teaching assistantships we potentially represented were not so desperately needed. Nevertheless, we felt that the Project was performing a useful service in Iran by providing advice on how to apply to Western graduate schools and how to pick a school. Our question "To which American universities do you plan to apply for admission to graduate study?" was answered all over Asia with disproportionately the same few names Berkeley, Stanford, the California Institute of Technology, and Princeton are named 25 percent of the time, by even the poorest students. A pamphlet (7) which the Project distributes at its interviews is an aid in informing foreign students of the names and addresses of the 180-odd U.S. schools with graduate programs in physics, and how to apply to them.

The demand for technical manpower in Malaysia, Indonesia, and Iran has a number of other implications. It suggests that students from those countries who obtain advanced degrees in the West, where they can rarely find jobs today, are likely to go back to their own countries and be gainfully employed. We have observed that this is the case for Ph.D.'s from Malaysia, Indonesia, Thailand, Singapore, and Sri Lanka. It would be better if Ph.D. training were provided in Asian countries, as part of a whole interwoven fabric of a scientific establishment. But Ph.D. programs do not exist in any of the nations named above, and until they do the West provides a valuable service in giving quality Ph.D. training, and we need not worry about brain drain. Here the Physics Interviewing Project has been helpful. In years when the Project visited the University of Malaya, for example, three or four persons were placed in U.S. graduate programs; during off years none or only one received offers (8).

On the other hand, students from the Indian subcontinent tend not to return home. (We are of the opinion, based on personal experience, not interviews, that this is also true of Taiwan, and to a lesser extent of Hong Kong.) During the Bangladesh war, emigré scientists from both Pakistan and Bangladesh were powerfully pulled by nationalism, but today the flow appears to be outward, although less than in the prewar years. This was attested to by the great number of students who wished to be interviewed; in 1975, there were 39 at the University of Dacca alone. Of the 19 we ultimately interviewed there, 14 left unanswered the question about graduate schools to which they were applying. One wrote, "any American university."

About the propriety of interviewing in such countries, we are torn. We find it hard to turn our backs on bright, eager young persons. But objective considerations argue against importing students who will, in all likelihood, not return to their native lands. This is particularly true of India (9), because the Indian universities are now well equipped to train their own Ph.D.'s. Developing countries need technically competent brainpower, and the United States already has a glutted job market (10).

Finally we must comment on the tragic state of affairs in Bangladesh. The high quality of physics, indeed the fact that research and education continue at all, is a testament to intellectual tenacity in the face of overwhelming adversity. On the 1973 and 1975 trips we interviewed almost a dozen excellent students at the University of Dacca. On both occasions we sensed the extraordinary Bengali thirst for knowledge (11). The university, utterly lacking in funds and in material things (there was no chalk, little paper, and no light bulb for the projector), is propelled mainly by enthusiasm and by the several first-rate Bengali scientists who returned home before and after the war. The Bengali intellectual tradition, renowned in the days of the British raj, remains intact.

This is about all that does remain intact in this country ravaged by man and nature alike. The 55,000 square miles of Bangladesh-the size of the state of Iowa-often flooded and much of it marshlands, supports a population of 80 million (12). The country has almost no raw materials. There are few exports, except for what remains of its oncethriving jute industry (a great deal of the jute is now smuggled illegally into Indian jute mills across the border). Rice is imported. The price of rice skyrocketed to 400 takkas a mound (50 cents a pound) in 1974, ten times the prewar cost, but has now fallen to 250 takkas a mound. We were warned not to use butter in the restaurants because diesel fuel is often substituted for it. Cement is unavailable, and so construction has ceased since the "successful" 1971 war of liberation. There is a widespread conviction now in both Pakistan and Bangladesh that Pakistan won by losing, but there is no going back. Too many people have been slaughtered for that.

On the last trip we arrived in Dacca immediately after the third of three bloody coups-one a month, the murder of the staff of a television station, the massacre in a Dacca prison of the top aides of the liberation leader Sheik Mujibur Rahman (who had himself been assassinated in the first coup in August along with almost all of his family), and the annihilation in Chittagong of 18 members of his administration. [This was reported in Indian newspapers; the censored Bangladesh press carried no word of this, and we knew more of what was going on than our hosts in Dacca (13)—in fact, more than the reality (14).] On the campus, as everywhere in Dacca, we were repeatedly confronted by beggars-legless, insane, palsied, blind, diseased, or merely starving. Swollen-bellied children surround one, imploring alms. Our interviews were stopped three times one afternoon by beggars who entered the campus office, shuffled close, and finally, emboldened by desperation, begged at our desk, their arms extended across our papers. A physics professor explained in quiet resignation: "If everyone would be willing to eat only one or two meals a day there would be food for all. But some people want to have three meals, and so, of course, others must have none."

The University, and all of Bangladesh, is in disarray. The 1974 bachelors degree graduation tests had not yet been given in 1976. Yet, somehow, it goes on. In this ambience the physics department pursues physics-theory of elementary particles, general relativity, many-body interactions in solids, critical exponents. And here we lectured to filled auditoriums on our seemingly arcane and irrelevant pursuits (15).

References and Notes

- 1. F. E. Dart, A. G. De Rocco, M. J. Moravcsik, M. D. Scadron, Exchange (fall 1975), pp. 29-
- A letter from a very good student, who was interviewed in 1975 and is now studying at one of our sponsoring institutions, reads in part: "Hong Kong is a small place and her institutions or the provide the provide the studying of the provide the studying of are unknown to most overseas institutions. Only very few students here can study abroad, not be-cause they are more eligible but only because they can afford. For most people who joined the local institutions, there is actually no way for them to show their potentiality for further study. I myself would not have been offered assistant-ships without the evaluations of your com-mittee. The work of the Interviewing Committee is really a great encouragement to the eligible candidates in unknown foreign institutions,

whose research interest and potentiality would otherwise have been ignored by the world." M. J. Moravcsik and J. Ziman, Foreign Affairs

- 3. 53. 669 (July 1975). 4. One of our interviewers, who spent a year helping to set up the course of physics instruction at Indian Institute of Technology, Kanpur, recalls a question from the ritualized annual examina-
- tions by which students were selected for ad-mission: (Q) Name the three elements of the earth's magnetism; (A) Intensity, variation, and dip. Kanpur students, however, are now among the best in Asia.
- R. P. Feynman, Phys. Rev. 76, 749 (1949). D. Halliday and R. Resnick, Physics for Stu-dents of Science and Engineering (Wiley, New
- York, 1960). 7. F. E. Dart and M. J. Moravcsik, *The Physics* for the barrier of the second second
- H. T. Tan, private communication
- The decision has been made for us in the case of India. After the 1971 tour, it was related to us that the Project had caused consternation in Indian government circles, where it was referred to as a CIA front. In preparation for the 1975 trip we had written to the University of Madras; the Indian Institute of Technology at Kanpur, Delhi, and Karagpur; and University College of Science and Technology, Calcutta. Madras re-sponded that "It is a question that can be dealt with only by the Government of India and not by the University. Hence it is regretted that it is not possible to accord the permission sought for. The Indian Institute of Technology at Kanpu Kanpur and Delhi wrote that the visit required government clearance, but seemingly either failed to apply for or to receive such clearance. heard from them no more. The Indian Institute of Technology, Kharagpur, and University College, Calcutta, never responded to our initial or follow-up letters of inquiry. The universities are not to be blamed for caution in the Indian politcal climate of the time
- Here the interest of U.S. universities runs coun-10. ter to the national interest and to that of the sci-ence professions. That the universities have endeavored to keep graduate classrooms filled, teaching and assistantship slots occupied, and research laboratories manned by graduate stu-dents by lowering standards domestically and by importing students from abroad, and have done this irrespective of the ultimate disposition of the Ph.D.'s produced, is but another example of the "tragedy of the commons" [see G. Hardin, Science 162, 1243 (1968)]. 11. Roughly 200 students and staff packed in for
- each of the three seminars we gave on the two
- 12. If the current growth rate of 3 percent continues, the population will rise to 230 million by the turn of the century. Even if the fertility rate were to drop immediately to the replacement level, the population would double in the next 22 years.
- A tightly controlled press is the rule in Asia. The newspapers read like advertising brochures. A front page story in the Tuesday, 25 November 1975 Karachi Sun read: "The people of Karachi gave a heart-warming send off to President Fahri S. Koruturk of Turkey vesterday morning on his 13. gave a heart-warming send off to President Fahri S. Koruturk of Turkey yesterday morning on his departure after a week-long historic visit to the country. Crowds thronging the airport burst into cheers and full-throated slogans of Pak-Turk Dosti Zinzbad as the Turkish head of state waved to them and said Khuda Hafiz.... Large-size portraits of President Koruturk and Prime Minister Rhutto morked the decoration of Prime Minister Bhutto marked the decoration of the airport terminal building. The building was also decorated with multi-colored buntings, fes-
- toons, banners and streamers." In November 1975, on the day we arrived on the 14 University of Dacca campus, Calcutta newspa-pers reported that "Dacca University continues to be closed "And on the day we interviewed to be closed. And on the day we interviewed there, the Indian press reported a student boy cott and demonstrations, shooting of 28 students by the army, and the arrest of student leaders. If any of this occurred we saw no sign and heard no word of it. But we saw plenty of barbed wire, closed-off streets, great army tanks at principal intersections, and police checkpoints enforcing
- the nightly curfew. Recent articles in the Western press point to two good rice harvests as a sign that this year things are better in Bangladesh, at least economically. In 1977 there was yet another military coup.