■ Transmutation of Nuclear Waste

Scientists Assess New Method for Destruction of High-Level Radioactive Waste

As the nuclear waste from nuclear power plants and weapons production grows, pressure mounts for scientists to devise a permanent storage solution for these high-level radioactive wastes (HLRW). Currently, nuclear power plants store their waste on-site, in holding tanks: these storage facilities are meant to be temporary and will eventually be filled to capacity. Additionally, the very criteria which are used in siting decisions for nuclear power plants (such as low propensity for earthquakes) often make them undesirable locations for storage of nuclear wastes (such as a site where the underlying water table is near the earth's surface).

Many nuclear power plants, which were built in the 1950s and 1960s, are now approaching the end of their 40-year licensing period, and are or will soon be applying to the Nuclear Regulatory Commission (NRC) for license renewals. Successful renewals hinge on the utilities' ability to convince regulators that they have viable plans for storage of the waste already created as well as the waste that will result from future operations.

Underground Storage

The federal government has designated Yucca Mountain in Nevada as the potential permanent site for HLRW and has been conducting feasibility studies of the site for a number of years. The site would be used as a geologic repository, which would isolate the waste from both atmosphere and the underlying ground water until the waste had decayed. While scientists at the Department of Energy (DOE) have conducted off-site laboratory and field tests, their efforts to begin on-site feasibility studies have been thwarted by Nevada State officials who refuse to issue permits for the testing. The officials' opposition to the project is based on the research of other scientists, including a prior member of the DOE's geologic survey team, who believe that Yucca Mountain is geologically unstable and that there is a significant risk that the water table will rise at some point over the next tens of thousands of years—the amount of time necessary for decay of some of the longer-lived radioactive isotopes in the nuclear waste mixture. Thus, the state of Nevada is trying to block the federal government from proceeding with its plan to deposit HLRW at Yucca Mountain.

Transmutation may reduce the half-life of nuclear waste from more than ten thousand years to a few hundred years.

Transmuted Waste Has Radically Shortened Half-Life

In response to these concerns, scientists have been researching methods for transforming nuclear wastes into forms that are partly nonradioactive and whose radioactive component will decay in hundreds rather than tens of thousands of years. If this can be accomplished, disposal in an underground repository will be a much more politically acceptable alternative, since the integrity of the structure will only have to be maintained for hundreds of years.

The concept of transforming nuclear wastes has been studied for thirty years and recent technological innovations in accelerator design are bringing these concepts closer to reality. There are a number of transmutation projects currently underway, both in the United States and abroad. Foreign projects include studies in France, Sweden, and Germany—Germany is especially interested as it has no geologic repository. Domestic transmutation projects include research programs at Los Alamos National Laboratory in Los Alamos, New Mexico and Brookhaven National Laboratory in Upton, New York, researching accelerator-induced transmutation, and a program at Argonne National Laboratory in Argonne, Illinois, researching reactor-induced transmutation.

The process of changing the nuclear waste elements from one form to another is called transmutation. This transmutation occurs naturally (although extremely slowly) through decay of the radioactive isotope into a stable isotope. Scientists hope to vastly speed up this process through an induced or artificial transmutation using an accelerator or a reactor. When atomic particles are bombarded with neutrons, the radioactive nuclei of the atoms absorb the neutrons and the atoms are transmuted into a different isotope, with a much shorter half-life, which then decays into a stable isotope. For example, when technetium-99, which has a half-life of 213,000 years and is a common waste product of the nuclear defense industry, is bombarded with neutrons, it is transmuted into technetium-100, which decays within 16 seconds to ruthenium-100, a stable isotope.

Another long-lived istope present in the nuclear waste stream is iodine-129, which has a half-life of 16 million years. Cesium-137 and strontium-90, two other nuclear waste components, have relatively short half-lives of 30 and 29 years, respectively, but give off an extreme amount of heat as they decay. This adds to the risk that nuclear waste will escape from containment barrels or tanks and leak into surrounding soil or rock. Since technetium is highly water soluble, such leakage increases the risk that technetium will contaminate the water table.

A draft report on the Los Alamos transmutation project, known as ATW (for accelerator transmutation of waste), describes the procedure proposed at Los Alamos. An accelerator

generates an intense neutron flux by directing a beam of protons into a target made of heavy metals, such as tungsten or lead. The interaction of the beam with the target produces a large number of neutrons, which then enter the surrounding heavy water. The heavy water slows down the motion of the neutrons, giving them a higher chance of reacting with the radioactive isotopes that are circulating as slurry in pipes within the water tank (see Figure 1).

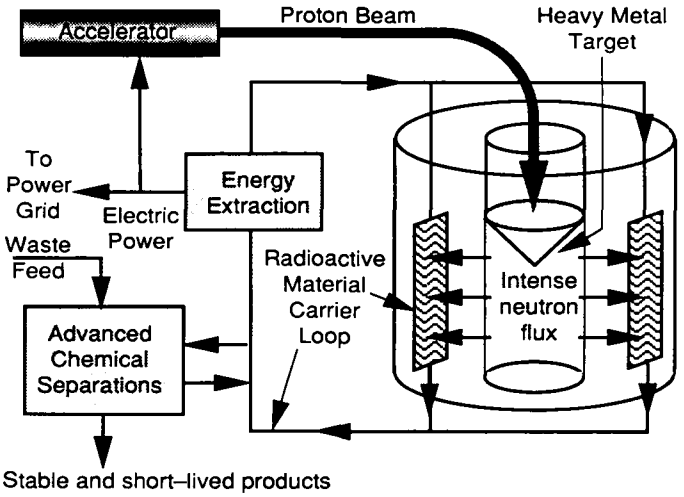


FIG. 1. The ATW concept combines a high-current accelerator, an intense neutron source, and advanced separation chemistry to provide safe and efficient transmutation of nuclear waste. *(Courtesy of Los Alamos National Laboratory.)*

Provides Electrical Power

The heat from the transmutation process is converted to produce electrical power (see Figure 2). According to the Los Alamos draft report, "power production efficiency is comparable to current reactor systems." The Los Alamos design would produce approximately 800 MeV, while the Brookhaven design, called Phoenix, would produce about 850 MW. According to Edward Arthur, PhD, program manager for the Los Alamos program, there is a lot of flexibility as to the siting of the accelerator; it could be sited at nuclear power plants or at nonnuclear electric utility plants.

Enhanced Safety

Proponents of accelerator-induced transmutation point out that the accelerator transmutation process is safer than reactor transmutation because with an accelerator there is no risk of a runaway nuclear reaction. The accelerator process is subcritical, that is, it is unable to create a self-sustaining chain reaction. Additionally, as a general safety principal, it is preferable to work with small amounts of nuclear products in one waste container. In the Los Alamos process, the transmutation is effective with an amount of waste totalling only 220 lbs. Earlier transmutation proposals required 11 tons of waste to work efficiently.

Dr. Arthur notes that while the accelerator transmutation process is expensive, it is in line with the cost of other advanced energy concepts, such as the integrated fast reactor program at Argonne. He expects that an ATW facility would cost $2-$3 billion to build and operate. While the ATW study is still in an early stage, he anticipates that all of the necessary technology will be developed and demonstrated within 12 to 15 years.

Transmutation's Future

The National Research Council is conducting a three-year study of the ongoing domestic and foreign transmutation projects to assess the economic feasibility of this technology. The Council will deliver its report to the DOE, which will assess the study in order to determine what part transmutation should play in the nation's energy policy. The DOE's task is complicated since it needs to take into consideration political as well as economic realities in reaching its decision.

Transmutation of nuclear waste, although still in its design stage, may provide a solution to the problem of where and how to store HLRW. If nuclear waste is transformed into a product whose components decay in hundreds of years, and the temperature of the decaying waste is reduced, surface or near-surface depositories may become a realistic option, while the number of potentially suitable deep-underground depositories will rise.

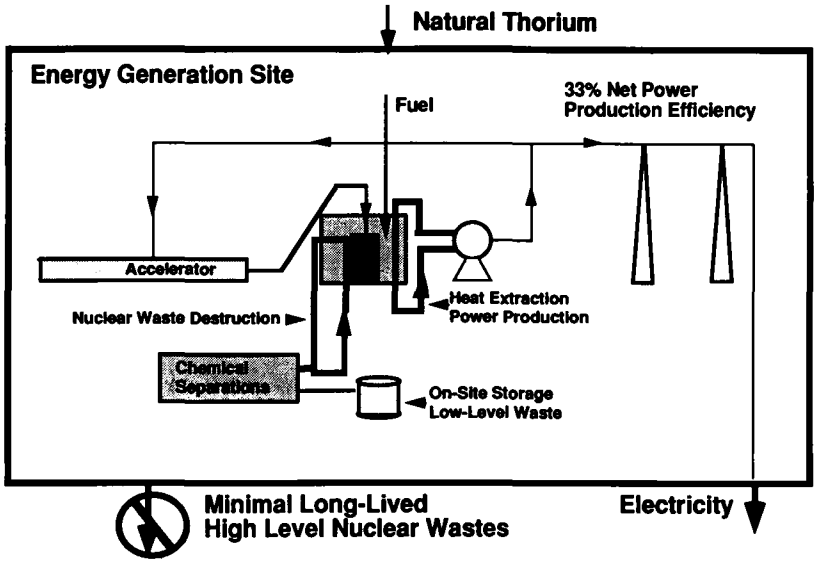


FIG. 2. Fission energy with minimal long-lived high-level waste stream. *(Courtesy of Los Alamos National Laboratory.)*

Joan Hiam
Managing Editor, *JNMT*

■ Misadministration Leads to Lawsuit

A 23-year-old San Diego woman has filed a lawsuit against Mercy Hospital, located in San Diego, CA, alleging that a nuclear medicine technologist injected her with a syringe used on a previously imaged patient, known to have tested positive for the HIV virus. A second technologist was also named in the lawsuit. The misadministration occurred on September 25, 1990, when the plaintiff was scheduled to receive a radionuclide bone scan of her lumbar spine and pelvis to detect the possibility of a herniated spinal disk.

The Centers for Disease Control (CDC) in Atlanta, Georgia, recently conducted an investigation of the incident, which was the third HIV-related nuclear medicine misadministration reported to the CDC within six months. (Recently, a misadministration in the Netherlands resulted in the patient testing positive for the HIV virus.)

An attorney for Mercy Hospital, Cary Miller, Esq., says that the misadministration occurred when the administering technologist found a recapped syringe near the area where doses for new injections are prepared and assumed it was a dose prepared for his patient. According to the CDC investigation, the syringe, previously used on a lung scan patient, was not disposed of in the hospital's hot lab. Rather, it was placed on top of a refrigerator, a space normally used for newly prepared syringes. The report also notes that materials left in the syringe were partially obscured by a lead shield.

The CDC report notes that despite the woman's late arrival for her scan, the technologist did not cancel the procedure, although he did express concern that the radiopharmaceuticals were time-calibrated. The technologist told CDC investigators that he did not read the color-coded labels on the syringe or the pig and that he inserted the needle into the woman's arm, covered it with a lead shield, drew back blood twice to make sure he was in a vessel, and made the injection. He then instructed the woman to return for her scan in three hours.

A report submitted by the Radiologic Health Branch of the California Department of Health Services (CDHS) to the Nuclear Regulatory Commission (NRC) says that the patient should have received 20 mCi of technetium-99m medronate (^{99m}Tc-MDP) for a bone scan and was instead injected with approximately 400 μCi of technetium-99m macro aggregated albumin (^{99m}Tc-MAA), in a syringe that had previously been administered to an HIV-positive lung scan patient.

A spokesperson for Mercy hospital, Michael Scahill, says that "there was no blood communication because the previous patient was not directly injected with the syringe." According to the CDC report, the HIV-positive patient was injected via a heparin lock on a peripheral intravenous line.

When the two technologists later reviewed their records, they realized that they had administered the wrong dose, reports Mr. Miller. However, he says, they were not aware that the syringe had been used on an HIV-positive patient. The woman's lawyer alleges that the technologists proceeded to perform a lung scan on her without her knowledge or consent and without physician approval. After completion of the procedure, the patient's lawyer further alleges, the technologists "falsely. . . represented to the plaintiff that the first injection had missed or burst the vein into which it had been placed" and administered a second injection followed by a bone scan, also without orders from a physician. The names of the technologists involved in the lawsuit were withheld by CDHS and Mercy Hospital, so they could not be reached for comment.

The CDC report states that the next morning, the technologists learned that the syringe had been previously used on an HIV-positive patient. Approximately thirty-eight hours post-exposure, the woman's referring physician notified her of the misinjection and, according to the CDHS report, gave her 250 mg of prophylactic AZT every four hours. Although the woman's HIV status has not been revealed, the lawsuit alleges that she has suffered "severe mental and emotional stress, extreme nervousness, emotional shock, physical illness, and stress."

According to the CDHS report, "the main breakdowns in routine procedures were: (1) the used lung scan syringe was not disposed of properly, immediately after the injection was completed; (2) the technologist injecting the bone scan patient did not check [assay the syringe in] the dose calibrator immediately prior to injection, did not read the patient ID label on the syringe or the pig (both were labeled), and did not notice the color coded (yellow) MAA sticker on the syringe."

Mercy Hospital has "tightened up its system" since the incident occurred, says Mr. Scahill. The hospital's procedure for "Radio-pharmaceutical Injection (I.V.) of the Patient" was revised, effective September 1990. Mercy Hospital's new procedure, according to the CDHS report, requires that the technologist who injects the radiopharmaceutical also prepare the radiopharmaceutical for injection and take steps to identify the patient and the radiopharmaceutical to be injected.

As a direct result of the Mercy Hospital incident, the Radiologic Health Branch and the Licensing and Certification Unit of the CDHS did a special study of general infection control, medical records, quality assurance, and radiation safety procedures at 14 nuclear medicine departments throughout California. According to the CDHS, the study is expected to result in the revision of Licensing and Certification Unit regulations (Title 22), along with careful inspection of nuclear medicine infection control practices by Consolidated Accreditation and Licensing (CAL) surveyors, during Joint Committee on Accreditation of Healthcare Organizations (JCAHO) inspections. The CDHS has also filed charges against the technologists directly involved, which may result in revocation of their California certificates to practice nuclear medicine.

Leigh Silverman
Section Editor, *JNMT*

■ News Briefs

NRC Studying Human Factors in Medical Misadministrations

A researcher with the Nuclear Regulatory Commission, who has embarked on a pilot study to root out the causes of human error in nuclear medicine misadministrations, suggested that the errors might be more likely to occur on certain days of the week. This was one of a number of findings that he presented at the Annual Meeting of the Human Factors Society in September 1991.

Dennis I. Serig, PhD, cautions that the results thus far are highly tentative. Apparent trends could, in fact, be merely artifacts, says the NRC senior human factors analyst, since his analysis is based only on the 388 misadministration reports filed by nuclear medicine departments in 1989. Since nuclear medicine misadministrations are so rare—about one per 10,000 procedures performed—looking for patterns of error requires a large data set. Dr. Serig says the nuclear medicine research will require several more years' worth of misadministration reports to complete.

But Dr. Serig adds that "the tentative evidence indicates that this type of examination is worth doing." He believes the project may yield information that could be used by physicians and technologists to prevent misadministrations of radiopharmaceuticals.

After entering the reports into a database, the NRC researcher sorted the information in a variety of ways to look for "nonrandomness," or patterns that might yield insights into systematic causes for so-called human error. (The expression "random human error" is often misleading, says Dr. Serig. Sometimes, human factors research reveals that design flaws in a system such as a nuclear medicine department are causing people to make choices other than the ones intended.)

Dr. Serig likens the data-sorting process to opening a small window and peering in at the hidden workings of a system. "If I add information, I open the window even wider," he says. By adding the day of the week to each misadministration report, for example, and then sorting the reports by days of the week, a pattern emerged showing that misadministrations occurred more often on Mondays and Fridays than on weekends or during the middle of the week (see box). Although this finding may only reflect the more popular days for scheduling procedures, Dr. Serig noted that this study did "look at indications of heavy workload by day of the week, but support for an effect based on that factor was not overwhelming."

1989 Radiopharmaceutical Misadministrations by Day of Week

Day of week	Number of Misadministrations
Monday	90
Tuesday	73
Wednesday	73
Thursday	59
Friday	84
Saturday	6
Sunday	3

The analysis also showed that patients not scheduled to receive a nuclear medicine procedure who were given one in error, most often received a bone scan. Patients scheduled for bone scans who were given a misadministration, most often were given technetium-99m. As before, the numbers could merely reflect the total relative frequencies of these procedures being performed.

Although encouraged by the preliminary results, he says the nuclear medicine project assumes lower priority than similar research in teletherapy and brachiotherapy because of the more dangerous consequences of misadminstrations of therapeutic radiation.

Laboratory Personnel Protest CLIA Revisions

A coalition of societies whose members work in clinical laboratories have written letters to Secretary of Health and Human Services (HHS) Louis W. Sullivan, MD, and U.S. Representative Henry A. Waxman, Chair of the House Subcommittee on Health and the Environment, protesting draft final rules—leaked last November— which they state would defeat the purpose of the Clinical Laboratory Improvement Amendments of 1988 (CLIA-88).

In a December 3, 1991 letter to Secretary Sullivan, the American Society of Medical Technology (ASMT), the nation's largest group of nonphysican laboratory professionals, expressed concern with the draft of revised CLIA-88 regulations. "Our particular concerns center on the significant weakening of personnel standards in currently regulated Medicare and CLIA-67 laboratories. We also believe that the regulations fail to provide the assurance of quality testing in unregulated labs, which was the motivating factor behind the CLIA legislation." While the ASMT agrees with HHS that personnel standards should be based on competency rather than solely credentials, the ASMT beieves that the supposed equivalency routes in the draft regulations "would permit anyone to perform laboratory testing and would be a major setback for the profession." The ASMT made the following recommendations in its letter.

- Reconsider allowing the use of testing personnel assistants (high school students with no formal laboratory training) to perform sophisticated tests in highly complex laboratories.
- Make a distinction between the scope of practice of testing personnel assistants and testing personnel. The former should be confined to performing tests within the moderately complex level.
- Require general supervisors in highly complex laboratories to have a baccalaureate degree in clinical laboratory science. Such individuals have primary responsibility for day-to-day management of the laboratory's operations and for ensuring laboratory quality. They should be held to the same minimum qualification standard as technical consultants in moderately complex laboratories (i.e., a baccalaureate degree).
- Physician directors who do not

have formal laboratory training approved by the Health Care and Financing Administration (HCFA) or who are not certified as directors of laboratories by an agency acceptable to HCFA should not be qualified to serve as technical consultants.

The ASMT letter was soon followed by a coalition letter to Secretary Sullivan, dated December 13, 1991, which made several recommendations for rule changes that the organizations believe would "ensure the intent and spirit" of CLIA-88. Among these recommendations were the following: laboratories that currently participate in proficiency testing under CLIA-67 and Medicare should be required to continue this participation; and all standards contained in the rules (except for proficiency testing) should apply to all affected laboratories within 180 days after the rules are implemented.

The following organizations were joint signers of the December 13 letter: the American Association for Clinical Chemistry (AACC), the American Association of Bioanalysts (AAB), the American Clinical Laboratory Association (ACLA), the American Medical Technologists (AMT), the AMST, the American Society for Microbiology (ASM), the Clinical Laboratory Management Association (CLMA), and the International Society of Clinical Laboratory Technology (ISCLT).

The second coalition letter, sent to Representative Waxman on January 23, 1992, restates the issues raised in the letters to Secretary Sullivan and adds the following points.

- Personnel standards for highly complex laboratories are substantially lower than current CLIA-67 requirements, thus deregulating over 50% of outpatient testing performed today.
- Final regulations should retain distinctions between the scopes of practice of medical technologists and medical laboratory technicians, which exists in clinical laboratories. The draft CLIA-88 regulations conflict with recent federal legislation to directly infuse money into medical technology programs in response to personnel shortages.

The following organizations were signers of the letter to Representative Waxman: the American Society of Clinical Pathologists, the AACC, ACLA, ASMT, ASM, and the CLMA.

Thwarting Physical Attacks on Animal Research Laboratories

Amid concerns about the "escalating violence" of animal rights activists, Congress appears ready to pass measures to impose stiff fines and tough prison terms for laboratory break-ins, thefts, and other attacks on biomedical investigators.

When the Senate approved "The Animal Research Facilities Protection Act" last October, the bill's sponsor Sen. Howell Heflin (D-Alabama) vowed that "animal rights-inspired violence must be stopped." The bill imposes penalties as high as $25,000 and prison sentences of up to 20 years for acts against research facilities, and it enables scientists to sue for lost equipment, data, animals, and for the costs of repeating ruined experiments.

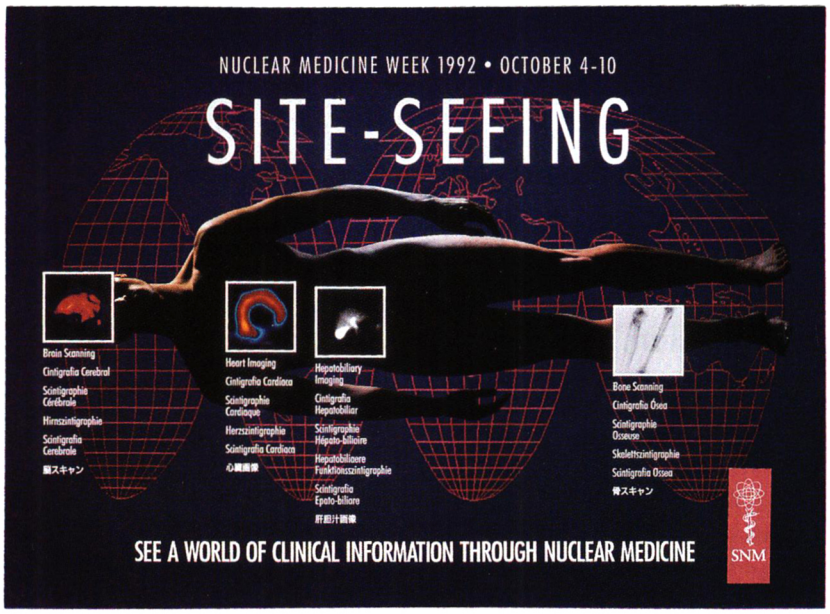
This month, the House Agriculture Committee is expected to approve a similar bill, "The Farm Animal and Research Facilities Protection Act," according to the staff of Rep. Charles W. Stenholm (D-Texas), who sponsored the bill with 250 other representatives. The House version is broader than the Senate legislation, covering ranchers, zoos, the food processing industry, and research institutions threatened by protest actions "that seem to be escalating both in number each year and in their level of violence," Mr. Stenholm said in a speech to fellow legislators last year.

MRI Used to Measure Fruit Ripeness

Soon, magnetic resonance imaging (MRI) will move from being strictly an imaging modality used in medicine to being a tool to aid consumers in their grocery purchases. Researchers at Purdue University, West Lafayette, Indiana, have developed a method using magnetic fields to determine sucrose levels in fruit. As fruit ripens, sucrose levels increase, so the device can be used to predict when a given piece of fruit is at its peak ripeness. The technique, which will be tested in Indiana grocery stores during 1992, should result in a lower level of fruit spoilage within grocery stores and a higher degree of satisfaction among customers. The produce will be marked with stickers that tell the consumer the date on which the fruit should be at its ripest.

Nuclear Medicine Week Poster is Unveiled

Design of the 1992 SNM Nuclear Medicine Week (NMW) poster has been completed pending final approval by the Technologist Section leadership at the Mid-Winter Meeting in Dallas. The version displayed here is the domestic version of the poster; the international version will not show the phrase Site-Seeing, as it would not be understood by a considerable portion of the foreign audience. In keeping with the international focus of NMW, the event will be celebrated during the week following the first Sunday in October: This year the dates will be October 4–10. Members who would like suggestions on ways to celebrate NMW may call Virginia Pappas, CAE, at the SNM central office or any member of the NMW Committee, chaired by Cynthia Wharton, CNMT.



TECHNOLOGIST JOB NETWORK

The New England Chapter—SNM/TS announces **"The Job Hotline,"** a national toll-free, hotline for nuclear medicine. The hotline is designed to provide a quick link for technologists seeking jobs and for hospitals seeking technologists. Institutions seeking technologists should call the hotline number, leave the name of the institution, title of the job opening, and name and number of the contact person; data are then stored for three months in a database for anyone who calls the hotline seeking employment. Technologists seeking employment should call the hotline number, specify state(s) which are of interest, specify type of job desired, and leave name and address. A listing will then be sent out in 48 hours; all inquiries are kept confidential. If an opening has not been filled within three months, the institution should call again to have it listed. The institution should also call if an opening has been filled so that it can be deleted from the database. The hotline numbers are **1-800-562-6387 (1-800-JOB-NETS)** or **1-990-4212 in Maine.** Questions or comments should be directed to: Tom Starno, Manager, Job Hotline, New England Chapter—TS at **(207) 945-7186.**

The Mideastern Chapter—SNM/TS will provide a referral network for technologists seeking employment and for hospitals in need of technologists. Interested individuals should call Cathy Gonzalez at **(301) 855-1712.** Please leave your name, address, phone number and a brief description of your request.

EDITOR'S NOTE

SNM chapters are invited to submit job referral service listings for publication. Pertinent information—name and brief description of the service, telephone numbers and/or address, name or number of contact person for inquiries—should be sent to: Leigh Silverman, Section Editor, *JNM/JNMT,* Society of Nuclear Medicine, 136 Madison Avenue, New York, NY 10016-6760.