Letters

Neutron Capture Therapy

We believe Mark Crawford's 13 April article concerning boron neutron capture therapy (BNCT), "Pork in a medical wrapping" (News & Comment, p. 156), does not provide an accurate assessment of BNCT research reactor needs. We therefore provide the following additional information.

The Brookhaven National Laboratory (BNL), the Massachusetts Institute of Technology (MIT), and the Georgia Institute of Technology do *not* have reactor facilities equivalent to the Idaho National Engineering Laboratory's (INEL's) Power Burst Facility (PBF) reactor. "Epithermal" neutrons (neutrons with energies between 0.5 and 10,000 electron volts) are necessary for tissue penetration sufficient to allow nonsurgical treatment of human tumors. The PBF reactor was specifically designed to produce epithermal neutrons; the other reactors were designed to produce thermal (0.025-electron-volt) neutrons and have a smaller epithermal-neutron component.

To ensure that an epithermal-neutron beam will permit treatment of deep-seated human tumors without causing unacceptable damage to normal tissue, three conditions must be met: (i) the ratio of fast-neutron dose to peak thermal-neutron flux developed in tissue must be as small as possible; (ii) the incident beam should be as monodirectional as practical (collimated); and (iii) the beam aperture should be adjustable so that the treatment field is only as large as necessary (similar to conventional radiation therapy). All three conditions are difficult to achieve while providing the desired epithermal-neutron intensity needed for practical treatment. Measures to meet these conditions reduce the desired epithermal-neutron intensity.

A neutron filter was designed and fabricated by the INEL PBF/BNCT program staff for the Brookhaven Medical Research Reactor (BMRR). This filter is near optimum for that facility, and the neutron beam produced has been well characterized by measurement (*1*). The measured values of neutron intensity and spectrum are in excellent agreement with INEL design calculations. Similar calculations for the proposed PBF beam show that (i) the undesired fast-neutron contaminant is only 10 to 25% of the BMRR value; (ii) a PBF neutron beam will be at least ten times greater than that of the BMRR in desired epithermal intensity; and (iii) the output of a PBF beam will be much more monodirectional than that of the BMRR, allowing desired aperture adjustment without significant loss of beam intensity (*2*). Therapy is limited by normal tissue tolerance. Therefore, a PBF neutron beam will deliver a significantly higher tumor dose than will the BMRR beam.

The INEL PBF/BNCT program participants are now conducting the biological research required to define the useful limits of the BMRR beam and to further refine the required design limit for high-energy neutrons. The greater intensity of the PBF source will allow even further reduction in the fast-neutron contamination, if required.

Because of the fundamental reactor design parameters, the Georgia Tech Research Reactor (GTRR) may produce a better BNCT neutron beam than the BMRR; the MIT reactor (MITR-II) beam will be significantly inferior to both.

Contrary to the statement in the article, assumptions about the acceptability or advantage from treatment fractionation are extrapolation from conventional photon irradiation response that may be incorrect.

Crawford's statement concerning the lack of human BNCT treatment, attributed to Ralph G. Fairchild, is incorrect: BNCT *has* been tested in humans. Thermal-neutron brain tumor BNCT conducted at BNL and MIT in the 1950s and early 1960s was unsuccessful. After additional boron compound development, more than 100 patients with brain tumors have been treated by H. Hatanaka, and six patients with malignant melanoma have been treated by Y. Mishima in Japan. Japan does not have a satisfactory source of penetrating epithermal neutrons. The brain tumors must therefore be exposed by neurosurgery, and the treatment for melanoma is limited to tumors near the surface. The results from these recent human studies are encouraging and provide the basis for a worldwide resurgence of interest in BNCT.

The INEL PBF/BNCT program plan was prepared under the guidance of an eminent biomedical advisory committee. The program has undergone four peer reviews. The researchers have developed analytical capabilities that are now in worldwide use. Two of these capabilities were recognized as "national resources" in the recent Health and Environmental Research Advisory Committee review (*3*). The research results are published in peer-reviewed journals and proceedings (*4*).

If BNCT proves to be effective in clinical trials, treatment of patients with lethal refractory tumors (brain tumors, metastatic melanoma, and so forth) will require the construction of dedicated treatment facilities in several cancer centers. Low intensity, epithermal-neutron sources (BMRR, MITR-II, and GTRR) will have useful applications in BNCT research. But it is by no means justified to restrict the available neutron sources to such limited facilities. The BNCT research necessary to optimize the design of dedicated treatment facilities requires an intense epithermal neutron beam. PBF is the only reactor that has the intensity required. The PBF reactor is an international resource that must be utilized if the full potential of BNCT is to be scientifically assessed.

RONALD V. DORN III
Mountain States Tumor Institute,
Boise, ID 83712 and
Principal Investigator,
Idaho National Engineering Laboratory,
Power Burst Facility/
Boron Neutron Capture Therapy,
EG&G Idaho, Inc.,
Post Office Box 1625,
Idaho Falls, ID 83415

*Co-signers: James A. Lake, Manager, Nuclear Engineering, EG&G Idaho, Inc.; Philip Rubin, Chair, Division of Radiation Oncology, University of Rochester Medical Center, Rochester, NY 14642; Paul W. Dickson, Former Director, Center for Nuclear Engineering and Technology, EG&G Idaho, Inc.; Lynn Loriaux, Clinical Director, National Institute of Child Health and Human Development, National Institutes of Health, Bethesda, MD 20817; Ratib Karam, Neely Nuclear Research Center, Georgia Institute of Technology, Atlanta, GA 30332; Peter Kohler, President, Oregon Health Sciences University, Portland, OR 97201; M. Frederick Hawthorne, Department of Chemistry and Biological Chemistry, University of California, Los Angeles, CA 90024; Patrick R. Gavin, Department of Veterinary Clinical Medicine and Surgery, Washington State University, Pullman, WA 99164; Merle L. Griebenow, Research Manager, Idaho National Engineering Laboratory, Power Burst Facility/Boron Neutron Capture Therapy Program, EG&G Idaho, Inc.

REFERENCES AND NOTES

1. F. J. Wheeler *et al.*, paper presented at the 4th Annual Meeting of the Japan/Australia Workshop on Thermal Neutron Therapy for Malignant Melanoma, Kobe, Japan, 14 to 16 February 1990; Y. D. Harker *et al.*, *1990 Ann. Meet. Am. Nucl. Soc.*, in press.
2. R. G. Fairchild *et al.*, *Strahlenther. Onkol.* **165**, 84 (February/March 1989); F. J. Wheeler *et al.*, *J. Nucl. Technol.*, in press.
3. Health and Environmental Research Advisory Committee, *Review of the Office of Health and Environmental Research Program Boron Neutron Capture Therapy* (Office of Energy Research, Department of Energy, Washington, DC, 1990).
4. See, for example, W. T. Bauer, D. A. Johnson, S. M. Steele, K. Messick, D. L. Miller, W. A. Propp, *Strahlenther. Onkol.* **165**, 176 (February/March 1989); P. R. Gavin, S. L. Kraft, L. R. Wendling, D. L. Miller, *ibid.*, p. 225.

Science is to be congratulated for its article "Pork in a medical wrapping" and its report of the manner in which funding is being sought to continue operations of the Department of Energy's (DOE's) reactor in Pocatello, Idaho. It is deplorable that the funding for the neutron capture therapy