food. In consuming *Legionella*, however, the amoebae can become infected with the disease and act like factories producing prolific amounts of the bacteria. In this way, high concentrations of *Legionella* were linked, in part, to the presence of amoebae.

Further, Seed Money researchers found that these two varieties of one-celled organisms shared an ability, as do *Legionella*, to tolerate and, in some cases, thrive in heated waters. In natural settings, amoebae populations peak in the summer months. In cold waters, by contrast, their concentrations are much less.

Thus, Seed Money research provided a plausible explanation of why Legionnaires' disease is associated with the dispersion of waste heat by means of building air conditioning systems and industrial cooling towers. Concentrations of disease producing organisms, including both amoebae and *Legionella*, may be amplified by heated waters. In addition, *Legionella* may be further and dramatically amplified by the presence of amoebae. Finally, the physical operation of cooling systems provides two aggravating conditions, namely the heated waters and the pathway into the lungs via airborne mist.

In another Seed Money project in 1983, researchers focused on the implications of this earlier work and found evidence of certain occupational risks associated with Legionnaires' disease. They examined blood samples taken from workers who cleaned cooling towers at electric power plants. Testing for the presence of antibodies associated with the disease, they found evidence that as high as 40 percent of the workers at some locations had been exposed.

The utilities in question took immediate and corrective action. Although the problem was corrected, the discovery of its existence underscored the need for more broadly based monitoring of similar situations. Further, the 1983 research showed that the amoebae and the bacteria could both be controlled with special chlorination techniques, pointing the way toward effective prevention programs.

Following up on the need for monitoring, Seed Money researchers in 1984 developed a fast and economic method of testing for Legionnaires' disease. While their method makes use of commercially available equipment and standard procedures in a technique called flow cytometry, this was the first application of this technique to Legionnaires' disease. Their method works on both clinical (blood) and environmental (water) samples and can positively identify the presence of *Legionella*, thus serving as an effective warning and screening technique.

In sum, as a result of these three Seed Money projects and their follow-on work, high risk areas can now be clearly identified. The availability of reliable methods for clinical and environmental testing is helping to minimize both occupational and public health risks of exposure. Importantly, the improved understanding of *Legionella* and the environmental factors affecting their growth has set the stage for the development and implementation of improved preventive and control measures.

Whole Body Radiation Counter

Since the earliest days of atomic energy, understanding the health effects of human exposure to radioactivity and minimizing the risks of associated occupational hazards have been of paramount importance to all involved. Routine monitoring, extensive precautions and decades of health effects research are hallmarks of the industry.

Yet in the case of uranium and other classes of the heavier man-made elements, one of the most difficult clinical problems is the accurate assessment of a person's cumulative exposure to these elements. While exposure may be inferred roughly from circumstances, external monitors, and medical records, an assessment using such methods is uncertain. Until recently, there existed no means of direct measurement.

In 1975 and 1976, however, Seed Money researchers laid the foundation for the development of a sophisticated diagnostic instrument, which later became the standard of the industry. Today, three private firms manufacture the instruments, called whole body radiation counters, and more than 20 of them are placed in key locations throughout the country.

These instruments are now used routinely in the precautionary screening of thousands of workers and researchers. They monitor the exposure history of each individual and can spot any new developments. The reliability of the machines, combined with the accumulating reports of a clean bill of health, lend confidence to both the workforce and the professional experts concerned with the safety of the work environment.

In the event of an accident, these instruments can provide rapid, accurate, and detailed information on the nature of the exposure. Such information is essential in determining the seriousness of the problem and prescribing the proper treatment. The instruments can then monitor treatment progress and the subsequent removal of the radioactivity from the body, ensuring that it does not become entrenched or concentrated in sensitive areas.

Aside from the development of this technology, the underlying research associated with this work resulted in many other valuable contributions to the broader field of health physics. The methods and data, original to this effort, improved the means by which assessments are made of the impacts on the environment of all aspects of the nuclear fuel cycle, from uranium mining to the disposal of waste. The results are also important to the development of nuclear safeguards, handling of special materials, and research