Office of Science
Notice 99-14

Low Dose Radiation Research Program

Department of Energy
Office of Science and
Office of Environmental Management

Office of Science Financial Assistance Program Notice 99-14; Low Dose Radiation Research Program

Agency: U.S. Department of Energy

Action: Notice inviting grant applications.

SUMMARY: The Offices of Science (SC) and Environmental Management (EM), U.S. Department of Energy (DOE), hereby announce their interest in receiving applications for research that supports the Low Dose Radiation Research Program. Research is sought in the following areas:

(1) Low dose radiation vs. endogenous oxidative damage the same or different?
(2) Understanding biological responses to radiation and oxidative damage.
(3) Thresholds for low dose radiation fact or fiction?
(4) Genetic factors that affect individual susceptibility to low dose radiation.
(5) Communication of research results.

This Program uses modern molecular tools to develop a better scientific basis for understanding exposures and risks to humans from low dose radiation that can be used to achieve acceptable levels of human health protection at the lowest possible cost. Proposed basic research should contribute to EM needs by decreasing health risks to the public and workers from low dose radiation, providing opportunities for major cost reductions in cleaning up DOE's environmental problems, and reducing the time required to achieve EM's mission goals.

DATES: Potential applicants should submit a one page preapplication referencing Program Notice 99-14 by 4:30 P.M. E.S.T., February 23, 1999. A response to preapplications discussing the potential program relevance of a formal application generally will be communicated within 7 days of receipt.

The deadline for receipt of formal applications is 4:30 P.M., E.D.T., April 13, 1999, in order to be accepted for merit review and to permit timely consideration for award in FY 1999.

ADDRESS: Preapplications referencing Program Notice 99-14, should be sent by E-mail to joanne.corcoran@science.doe.gov. Preapplications will also be accepted if mailed to the following address: Ms. Joanne Corcoran, Office of Biological and Environmental Research, SC-72, U.S. Department of Energy, 19901 Germantown Road, Germantown, MD 20874-1290.

Formal applications, referencing Program Notice 99-14, should be sent to: U.S. Department of Energy, Office of Science, Grants and Contracts Division, SC-64, 19901 Germantown Road, Germantown, MD 20874-1290, ATTN: Program Notice 99-14. This address must be used when submitting applications by U.S. Postal Service Express, commercial mail delivery service, or when hand carried by the applicant.

FOR FURTHER INFORMATION CONTACT: Dr. David Thomassen, telephone: (301) 903-9817, E-mail: david.thomassen@science.doe.gov, Office of Biological and Environmental Research, SC-72, U.S. Department of Energy, 19901 Germantown Road, Germantown, MD 20874-1290 or Mr. Mark Gilbertson, Office of Science and Risk Policy, Office of Science and Technology, Office of Environmental Management, 1000 Independence Avenue, SW, Washington, D.C. 20585, telephone: (202) 586-7150, E-mail: mark.gilbertson@em.doe.gov.

SUPPLEMENTARY INFORMATION:

Low Dose Radiation Research Program

Background and Overview

Each and every cell in the human body is constantly engaged in a life and death struggle to survive "in spite of itself." Normal physiological processes needed for cell survival generate toxic oxidative products that are damaging, even mutagenic, and potentially carcinogenic. Yet cells and people survive because of the cell's remarkable capacity to repair the majority, if not all, of this oxidative damage. We don't know, however, the relationship between this normal oxidative damage and the high frequency of cancers that exist in all human populations. Is cancer a price we pay for the very biological processes that keep us alive?

We are also constantly exposed to low levels of natural background radiation from cosmic radiation and from naturally occurring radioactive materials in soils, water, and even living things. Research has taught us that while even low levels of radiation induce biological damage, the damage is very similar to the oxidative damage induced by normal cellular processes. Thus a critical, yet unanswered, question in radiobiology is **whether the biological damage induced by low doses and low dose rates of radiation is repaired by the same cellular processes and with the same efficiency as normal oxidative damage that is a way of life for every living cell.**

The Low Dose Radiation Research Program will conduct research to determine if low dose and low dose-rate radiation present a health risk to people that is the same as or greater than the health risk resulting from the oxidative by-products of normal physiological processes. This information is a key determinant in decisions that are made to protect people from adverse health risks from exposure to radiation.

Extensive research on the health effects of radiation using standard epidemiological and toxicological approaches has been used for decades to characterize responses of populations and individuals to high radiation doses, and to set exposure standards to protect both the public and the workforce. These standards were set by extrapolating from the biological effects observed in high-dose radiation studies to predicted, but unmeasurable effects, at low radiation doses, using modeling approaches. This approach was chosen because of our inability to detect changes in cancer incidence following low doses of radiation. Thus, the historic approach has been the Linear-no-Threshold model that assumes each unit of radiation, no matter how small, can cause cancer. As a result, radiation-induced cancers are predicted from low doses of radiation for which it has not been possible to directly demonstrate cancer induction.

Most of the projected radiation exposures associated with human activity over the next 100 years will be to low dose and low dose-rate radiation from medical tests, waste clean-up, and environmental isolation of materials associated with nuclear weapons and nuclear power production. The major type of radiation exposures will be low Linear Energy Transfer (LET) ionizing radiation from fission products. The DOE Low Dose Radiation Research Program will thus concentrate on studies of low-LET exposures delivered at low total doses and dose-rates.

The overriding goal of this program is to ensure that human health is adequately and appropriately protected. It currently costs billions of dollars to protect workers and the public from exposure to man-made radiation, often at exposure levels lower than the natural background levels of radiation. If it could be demonstrated that there is no increased risk associated with these exposures, these resources could be directed toward more critical health related issues.

The research program will build on advances in modern molecular biology and instrumentation, not available during the previous 50 years of radiation biology research, to address the effects of very low levels of exposure to ionizing radiation. It will concentrate on understanding the relationships that exist between normal endogenous processes that deal with oxidative damage and processes responsible for the detection and repair of low levels of radiation-induced damage. Research will focus on understanding the normal cellular processes responsible for recognizing and repairing normal oxidative damage and radiation-induced damage. If the damage and repair induced by low dose radiation is the same as for normal oxidative damage, it is possible that there are thresholds of damage that the body can handle. In contrast, if the damage from ionizing radiation is different from normal oxidative damage, then its repair, and the hazard associated with it, may be unique.

Research conducted in this program will help determine health risks from exposures to low levels of radiation, information that is critical to adequately and appropriately protect people and to make the most effective use of our national resources.

Research Needs

To understand the relationship between normal oxidative damage and radiation-induced damage, studies will be conducted at very low, doses and dose-rates and the perturbation of the normal physiological processes will be characterized at all levels of biological organization - from genes to cells to tissues to organisms. Research needs are identified in interrelated five areas:

1. Low dose radiation vs. endogenous oxidative damage - the same or different?

A key element of this research program will be to understand the similarities and differences between endogenous oxidative damage, damage induced by low levels of ionizing radiation, and the health risks from both.

Research is needed to understand and quantify real, not calculated, differences or similarities in DNA damage induced by normal oxidative processes versus low doses or low dose rates of ionizing radiation. This information is the foundation for the entire low dose radiation research program. Although always needed, it was not previously attainable because critical resources and technologies were not available. Today, technologies and resources such as those developed as part of the human genome program, e.g., coupled capillary electrophoresis and mass spectrometry systems and DNA sequence information, have the potential to detect and characterize small differences in damage induced by normal oxidative processes and low doses of radiation.

A significant investment in technology development will be required to expand current capabilities for identifying and quantifying small amounts of oxidative or radiation. Radically new technologies are likely not needed but current technologies will need to be modified. Methodologies having high sensitivity as well as high signal-to-noise ratio will be critical in this effort.

A significant research effort will also be required to characterize and quantify normal oxidative damage in cells and the incremental increases induced by low doses of ionizing radiation. Partnerships are encouraged between laboratories involved in characterization and quantification of radiation and oxidative damage and groups with expertise in or developing new technology to facilitate progress in both areas simultaneously.

A critical goal of the research component of this program is to quantify levels of damage induced by normal oxidative processes and the incremental increases due to low dose radiation. Qualitative descriptions of differences and/or similarities between the types of damage induced under both conditions are useful in the design and interpretation of experiments in other parts of the Low Dose Radiation Research Program. To be most useful in risk models and for regulators these differences or similarities must be quantified.

2. Understanding biological responses to radiation and endogenous damage.

Molecular, cellular, and tissue responses modify the processing of radiation induced damage and/or determine whether or not damaged cells are eliminated, inhibited, or expressed. These responses impact cancer risks from radiation.

Research is needed to understand and quantify real, not extrapolated or assumed, differences or similarities in biological changes and responses observed following exposures to low doses or low dose rates of ionizing radiation. This research covers the breadth of radiation and cancer biology from the initial recognition and processing of radiation damage by a cell to the potential development of cancer. Not all research, no matter how important to our understanding of the mechanisms of cellular responses to low dose radiation or of cancer development, will necessarily be useful for estimating health risks from low dose radiation or in choosing low dose radiation risk models. However, understanding and quantifying key aspects of the biological changes and responses induced by low dose radiation is likely to have dramatic impacts on our ability to efficiently and effectively protect people from unnecessary and avoidable health risks.

Research will benefit from the rapidly increasing availability of DNA sequence data from humans and other model organisms including mouse, yeast, fruit fly, etc. Recently developed technologies for characterizing and quantifying gene expression should be exploited. In some cases, further improvements in these technologies will be needed, such as increases in the sensitivity for detecting and quantifying gene expression. Cytogenetic techniques that couple traditional cytogenetic approaches with advances in molecular biology and automation will likely be useful in efforts to determine how accurately low dose radiation damage is repaired. Advances in the use and development of model organisms and of advanced systems for studying "normal" cells in culture should also be exploited to study the more complex interactions of cells and tissues in determining the biological effects of low dose radiation.

Research is needed that addresses the following six key questions:

Do cells recognize and respond to low doses of ionizing radiation the same way that they do to high doses of radiation? Much of the damage induced by radiation and normal oxidative processes is the same. Research should concentrate on damage that is unique to low doses of radiation and on differences or similarities between biological responses following high versus low doses of radiation. It must be determined which genes and proteins are specifically induced in response to low doses of ionizing radiation, how these relate to other oxidative stresses, and importantly, how the induced genes and proteins affect endpoints relevant to radiation-induced cancer. It must also be determined if the ability and efficacy of cells to recognize and repair radiation damage is affected by the radiation dose.

Do cells repair DNA damage induced by low doses of ionizing radiation the same way that they do damage induced by high doses of radiation? The repair or misrepair of radiation-induced DNA damage is of fundamental importance to all aspects of a cell and/or an organism's responses to radiation exposure. The fidelity of the repair and damage processing systems will significantly affect the dose response curve for cancer induction, particularly at low doses. Ineffective repair or misrepair of radiation damage and subsequent processing of this unrepaired or misrepaired damage can significantly impact genomic integrity resulting in radiation-induced mutations, chromosomal aberrations, chromosomal stability, and cancer. Quite simply, if radiation-induced damage is faithfully repaired and processed, a threshold is expected. On the other hand, if repair and subsequent processing can lead to errors at low doses but not at high doses, an expectation of a threshold is not warranted.

Additional understanding of the molecular mechanisms involved and in the closely linked damage signaling pathways will provide information relevant to the faithful repair of specific lesions, the molecular responses of cells to specific lesions and the consequences of cellular processing of radiation-induced damage compared to that of endogenous damage. Many of these consequences can be assessed using rapidly developing molecular cytogenetic technology such as combinatorial fluorescence in situ hybridization (FISH). Because cytogenetic effects represent the synthesis of damage induction, repair and processing, these new technologies provide the opportunity to directly test certain key predictions of models of radiation effects at low doses. Substantially more information is also need on 1) the underlying repair processes; 2) the role of DNA sequence and chromatin structure in determining radiation response and target size for biological endpoints relevant to cancer; and 3) how and if the processing of damage induced by low doses of radiation leads to mutations, chromosomal aberrations, and genomic instability.

How much do low doses of radiation "protect" cells against subsequent low doses of ionizing radiation? If low doses of radiation regularly and predictably induce a protective response in cells to subsequent low doses of radiation this could have a substantial impact on estimates of adverse health risk from low dose radiation. The generality and the extent of this apparent adaptive response in cells irradiated with small doses of ionizing radiation needs to be quantified.

Are the potentially damaging effects of low dose radiation amplified by interactions between cells? It is important for this program to determine if these so-called by-stander effects can be induced by exposure to low LET radiation delivered at low total doses or dose-rates. If such an effect is demonstrated and quantifiable, it could, potentially, increase estimates of risk from low dose radiation. This by-stander effect, in essence, "amplifies" the biological effects of a low dose exposure by effectively increasing the number of cells that experience adverse effects to a number greater than the number of cells directly exposed to radiation.

Is genetic instability, a key step in the development of cancer, induced or initiated by low doses of radiation? Current evidence suggests that DNA repair and processing of radiation damage can lead to instability in the progeny of irradiated cells and that susceptibility to instability is under genetic control. However, there is virtually no information on the underlying mechanisms and how the processing of damage leads to instability in the progeny of irradiated cells several generations later. Further, while there has been considerable speculation about the role of such instability in radiation-induced cancer, its role in this process remains to be determined.

Is the development of cancer induced by low (versus high) doses of radiation affected by the unirradiated normal tissues that surround the potential cancer cells? The ability of an irradiated cell to escape normal tissue regulatory processes or of a tissue to inhibit the further progression of precancerous cells may be differentially affected by high versus low doses of radiation. Exposure- and dose-response studies should be conducted to determine if the basic mechanisms of radiation action change as a function of total radiation dose and dose rate. High doses of ionizing radiation induce matrix and tissue disorganization, cell killing, changes in cell proliferation kinetics, induction of a multitude of genes and growth factors, and extensive chromosome and genetic damage. It is important to determine if low doses of ionizing radiation can induce these biological changes. It will also be important to determine if cancer can be induced by doses that are too low to produce such changes.

3. Thresholds for low dose radiation - fact or fiction?

We don't know if there are radiation doses or energies below which there is no significant biological change or below which the damage induced can be effectively dealt with by normal cellular processes. If there are, then there should be no regulatory concern for exposures below these thresholds since there will be no increase in risk.

The principal focus of research in this component of the Low Dose Radiation Research Plan is to develop methods to synthesize or model new molecular level information on low dose radiation induced damage and biological responses to that damage into a low dose radiation risk model. The goal of this research program is to develop scientifically defensible tools and approaches for determining risk that are widely used, accepted, and understood. Research should include, but not be limited to development of computational techniques, e.g., algorithms and advanced mathematical approaches, for use in determining risk, that model new information from cellular and molecular studies together with available data from epidemiologic and animal studies.

A secondary, but essential component of this component of the Low Dose Radiation Research Plan, will be the design and conduct of additional biological experiments to address specific questions or predictions made by these new computational approaches. These biological experiments, though likely complementary to research described above, will be designed and conducted in collaboration with modelers.

4. Genetic factors that affect individual susceptibility to low dose radiation.

Do genetic differences exist making some individuals more sensitive to radiation-induced damage? Such genetic differences could result in sensitive individuals or sub-populations that are at increased risk for radiation-induced cancer.

The Low Dose Radiation Research Program should have three main goals in terms of genetic susceptibility to low dose radiation: (1) identify genes involved in the recognition, repair, and processing of damage induced by ionizing radiation, (2) determine the frequencies of polymorphisms in these genes in the population, and (3) determine the biological significance of these polymorphisms with respect to cancer and radiation sensitivity.

Research in these three areas will strongly complement ongoing initiatives at the National Institutes of Health (NIH). DOE staff will work with staff at the NIH to ensure that research in the Low Dose Radiation Research Program is complementary to and not duplicative of research funded by NIH programs.

The National Human Genome Research Institute (NHGRI) is funding research to identify common variants in the coding regions of the majority of human genes identified during the next five years with the goal of developing a catalog of all common variants in all. The NHGRI is also working to create a map of at least 100,000 single nucleotide polymorphisms, the most common polymorphisms in the human genome representing single base-pair differences between two copies of the same gene. These so-called SNPs will be a boon for mapping complex such as cancer, cancer susceptibility, and susceptibility to low dose radiation.

The National Institute of Environmental Health Science (NIEHS) is funding research as part of its Environmental Genome Project to understand the impact and interaction of environmental exposures on human disease. The NIEHS project includes efforts to understand genetic susceptibility to environmental agents that will allow more precise identification of the environmental agents that cause disease and the true risks of exposures. The principal focus of NIEHS research will be on chemicals so the focus on radiation in the Low Dose Radiation Research Program is highly complementary. Initially, the Environmental Genome Project will focus on categories of genes including: xenobiotic metabolism and detoxification genes; hormone metabolic genes; receptor genes; DNA repair genes; cell cycle genes; cell death control genes; genes mediating immune and inflammatory responses; genes mediating nutritional factors; genes involved in oxidative processes and, genes for signal transduction systems.

Identification of potential susceptibility genes and polymorphisms in those genes is only the first (and perhaps the easiest) step in the program to characterize and understand genetic susceptibility. Determining the biological significance of these genetic polymorphisms with respect to cancer and radiation sensitivity is the ultimate goal and the more difficult task. The international human genome project, structural biology research, and the NHGRI and NIEHS efforts described above play important roles determining which polymorphisms are most likely to influence gene function. Population genetics and computational biology approaches will be required to estimate the potential impact on estimates of population and individual risk. Genetic epidemiology approaches will also be needed to relate specific polymorphisms and combinations of polymorphisms with cancer risk. Inbred mouse strains and other model organisms with well-characterized differences in susceptibility to radiation-induced cancer are also important tools for identifying significant polymorphisms. Direct assessment of the biological significance of candidate "susceptibility genes" can also be undertaken using animal models such as knock-out and knock-in mice, mice with specific genes removed or added.

5. Communication of research results.

This research program will only be a success if the science it generates is useful to policy makers, standard setters, and the public. Research results must be effectively communicated so that current thinking reflects sound science.

The Low Dose Radiation Research Program should have two main research goals for communicating the Program's research results: (1) develop a public communication program based on principles of risk communication and (2) develop a public education program based on principles of risk communication science.

Communication with the public about low dose management, requires a well-developed plan based on strong basic social science research. The goal of communication research in this program should be to understand the likely public responses to scientific findings from the Low Dose Radiation Research Program and responses to the plans that might result to modify existing standards based on these scientific findings. The following topics should be included in determining public responses to issues regarding low dose radiation exposures: (i) public perceptions of risk from exposure to radiation; (ii) the perceived importance of the activities and conditions that produce low dose radiation; (iii) trust and confidence in risk managers, regulators, and decision makers; (iv) the role of the media in characterizing different positions on risk controversies; (v) the role of advocacy groups; (vi) the manner by which risk is characterized and assessed; and (vii) procedures by which decisions are made.

To present developments from this program in a form that is useful and easily understood by the public, the education program would develop web pages, written resources for public schools, and coordinate multimedia coverage of research results and public meetings. Public meetings would provide opportunities for the public to meet with scientists and regulators involved in policy making, facilitating public input into the decision making process.

Radiation Doses of Interest

The focus of research in the Low Dose Radiation Research Program should be on doses of low linear energy transfer (LET) radiation that are at or below current workplace exposure limits. In general, research in this program should focus on total radiation doses that are less than or equal to 10 rads. Some experiments will likely involve selected exposures to higher doses of radiation for comparisons with previous experiments or for determining the validity of extrapolation methods previously used to estimate the effects of low doses of radiation from observations made at high doses.

Supplementary Materials

A draft of the DOE Low Dose Radiation Research Program Plan is available on the World Wide Web at http://www.er.doe.gov/production/ober/berac/draftld.pdf. This research plan outlines a ten-year research strategy to help determine the risks to human health from exposure to low doses of ionizing radiation.

Success of the Low Dose Radiation Research Program depends on maintaining a diverse and balanced set of research projects that span the research needs outlined above. A list and a brief description of projects currently funded as part of the Low Dose Radiation Research Program is available at http://www.er.doe.gov/production/ober/ldprojlist.html on the World Wide Web. These projects were funded as part of solicitation number 98-11 that can be found on the World Wide Web at http://www.er.doe.gov/production/grants/fr98_11.html.

Program Funding

It is anticipated that up to $4.0 million will be available for new grant awards during FY 1999, contingent upon the availability of funds. Multiple year funding of grant awards is expected, and is also contingent upon the availability of appropriated funds, progress of the research, and continuing program need. It is expected that most awards will be from 1 to 3 years and will range from $200,000 to $400,000 per year (total costs).

Preapplication

A preapplication should be submitted. The Preapplication should contain a title, list of investigators, address, telephone, fax and E-mail address of the Principal Investigator, and no more than a one page summary of the proposed research, including project objectives and methods of accomplishment. Preapplications will be reviewed by program managers from SC and EM relative to the scope and research needs of the DOE Low Dose Radiation Research Program and the Environmental Management Science Program (EMSP). Responses to the preapplications, encouraging or discouraging formal applications, will generally be communicated within 7 days of receipt. Notification of a successful preapplication is not an indication that an award will be made in response to the formal application.

Applications

(PLEASE NOTE CRITICAL INFORMATION BELOW ON PAGE LIMITS)

Information about the development and submission of applications, eligibility, limitations, evaluation, selection process, and other policies and procedures may be found in the Application Guide for the Office of Science Financial Assistance Program and 10 CFR Part 605. Electronic access to the Guide and required forms is made available via the World Wide Web at: http://www.er.doe.gov/production/grants/grants.html.

The Project Description must be 25 pages or less, exclusive of attachments. **Applications with Project Descriptions longer than 25 pages will be returned to applicants and will not be reviewed.** The application must contain an abstract or project summary, letters of intent from collaborators, and short curriculum vitaes consistent with NIH guidelines.

Adherence to type size and line spacing requirements is necessary for several reasons. No applicants should have the advantage, or by using small type, of providing more text in their applications. Small type may also make it difficult for reviewers to read the application. Applications must have 1-inch margins at the top, bottom, and on each side. Type sizes must be 10 point or larger. Line spacing is at the discretion of the applicant but there must be no more than 6 lines per vertical inch of text. Pages should be standard 8 1/2" x 11" (or metric A4, i.e., 210 mm x 297 mm).

Applicants are expected to use the following ordered format to prepare Applications in addition to following instructions in the Application Guide for the Office of Science Financial Assistance Program. Applications must be written in English, with all budgets in U.S. dollars.

- Face Page (DOE F 4650.2 (10-91))
- Project Abstract (no more than one page)
- Relevance to EM needs (Applicants should use no more than one page to describe how the proposed basic research contributes to EM needs by decreasing health risks to the public and workers from low dose radiation, providing opportunities for major cost reductions in cleaning up DOE's environmental problems, or reducing the time required to achieve EM's mission goals.)
- Budgets for each year and a summary budget page for the entire project period (using DOE F 4620.1)
- Budget Explanation
- Budgets and Budget explanation for each collaborative subproject, if any

- Project Description (The Project Description must be 25 pages or less, exclusive of attachments. **Applications with Project Descriptions longer than 25 pages will be returned to applicants and will not be reviewed**.)
    - Goals
    - Significance of Project to EM needs
    - Background
    - Research Plan
    - Preliminary Studies (if applicable)
    - Research Design and Methodologies
- Literature Cited
- Collaborative Arrangements (if applicable)
- Biographical Sketches (limit 2 pages per senior investigator)
- Description of Facilities and Resources
- Current and Pending Support for each senior investigator

The Office of Science, as part of its grant regulations, requires at 10 CFR 605.11(b) that a recipient receiving a grant to perform research involving recombinant DNA molecules and/or organisms and viruses containing recombinant DNA molecules shall comply with the National Institutes of Health "Guidelines for Research Involving Recombinant DNA Molecules", which is available via the world wide web at: http://www.niehs.nih.gov/odhsb/biosafe/nih/rdna-apr98.pdf, (59 FR 34496, July 5, 1994), or such later revision of those guidelines as may be published in the Federal Register.

Collaboration

Applicants are encouraged to collaborate with researchers in other institutions, such as universities, industry, non-profit organizations, federal laboratories and Federally Funded Research and Development Centers (FFRDCs), including the DOE National Laboratories, where appropriate, and to incorporate cost sharing and/or consortia wherever feasible.

Merit and Relevance Review

Applications will be subjected to scientific merit review (peer review) and will be evaluated against the following evaluation criteria listed in descending order of importance as codified at 10 CFR 605.10(d):

1. Scientific and/or Technical Merit of the Project
2. Appropriateness of the Proposed Method or Approach
3. Competency of Applicant's Personnel and Adequacy of Proposed Resources
4. Reasonableness and Appropriateness of the Proposed Budget.

The evaluation will include program policy factors such as the relevance of the proposed research to the terms of the announcement and the Department's programmatic needs. External peer reviewers are selected with regard to both their scientific expertise and the absence of conflict-of-interest issues. Non-federal reviewers may be used, and submission of an application constitutes agreement that this is acceptable to the investigator(s) and the submitting institution.

Subsequent to the formal scientific merit review, applications that are judged to be scientifically meritorious will be evaluated by DOE for relevance to the objectives of the EMSP which include protecting the health of the populations that live near or work at DOE sites. Additional information on the EMSP can be obtained at http://www.em.doe.gov/science; on the World Wide Web.

Environmental Management Science Program Overview

Purpose

The need to build a stronger scientific basis for the Environmental Management effort has been established in a number of recent studies and reports. The Galvin Commission report ("Alternative Futures for the Department of Energy National Laboratories," February 1995) also provided the following observations and recommendations:

> "There is a particular need for long term, basic research in disciplines related to environmental cleanup" ... "Adopting a science-based approach that includes supporting development of technologies and expertise" ... "could lead to both reduced cleanup costs and smaller environmental impacts at existing sites and to the development of a scientific foundation for advances in environmental technologies."

The Environmental Management Advisory Board Science Committee (Resolution on the EMSP, May 2, 1997) made the following observations:

> "EMSP results are likely to be of significant value to EM" ... "Early program benefits, include: improved understanding of EM science needs, linkage with technology needs, and expansion of the cadre of scientific personnel working on EM problems" ... "Science program has the potential to lead to significant improvement in future risk reduction and cost and time savings."

The objectives of the EMSP are to:

- Provide scientific knowledge that will revolutionize technologies and clean-up approaches to significantly reduce future costs, schedules, and risks;

- "Bridge the gap" between broad fundamental research that has wide-ranging applicability such as that performed in DOE's Office of Science and needs-driven applied technology development that is conducted in EM's Office of Science and Technology; and
- Focus the Nation's science infrastructure on critical DOE environmental management problems.

Representative Research Areas

The EMSP solicits basic research in all areas of science that have the potential for addressing one or more of the areas of concern to the Department's Environmental Management Program. Overall, the scientific disciplines relevant to the EMSP include, but are not limited to:

- biology (including cellular and molecular biology, ecology, bioremediation, genetics, biochemistry, and structural biology)
- chemistry (including analytical chemistry, catalysis, heavy element chemistry, inorganic chemistry, organic chemistry, physical chemistry, and separations chemistry)
- computational sciences (including research and development of mathematical/numerical, informatics, and communication procedures and software technology, e.g., for deterministic simulations and optimization)
- engineering sciences (including control systems and optimization, diagnostics, transport processes, thermophysical properties and bioengineering)
- geosciences (including geophysical imaging, physicochemical dynamics and chemical transport in fluid-rock systems, and hydrogeology)
- health sciences
- materials science (including condensed matter physics, metallurgy, ceramics, waste minimization, welding and joining, degradation mechanisms, and remote sensing and monitoring)
- physics (including atomic, molecular, optical, and fluid physics)
- plant science (including mechanisms of mineral uptake, intercellular transport, and concentration and sequestration).

Major Environmental Management Challenges

This research notice is part of a long-term program within Environmental Management to provide continuity in scientific knowledge that will more effectively protect workers and the public and revolutionize approaches for solving DOE's most complex environmental problems. The following is an overview of the major technical challenges facing the Environmental Management Program. More detailed descriptions of the specific technical work performed at DOE sites can be found in the background section of this Notice.

The Department is the guardian of over 300 large storage tanks containing over 100 million gallons of highly radioactive wastes, that include organic and inorganic chemical compounds, in solid, colloidal, slurry, and liquid phases. The environment within the tanks is highly radioactive and chemically harsh. A few of the tanks have leaked to the environment while others are corroding. The contents of these tanks need to be characterized, removed from the tanks, treated, and converted to safe forms for disposal.

The Department is the custodian of several thousand metric tons of spent nuclear reactor fuels, resulting primarily from weapons fabrication activities during the Cold War, but also including fuel from research and naval reactors. The long-term containment performance of the fuel under storage and disposal conditions is uncertain. Such uncertainties affect the ability to license disposal methods.

The Office of Environmental Management is the custodian of large quantities of fissile materials which were left in the manufacturing and processing facilities after the United States halted its nuclear weapons production activities. These materials include plutonium solutions, plutonium metals and oxides, plutonium residues and compounds, highly enriched uranium, and nuclides of other actinides. Additional scientific information is required to choose processes for converting these materials to stable forms.

The Department currently has on its sites over one hundred sixty thousand cubic meters of waste containing both radioactive and hazardous materials. This mixed waste contains a wide variety of materials, as varied as protective clothing, machining products and wastes, packaging materials, and process liquids. Fundamental scientific data are needed to improve processes associated with treatment systems, such as characterization, pre-treatment, and monitoring.

The Department is committed to the safe disposal of all radioactive wastes, including high-level wastes, mixed wastes, and fissile materials. Safe disposal of these materials requires that the wide range of potential waste streams be converted into insoluble materials for long term storage. Some radioactive material-containing forms have been successfully developed and are being produced; however, at present, research challenges still exist in developing suitable forms for each material to be stored.

The Department is currently conducting cleanup activities at many of its sites, and is preparing plans for additional remediation work. There is much scientific uncertainty about the levels of risk to human health at the end stages of the DOE clean-up effort. This notice for new research in FY 1999 is intended to address these uncertainties.

Background

The United States involvement in nuclear weapons development for the last 50 years has resulted in the development of a vast research, production, and testing network known as the nuclear weapons complex. The Department has begun the environmental remediation of the complex encompassing radiological and nonradiological hazards, vast volumes of contaminated water and soil, and over 7,000 contaminated structures. The Department must characterize, treat, and dispose of hazardous and radioactive wastes that have been accumulating for more than 50 years at 120 sites in 36 states and territories.

By 1995, the Department had spent about $23 billion in identifying and characterizing its waste, managing it, and assessing the remediation necessary for its sites and facilities. Over the next ten years at current budget projections, another $60 billion will be spent. The DOE cleanup of the Cold War legacy is the largest cleanup program in the Federal Government, even larger than that of the Department of Defense legacy.

The Office of Environmental Management is responsible for waste management and cleanup of DOE sites. The EM operations have been historically compliance-based and driven to meet established goals in the shortest time possible using either existing technologies or those that could be developed and demonstrated within a few years. Environmental Management is also responsible for conducting the program for waste minimization and pollution prevention for the Department.

The variety and volume of the Department's current activities make this effort a challenge itself. In some cases, fundamental science questions will have to be addressed before a technology or process can be engineered. There is a need to involve more basic science researchers in the challenges of the Department's remediation effort. The Office of Science addresses fundamental, frequently long-term, research issues related to the many missions of the Department. The EMSP uses SC's experience in managing fundamental research to address the needs of technology breakthroughs in EM's programs.

Details of the programs of the Office of Environmental Management and the technologies currently under development or in use by Environmental Management Program can be found on the World Wide Web at http://www.em.doe.gov; and at the extensive links contained therein. These programs and technologies should be used to obtain a better understanding of the missions and challenges in environmental management in DOE when considering areas of research to be proposed.

References for Background Information

Note: World Wide Web locations of these documents are provided where possible. For those without access to the World Wide Web, hard copies of these references may be obtained by writing Mr. Mark A. Gilbertson at the address listed in the **FOR FURTHER INFORMATION CONTACT** section.

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http://www.nsf.gov/sbe/srs/ostp/assess/

The Catalog of Federal Domestic Assistance Number for this program is 81.049, and the solicitation control number is ERFAP 10 CRF Part 605.

John Rodney Clark
Associate Director of Science
for Resource Management

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