Letters

Petroleum Reserves

Along with other Americans, my associates of the American Petroleum Institute and I welcome the practical application of nuclear power to peaceful uses. Skillful use of technical innovations for the betterment of the general economy is an inevitable and necessary concomitant of our free enterprise system. As an industry, however, we feel that we have been wrongly cast in the role of a "has been" by your editorial "Civilian nuclear power" [*Science* **138**, 1231 (1962)]. It unfortunately implies that the nation's petroleum resources, including natural gas, are near the vanishing point.

In the 103 years since the petroleum industry's birth, approximately 71 billion barrels of oil and 214 trillion cubic feet of gas have been produced in this country. The record has been compiled in the face of predictions—dating as far back as 1916—that we were rapidly approaching the limit of our reserves. Fortunately, such predictions have proved to be unfounded. The discovery of new petroleum reserves has consistently outpaced demand, with the result that year after year the figures on proved reserves have increased.

Proved reserves of oil and gas are now higher than at any time in the country's history. Proved reserves of liquid hydrocarbons at the end of 1961 amounted to 38.8 billion barrels; proved reserves of gas totaled 267.7 trillion cubic feet. And these figures are conservative. They represent only the minimum reserves recoverable from existing fields under present economic and operating conditions.

Authorities estimate that there are, in this country, an additional 200 to 400 billion barrels of oil as yet undiscovered beneath the surface. As long as men are willing to face the difficulties involved in finding it, this oil will become available to us.

In addition to its reserves of liquid hydrocarbons, the United States has tremendous deposits of oil shale. These deposits, according to the U.S. Department of the Interior, could eventually yield at least a trillion more barrels of oil.

America's petroleum supplies will stretch far into the future.

JOHN BIVINS
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Bivins has presented a reassuring assessment of our petroleum reserves. He neglects, however, an important factor —the increasing cost of discovering more oil in this country. At one time exploration companies spent about 10 cents a barrel to find oil. That cost has risen to more than $1, and it continues to rise. In contrast, in other parts of the world oil is being discovered for a small fraction of what it costs here. We are already priced out of the world petroleum market.

The natural gas that is burned as a cheap fuel could, if preserved, serve as an extremely important industrial raw material later on.

Our present haste to consume our petroleum reserves will lead to higher costs for hydrocarbons in the future, with a consequent weakening of our international position when petrochemicals assume the enormous role they are destined to play.—P.H.A.

Creativity of the Individual

The editorial "Manpower or mind power" [*Science* **139**, 79 (1963)], in the course of issuing, quite properly, warnings concerning a possible decrease in the quality of graduate students, with larger numbers of students entering graduate school, made a number of unsupported statements about the lack of motivation of present-day graduate students, subsidies for graduate work, and a hypothetical negative relationship between financial security and "the search for truth." The approach taken in the editorial to the issue of subsidies for graduate students was so ultraconservative that it was virtually a parody of the elder-statesman shaking his head and deploring the fact that "things aren't what they used to be" when he was a boy, that "some recent Ph.D. theses would barely have earned an M.S. degree in an earlier period," and that "many papers today seem pedestrian." Shades of the blizzard of '88!

The writer of the editorial believes that increasing the number of Ph.D.'s through government support will "diminish the probability of fostering . . . geniuses." His grounds for qualifying the usual laws of probability are that "most individuals seem to need a hardening experience to bring out their best." He goes on to assert that the "Great Depression" was valuable to those scientists who grew up in it, since they were forced to turn away from the search for money and concentrate upon the search for truth. All of this adds up to a "counterirritant" theory of creativity. There must be adversity so that the individual may transcend it and the quest for knowledge may be ennobled.

Our dissatisfaction with this argument concerns its misplaced emphasis. Adversity and struggle may be involved in the creative process and in achievement, but there is no evidence that financial insecurity is either a necessary or a facilitating condition. We submit that the really significant struggle which the creative scientist engages in is struggle in and with his work. In the good graduate department the student encounters appropriate adversity and challenge in meeting and surpassing the standards set for him, and in proving his potentialities for significant research. Furthermore, the assumption that students come to graduate school with the drive and motivation of the scientist is unwarranted; there is growing evidence that they develop this motivation as they *become* scientists.

It seems more likely to us that the provision of subsidies permitting students to enter graduate school will allow some geniuses who might otherwise have been lost to science to begin scholarly, creative careers. To speak of

luring students into graduate school with increased subsidies seems ludicrous to us in view of the really small purchasing power of these stipends (surely not much above subsistence levels) as compared to the salary the student might earn if he went directly into the job market. Rather, the real issue raised by the support of graduate students is not whether the student will become soft but whether departments will become soft. The burden, as always, is upon the graduate departments to maintain a stimulating, challenging environment and enforce standards of achievement. It may very well be that, when faced with a larger number of students among whom to choose, many departments will be enabled to raise their standards, not tempted to lower them.

Finally, the editorial does not appreciate the broader social necessities implied in the recommendations of the President's Science Advisory Committee. As the technological base of our society becomes more complex and develops more and more rapidly, larger and larger proportions of our population must have higher education, including education beyond college. Of the larger numbers of students acquiring Ph.D.'s, perhaps only a small group, as in the past, will develop a real flair for scientific investigation and prove truly creative. The remainder will provide the good, solid work which is necessary to fill in data in an area which has been mapped out in broad outline by the "genius" in the forefront. If such scientists are not also being trained, a national emergency may arise, for there are many kinds of jobs to be filled in the vast vineyard of science and technology developing in our country today.

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The editorial "Manpower or mind power" [*Science* **139**, 79 (1963)] was excellent and said something badly in need of being said. The change in attitude of the graduate students (particularly in physics, which is my field) during the last 25 years is almost unbelievable. Most of them seem to have a conviction that their having elected to do advanced work is all that was needed for them to merit comfortable support for their families and themselves, and this with 40 hours' work (including coffee breaks) a week. This attitude has, I am sorry to say, been frequently given tacit approval by faculty members who build small empires on grants and contracts.

Science continues to advance rapidly, but I am convinced that this is due only to the tremendous increase in the number of persons involved, which compensates for the decrease in output of the individual, who is, in many cases, little more than a black-box manipulator and a collector of data of dubious significance. We seem to lack the truly great minds which in the past were, if not prevalent, at least not infrequent, and I even venture to doubt that the average scientist of today is as able intellectually as his predecessor of a hundred years or more ago.

I hope that your editorial will be read, absorbed, and heeded.

E. SCOTT BARR
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"Activated" Sleep in the Rat

Swisher [*Science* **138**, 1110 (1962)] has described for the rat a type of sleep that is analogous, perhaps, to the "activated" or "paradoxical" sleep that has been described by Jouvet, among others, for several species. One very striking feature of this state in the rat is the very regular electroencephalographic (EEG) activity of approximately 7 cy/sec.

Our own observations agree quite well with Swisher's in every respect but one: Swisher has noted that rats, unlike cats in paradoxical sleep, do not assume very relaxed postures, but rather undergo "shifts in muscle tone, occasionally of considerable magnitude." In our experiments, in which electromyograms were obtained for the rats' neck muscles, we have found that when the EEG displays very regular 7-cy/sec activity, the neck muscle potentials are much reduced, usually to about one-quarter the magnitude (root-mean-square values) of those found in sleep characterized by large, slow EEG potentials. Periods marked by the highly rhythmic EEG and very low neck muscle potentials are often terminated by movements which usually appear to be shifts in posture; however, during these periods no changes in electromyographic activity can be detected by electrodes located in the neck musculature.

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