Letters

Laser Isotope Separation

The report on uranium enrichment by Robert Gillette (News and Comment, 22 Mar., p. 1172) is an excellent summary of interest in the possibility of laser isotope separation (LIS). However, some of the statements may inadvertently help to perpetuate common misconceptions regarding the role of enrichment in the economics of nuclear power. Many assume that LIS will result in greatly reduced costs of generating nuclear power. The projected fuel costs of nuclear power for the plants now planned and under construction are 12 to 15 mils per kilowatt-hour. Since the present cost of the enrichment part of the fuel cycle is only about 0.5 mil/kw-hr, the result is likely to be a reduction in the total cost of nuclear power from 15 mil/kw-hr to approximately 14.5 mil/kw-hr, an important but not earth-shaking saving. The recent dramatic price increase in oil and coal have increased the price of some fossil-generated electricity by 15 to 20 mil/kw-hr, to a present total of 25 to 30 mil/kw-hr.

The possibility of removing 100 percent of the ^{235}U from the ^{238}U is an intriguing prospect but one which is probably not practical with LIS. However, if this goal is achieved it would indeed increase the nuclear fuel supply by the amount of ^{235}U now left in the "tails" from the diffusion plant. A successful centrifuge enrichment plant might show a similar although smaller advantage if it is desirable and economic to operate it in this mode. The obsolete electromagnetic separation process achieved almost complete removal of ^{235}U from the tails and had low power costs, but it failed to meet the economic criteria.

The effect of LIS on breeder reactor economics will be negligible because the breeder reactor requires so little uranium fuel that even at $500 a pound the uranium fuel cost is less than 1 mil/kw-hr. By the year 2000 there will be enough uranium in our stockpile of tails from enrichment plants to fuel 1000 breeder reactors for 300 years. The existence or nonexistence of a cheap isotope separation method will have a second-order effect on the complex mix of calculations involving capital, uranium ore, enrichment, and other fuel cycle costs used in determining the comparative economics of breeder and light water reactors. The United States has enough reserves at less than $500 a pound to fuel a greatly expanded breeder nuclear electric company for 100,000 years at a cost for the uranium fuel of less than 1 mil/kw-hr.

There is no doubt about the importance of active research in this field, but one needs to be cautioned against expecting early commercial success. There is a very low probability that this process can be brought to the point where it will affect plans for expanding enrichment production facilities to meet the nuclear fuel needs of the 1980's. Further, the private U.S. corporations that are actively working in the uranium enrichment area will be given the opportunity to review LIS work at the laboratories of the Atomic Energy Commission in order to make an independent judgment of the future commercial potential of the process.

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Disruptions at AAAS Meetings

Now that disruptions at AAAS meetings have largely subsided, a backward glance provides some perspective about the unique phenomenon known generally as "Science for the people." I have attended AAAS meetings at intervals since 1933, served on the AAAS council for a number of years, and had the opportunity to observe rather closely and to attend some of the meetings and planning sessions of the activists since the Boston meeting in 1969. My impressions can be summarized as follows.

1) There is a lack of unity within the activist group. They fight among themselves and accuse each other of having the same faults as those they attack. They yell obscenities at each other as violently as they do at the "establishment." Their own meetings often end in disruption.

2) They lack a positive program or cause. They are "against" the establishment, but not really "for" anything specific. Their criticism is destructive rather than constructive in nature.

3) The dissidents and activists have the same symptoms of "illness" as they claim for society. They seem to be driven by fear and frustration occasioned by the draft (in earlier years), unemployment, lack of political power and recognition by society, and mistrust of their elders.

Some of them are undoubtedly sincere in their beliefs and some are worthy of careful attention, but they are learning that disorderly protest and violence are not the answers. They can bring problems to the surface, but they cannot solve them by their tactics.

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Japanese Conception of Nature

In "The conception of nature in Japanese culture" (25 Jan., p. 279) Masao Watanabe lists two examples of possibly "positive and unique contributions to science that were related to the intellectual and spiritual traditions of Japan and that would not likely have been made by Western scientists. No doubt the examples Watanabe cites will provoke disclaimers, but I should like to offer what may be an equally good example of what he proposes. The case I have in mind relates to China rather than Japan, but from the context of Watanabe's account and from some of the specific stories he relates, this example would undoubtedly reinforce his arguments.

In 1957, Lee and Yang published an unexpected theory on the nonconservation of parity. The first confirmation came from experimental work done by Wu at the National Bureau of Standards. My wife, who is an artist, ob-

served at that time that this creative departure from deeply rooted assumptions of contemporary science might be more likely to occur in the minds of persons who grew up in a radically different cultural tradition, and that it would be more likely to be assumed worthy of testing by a like-minded individual (*1*). She noted that Lee, Yang, and Wu had all been born in China, where there is less of an obligation, in traditional art forms, to paint "a balanced picture," and where writing is in ideographs instead of in an alphabet and is vertical from top to bottom and right to left instead of horizontal from left to right. It was her surmise that Lee, Yang, and Wu, having grown up in one tradition and converted for the purposes of their scientific pursuits to another tradition, could scarcely be unaffected by their prior cultural upbringing and linguistic tradition. They would perhaps be more skeptical of the Western conception of the conservation of parity than would a scientist confined to the Western cultural traditions.

The creative process in science has been considerably neglected, especially in recent decades, in Western science. There is a tendency to favor the logical positivist explanations as to how science progresses. Whorff (*2*) and Vygotsky (*3*) among others have perceived that differences of language impose differences of thought processes that are bound to affect our conceptions of reality. This argument is not refuted by evidence of the common denominators among different languages (*4*). Exceptional thinking is what progress in any field depends upon. Boulding (*5*) rightly indicates that all we have access to are images, of which only rude elements can be considered innate. Boulding proposes "eiconics" as a discipline that aims to discover how images are processed during thinking and suggests that study in this direction could open new dimensions in science.

Perhaps one of the most useful practices in science, recently badly neglected, is the cultivation of cross-cultural communication, through the international exchange of scholars, and the furtherance of research into the creative processes involved in science. Cross-cultural exchanges that result in unusual combinations of thinking may greatly facilitate the effective pursuit of science. Perhaps investigations of these processes can be fostered even within Western scientific traditions by proper utilization of materials in the history of science and the history of ideas in reference to social and cultural differences.

There has been much talk, needed and appreciated, about the limits to growth, but as far as the future can be envisioned, there seems to be an unlimited opportunity for growth of constructive thinking, an important ingredient of which may be the utilization of schemes of consciousness that have only tenuous credentials in our own tradition of thinking. It is for this reason that Watanabe's contribution is so refreshing.

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2. B. L. Whorff, *Language, Thought and Reality*, J. B. Carroll, Ed. (MIT Press, Cambridge, Mass., 1956).
3. L. S. Vygotsky, in *Thought and Language*, E. Hanfmann and G. Vakar, Eds. and Trans. (MIT Press, Cambridge, Mass., 1962).
4. N. Chomsky, *Language and Mind* (Harcourt, Brace and Jovanovich, New York, 1972).
5. K. E. Boulding, *The Image* (Univ. of Michigan Press, Ann Arbor, 1956).

Watanabe states that, "although the Japanese people have been frequently visited by earthquakes, they did not initiate the scientific study of earthquakes. This can be explained largely by their attitude of coexisting with nature."

The realities may be more complex than this explanation suggests. It would be incorrect, of course, to argue that there is nothing distinctive about the Japanese attitude toward nature as contrasted with the Chinese attitude. However, most of the elements that Watanabe has chosen to describe in connection with the Japanese conception of nature were also (and in many cases, originally) Chinese, as, for example, the idea of the heavenly stems. Yet the Chinese did, in fact, study earthquakes at a very early date and even seem to have invented a machine to study earthquakes in the first half of the second century A.D.

The biography of Chang Heng (A.D. 78–139) in the *Hou Han-shu* (*History of the Latter Han Dynasty*) contains the following remarkable entry (*1*).

> In A.D. 132 Chang Heng again constructed an instrument to indicate the weather and earthquakes, cast from fine copper, . . . eight feet [in] diameter, which, with its cover, stood up like a wine amphora. It was adorned with seal characters, mountains, turtles, birds, and animals, had a main prop in the centre and eight gro[o]ves at the sides. Bolts could be opened and a mechanism set in motion. Outside there were eight dragon heads with copper balls in their mouths and, below, toads which could receive these balls in their open mouths. The cogged wheels were very elaborate, but all concealed in the amphora, the lid of which was tightly closed, leaving no fissure. When there was an earthquake, the amphora shook the dragons, the mechanism became stirred, and they vomited the balls, which were caught by the toads. The sound of the concussion was the signal to rouse the observer. Even if only one dragon was set in motion and seven heads were not stirred, upon investigating the environs the place of the earthquake was discovered. There was the most wonderful agreement with facts, and nothing similar had happened since records were kept. Once the mechanism of one dragon moved, but no earthquake was felt. All the scholars in the capital were surprised at this inaccuracy, but several days later a courier brought the news that in fact there had been an earthquake in Shensi. Then all believed in this wonderful invention, and an astronomer was ordered to record all the places from where earthquakes started.

Early Chinese work in seismology was, according to this and other indications, very advanced, and yet it could never be said that the Chinese were not deeply imbued with "the attitude of coexisting with nature."

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Watanabe presents an interesting view of the potential contribution to science of traditional Japanese attitudes toward nature, but by relying on an outdated article by Frisch (*1*) to characterize field studies of nonhuman primates by Western scientists, he creates an artificial gap between West and East.

Although some nonhuman primates have been caught and subsequently tattooed for ease of identification, this procedure is the exception for Western fieldworkers, rather than the rule, as Frisch seems to imply. I do not wish to denigrate the contribution of Japanese primatologists, which has been of great value. However, equally abundant and significant data have been obtained by Western field observers who have used techniques that do not differ from those described as typically Japanese. Far from regarding the animals

they study as "bacteria under the microscope," non-Japanese primatologists, as a matter of course, have made a point of learning about their subjects' life histories and personalities. Indeed, van Lawick-Goodall (*2*), whose work in this field is perhaps the best known to nonprimatologists, began by naming some of her chimpanzee subjects after "popular and traditional figures," for example, Huxley and Leakey.

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Born into Japanese culture, having studied science and technology in Japan, and having had the opportunities of studying and teaching in America and of visiting both European and Asian countries, I have come to be very much aware of the cultural differences between the West and Japan. Such consciousness provided the impetus for my article, although its basic idea was shaped some 10 years ago. To my surprise and delight, I am now getting a wide response, regardless of the fact that I could only present a sketchy description of the theme.

I am glad that Robert B. Livingston has reinforced my point with an additional example drawn from the field of contemporary physics. I agree with him in his emphasis on the fruitfulness of cross-cultural exchanges; modern science and technology should be considered more in relation to the cultural soil in which they were born and into which they are introduced.

It is true, as Irene Bloom states, that the Chinese invented instruments to study earthquakes at a very early date. The Japanese also, for example, developed an exquisite metallurgical art of producing swords and invented an advanced form of mathematics called *wasan*. Yet, none of these inventions and techniques gave birth to modern science. Modern science, at least at the time of its birth, premised a certain world view which, I believe, is uniquely Occidental.

Regarding the comment by Robert S. O. Harding about my example of the field studies of nonhuman primates, I want to reply that there existed a big

natural "gap between West and East," and this gap has been artificially narrowed down to its present state primarily as a result of mutual exchange. I strongly suspect that it was the Japanese workers that first started to name the animals they studied and that there still is something different between the respective approaches of Western and Japanese researchers.

In closing, let me cite the following passages from the preface of Robert Hooke's *Micrographia* (1665) (*1*).

> It is the great prerogative of Mankind above other Creatures, that we are not only able to behold the works of Nature, or barely to sustein [sic] our lives by them, but we have also the power of considering, comparing, altering, assisting, and improving them to various uses. . . . And as at first, mankind fell by tasting of the forbidden Tree of Knowledge, so we, their Posterity, may be in part restor'd by the same way, not only by beholding and contemplating, but by tasing [sic] too those fruits of Natural knowledge, that were never yet forbidden.

This will help illustrate how deeply and positively modern scientific investigation of nature was rooted in Western thought and culture.

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Oncogene Theory

In reference to the oncogene theory of Huebner and Todaro, Thomas H. Maugh II (Research News, 22 Mar., p. 1181) states that ". . . it offers no normal role for the oncogene or the virogene."

The proponents of the oncogene theory have clearly suggested a role for the type C RNA genome in embryonic development (*1*). This possibility, as well as others, has been reiterated by Bryan (*2*).

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