Lawrence Livermore National Laboratory

Lawrence Livermore National Laboratory (LLNL) was founded in 1952 as the nation's second nuclear weapons design laboratory. Over the years, the Laboratory's mission has evolved to address changing national security needs. Today, Lawrence Livermore is one of the world's premier applied science laboratories, where cutting-edge science and engineering are used to ensure the safety and reliability of the U.S. nuclear stockpile and to address other problems of national importance, including nonproliferation, homeland security, biology, energy, and environmental science. Annual Laboratory funding is approximately $1.6 billion; current staffing is approximately 8000.

In executing its national security mission, Lawrence Livermore draws on broad-based capabilities in multiple scientific and technical disciplines, including:

* Atmospheric science
* Biology
* Chemistry
* Computing
* Defense technologies
* Earth science
* Emergency response
* Energy research
* Engineering
* Environmental science
* Information operations
* Intelligence analysis
* Lasers and optics
* Materials science
* Micro/nanotechnology
* Modeling and simulation
* Nuclear weapons
* Physics
* Safety and security
* Systems analysis

Accomplishments

Over its 50 + year history, Lawrence Livermore National Laboratory has made many scientific and technological achievements, including:

- Critical contributions to the ***Stockpile Stewardship Program***, by which the safety and reliability of the U.S. nuclear stockpile is ensured without underground nuclear testing.
- Design, construction, and operation of a series of ever larger, more powerful, and more capable ***laser systems***, culminating in the 192-beam National Ignition Facility (currently under construction, with first light achieved in 2003).
- Advances in ***accelerator and fusion technology***, including the mirror concept for magnetic fusion, the development of free-electron lasers and accelerator mass spectrometry, and breakthroughs in inertial confinement fusion.
- Breakthroughs in ***high-performance computing***, including the development of novel concepts for massively parallel processing and the design and application of computers that can carry out hundreds of trillions of operations per second.
- Development of ***extreme-ultraviolet lithography*** for fabricating next-generation computer chips, and the successful transfer of the technology to industry.
- First-ever detection of ***massive compact halo objects*** (MACHOs), a suspected but previously undetected component of dark matter.

- Advances in ***genomics and biotechnology***, including major contributions to the complete sequencing the human genome through the Joint Genome Institute and the development of PEREGRINE, a vastly improved method for radiation treatment of cancer.
- Development and operation of the ***National Atmospheric Release Advisory Center,*** which provides real-time, multi-scale (global, regional, local, and urban) modeling of hazardous materials released into the atmosphere.

Homeland Security

LLNL was able to respond broadly and effectively to September 11, 2001, and its aftermath because we already had numerous projects under way aimed at preventing, detecting, and responding to terrorist use of nuclear, radiological, chemical, or biological weapons. Of particular note:

- The ***Nuclear Assessment Program***, which is a cornerstone of U.S. efforts to defend against nuclear threats and counter nuclear smuggling.
- ***Radiation detection technologies*** to prevent nuclear terrorism, including the RadScout portable detector and identifier, the technology for which has been successfully commercialized.
- ***Nuclear incident response*** capabilities, including instruments for detecting and characterizing radioactive materials and unique tools for disabling terrorist nuclear devices.
- Activities in ***cargo container security***, including research to identify new signatures for rapidly detecting the presence of nuclear material hidden inside loaded cargo containers.
- ***Tactical simulation tools*** for assessing the vulnerabilities of potential target facilities, evaluating strategies for dealing with terrorist attacks, and managing response operations in the event of an attack.
- The ***Forensic Science Center***, a center of excellence in forensic science and analysis.
- ***Breakthroughs in biodetection technology***, including the rapid PCR (polymerase chain reaction) technology that lies at the heart of today's most advanced DNA detection instruments.
- The ***Computer Incident Advisory Capability***, which is the Department of Energy's cyber alert and warning center and develops science and technology solutions to enhance computer network defense.

Benefits to the Nation

Fifteen years ago, the consuming security threat to the U.S. was the nuclear arsenal of the Soviet Union. The energies, talents, and resources of Lawrence Livermore National Laboratory were dedicated to checkmating that threat. Today, the Soviet threat no longer exists, and new threats have arisen that are radically different and vastly more complex. Lawrence Livermore is applying its world-class scientific and technological resources—people, equipment, and facilities—to meet the country's national security needs. Even as we provide critical elements of the nation's defense against nuclear, chemical, and biological terrorism, we are also pushing the frontiers of science and technology to make the breakthroughs that will be required to meet U.S. national security needs in the future.

1. Start and end dates:

LLNL can start accepting students by mid May through the 3rd week of June with departure through September. Arrivals outside of mid May to the 3rd week of June requires administrative approval and a LLNL PI supporting the placement and schedule. Typical start dates for Summer'08 will be on Mondays. While DHS requires a 10 week internship, LLNL would encourage interns to consider 12 weeks. DHS will require confirmation and justification from the Lab mentor when appointments are more then 10 weeks. Note that assignments for greater then 10 weeks may require alternate lodging arrangements.

2. Ending Assignments early:

LLNL is a defense and national security laboratory. Any infraction to prohibited items can result in pulling ones badge and depending on the infraction, an investigation, leading to ending the appointment early. LLNL will provide a list of prohibited items but as an example, this includes bringing onsite cell phones with cameras, recording devices, personal computers (especially with wireless capability) and controlled substances including illegal drugs and associated paraphernalia (except prescription drugs in their original containers). If a drug test is requested, LLNL is not responsible for the cost of the test.

3. A brief plan how students will be integrated (both work and social):

Once an offer is extended, the student(s) and researchers will be encouraged to contact each other and for the researchers to provide reading material, web site links, ongoing communications to bring the student up to speed on the project – as much as possible and can be done based on the students school schedule.

Students are also encouraged to access http://internships.llnl.gov/sbb/ and the link to 'previous events' to view an example of last summers student program. All starts will be on a Monday to include one and a half days of orientation which will cover required safety, cyber security and other student events and start information. Additional safety courses are project specific and will be required to be completed prior to being able to start ones research. Safety is taken very seriously at LLNL, especially when here for a short period of time like 10 weeks. It is common that one may take 2 to 4 weeks before having completed all the safety requirements, cyber security, gaining access to networks, and being trained before being comfortable working with expensive equipment, starting to become productive and working without or with less supervision.

LLNL hosts approximately 500 upper level undergraduates and graduates every summer. In addition to lectures held with in a Directorate, Department and Program, there is a whole series of summer students lectures, panels, socials, networking, etc. – and oh yes, the research project. So there are plenty of things to do and opportunities to network – both between other students and the Lab researchers. Of course, within the DHS Scholars/Fellows program there is also a required weekly briefing. Failure to participate in the DHS briefings can result in ending the assignment early.

LLNL is located in a mile square facility with 2 cafeterias. Pending one's research area, the dress in the summer is usually similar to what a student wears on campus. While work hours are from 8:00 AM – 4:45 PM, the specifics of when a student arrives and departs is agreed upon with the supervisor. Students are not allowed to work alone and initially, without supervision.

LLNL is located approximately 50 miles East of San Francisco. A BART (Bay Area Rapid Transit) station is located in Pleasanton (10 miles west of Livermore) for access to the Bay Area. Monterey, Napa Valley and Yosemite are within a few hours drive and popular tourist spots.

Lodging: Lodging will be facilitated by LLNL but will be the responsibility of the individual. LLNL is allowed to provide a $39/day per diem called CONUS. This is not compensation for the internship but subsistence and is ONLY authorized during the workweek (no weekends and excluding holidays). The good news is with 4 students per apartment (2 bedroom/2 bath unit), the estimated cost for 2008 will be $25/night/student. So at $39/day during the workweek, CONUS should cover lodging costs during the entire week or 7 days. This will require all 4 students to start and end on the same day. If a student is unable to arrange his or her schedule to accommodate this, he or she can identify their own lodging. LLNL will still be able to provide the CONUS and will be able to direct the student to resources that might be helpful. Any participants living locally in the Bay Area will not be authorized CONUS. As a reminder, CONUS is subsistence, whether used for lodging or other costs is the decision of the student but students accepting the housing arrangements by LLNL will be direct billed for their lodging and will be required to submit a credit card for their lodging costs to the leasing agent. This credit card will also be held for any damage, missing items or failure to clean sufficiently upon your departure. Charges to your credit card will be at the discretion of the leasing agent.

Relocation: LLNL is no longer able to provide any assistance with relocation. If you fly, students are encouraged to ship a bike. Bike boxes for shipping can be obtained (usually free) from your local bike store. If you have the opportunity to bring a car, it is encouraged. While there is local transportation available, it is less convenient then having your own car and may not be available from every apartment used for lodging. Further, your popularity among other students increase if you have a car and there are plenty of places to go on the weekends!

Research Paper/Poster: LLNL traditionally requires an oral presentation at the conclusion of a summer assignment and participation in the Lab-Wide Summer Student Poster Symposium.   The poster symposium is usually the second Thursday in August. It is advantageous to arrange your dates to be here during this time.

Internship Opportunities in Homeland-Security-Related Research
at Lawrence Livermore National Laboratory

Summer 2008
UCRL-BR-207856, Revision 3

Biological Countermeasures

Assessment of Biotechnology and Emerging Threats

The Biodefense Knowledge Center (BKC), supported by DHS and headquartered at LLNL, provides actionable scientific and technology information to the homeland security community. The BKC evaluates recent scientific advances and emergent and emerging technologies that could enhance the capabilities of an adversary intent on using biological weapons against U.S. interests. The goal of this project is to complete paper-based assessments aimed at providing decision-makers with accurate analyses of the immediate and near-term applicability of potential dual-use biotechnologies from a biological threat perspective and the nation's ability to counter the threat. Students will have the opportunity to leverage their interest in cutting-edge science and their ability to understand and analyze developments in a broad range of biological fields. Students must be able to communicate their technical findings in ways that are understandable and meaningful to both technical and nontechnical audiences.
Contact: Tom Bates (925-423-3055; twbates@llnl.gov)

Rapid Identification and Characterization of Previously Unknown or Emerging Pathogens

As highlighted by the 2003 outbreak of SARS (severe acute respiratory syndrome), there is a pressing need for capabilities that enable the rapid identification and characterization of previously unknown or emerging pathogens. Such capabilities will be critical for mounting a timely and effective response to a nationwide bioterrorism event. To date, the nation has focused on short-term production of assays for the specific identification of high-threat and naturally emerging pathogens. While necessary, this focus on species identification has created a gap in our defensive and public health arsenal. As a result, the nation is ill-prepared to deal with novel pathogens (natural or engineered) or complex mixtures of organisms or to detect virulence regardless of the organism conferring it. This problem is compounded by a near-total lack

of knowledge of "normal" microbial backgrounds in environmental, human, and agricultural samples. Students participating in this project will assist in the development of new technologies for dynamically responding to emerging threats using advanced genomic and proteomic approaches.
Contact: Christopher Bailey (925-422-0578; bailey38@llnl.gov)

Enhanced Bioaersol Detector System and Single-Particle Mass Spectrometry

The Bioaerosol Mass Spectrometry (BAMS) research team is developing a novel instrument for the rapid analysis of single cells and the identification of individual bioaerosol particles for applications in homeland security and biomedicine. This instrument is based on a combination of advanced optical techniques, laser desorption mass spectrometry, high-speed data acquisition, and novel identification algorithms. A first prototype of the system can already discriminate, particle by particle, between bacterial spores and other aerosols or hoax materials ("white powders"). It can also distinguish between several species of bacteria. The team is expanding the scope of its research to include basic biology studies of cell differentiation, applications of bioaerosol analysis in biomedicine and environmental microbiology, studies of optical properties of aerosol particles, research into the physics of laser-biomolecule interactions, and the development of smarter and faster algorithms for particle identification based on optical properties and mass spectral fingerprints.

Research projects are available in the following areas:

- Microbial Ecology. BAMS can be used as a novel tool to study the microbial diversity of the air. Interested students would develop BAMS signatures for a variety of bacterial and fungal organisms commonly found in California air. Following signature development, students will analyze air and use an LLNL-developed neural network to characterize the ecology of the air. Results will be compared to more traditional methods of analysis, including DNA probe microarrays of community small-subunit rDNA. Interested individuals should have interests in biodefense, microbial ecology, and the use of novel analytical tools for microbiology.
- Real-Time Determination of the Viability of Individual Airborne Microorganisms. Currently, no technique exists that can characterize the living state of individual airborne microorganisms in situ and in real time. For this project, the student will (1) develop laboratory-based techniques for the controlled production of airborne microorganisms in their viable and other states, (2) characterize the viability and morphology of laboratory-generated microbial aerosols using established microbiological techniques, and (3) relate the measured biochemical signatures of individual airborne microorganisms to their living states using BAMS.
- Highly Efficient Sampling of Individual Microbes for Rapid Pathogen Detection. The particle inlet is a critical component of BAMS because it defines the sampling rate and is responsible for creating a low-divergence particle beam for efficient and effective analysis of individual particles within the high-vacuum region of the instrument. We are developing novel particle focusing devices to increase aerosol collection into vacuum by two to three orders in magnitude. For this project, the student will evaluate the performance of current and new particle inlet configurations for BAMS.
- Real-Time Optical Analysis Techniques for Aerosol Prescreening. BAMS instruments will incorporate additional optical stages, currently in development, that will probe aerosol particle shape through Mie scattering patterns and the UV fluorescence of particles to determine their organic properties. These optical properties provide information about the aerosol particles (orthogonal to mass spectrometry), which will help to rapidly sort out potentially interesting biological particles from background aerosols. Research in this area includes the study of optical absorption, back-scattering patterns, and fluorescence properties of individual bacterial cells and other biological particles as a function of excitation wavelength.
- Advanced Laser Mass Spectrometry. We are exploring a wide range of laser wavelengths to be used to improve the desorption and ionization of biomolecules from cells. Using a variety of different advanced laser systems, students working in this area will help investigate the fundamental physics of laser desorption and photo-ionization of biomolecules from single cells or bacterial spores as well as the flow of the resulting biomolecular ions into a time-of-flight mass spectrometer. Students should have an interest or background in lasers and photonics and optical techniques, as well as the desire to understand complex physical processes at the interface between physics and biology.

Contact: Matthias Frank (925-423-5068; frank1@llnl.gov) or George Farquar (925-424-4275; farquar2@llnl.gov)

Rapid Methods of Detecting Molecular Changes Associated with Antibiotic Resistance in *B. anthracis*

The majority of effort to detect potential biothreat agents has, until now, been focused primarily on unmodified classical threat agents. However, this is only the first step required to keep up with rapidly moving biotechnology. As the mechanisms of virulence and pathogenicity, resistance to different antibiotics, and resistance to currently effective therapies are understood, the very methods used to elucidate this information can be used to engineer microbes with these traits. The result could easily be microbes that are not detected by current methods, microbes that are detected but that carry traits not usually characteristic of the target, and microbes for which no effective therapy is available.

This project is focusing on the development of rapid assays to detect resistance to two key groups of antibiotics, the fluoroquinolones and the penicillins. Molecular signatures of ciprofloxacin resistance in *B. anthracis* are based on known point mutations that confer resistance to this antibiotic and on knowledge of the substructure of DNA gyrase and other type II topoisomerases, the cellular targets of ciprofloxacin and other fluoroquinolone antibiotics. This project is developing molecular assays that detect changes in genes encoding type II topoisomerases that are associated with antibiotic resistance. The project is also developing molecular assays to detect penicillin resistance in this threat pathogen. Penicillin is highly effective against *B. anthracis*; however, resistance can result from a change in beta-lactamase gene expression that is, in turn, controlled by gene regulatory elements. Work to characterize the molecular mechanisms behind altered beta-lactamase gene expression focuses on specific molecular changes associated with penicillin resistance in two *B. anthracis* isolates. Assays that detect these changes are being developed and will be used to demonstrate whether these changes are also responsible for resistance in other isolates or are specific only to the isolates so far studied.
Contact: Paul Jackson (925-424-2725; jackson80@llnl.gov)

High-Throughput Automated Nucleic-Acid-Based Methods for Detection of Viable Pathogens in Environmental Samples

Improved turnaround times for sample analysis are required to rapidly characterize and restore facilities following a biothreat agent release. Current methods for characterization and clearance using surface samples are limited by low-throughput manual processing protocols and the long time periods required for traditional culture-based detection and biochemical confirmation of viable biothreat agents. Automated protocols are being developed for processing diverse sample types and are being optimized to accommodate large amounts of background debris from indoor and outdoor sources. Automated processing increases throughput, standardizes protocol steps, and decreases exposure to potentially infectious samples. The automated protocols are compatible with methods to determine viability of ~10 spores on dirty wipe and filter samples within hours. Specifically, the detection method uses accurate and sensitive real-time quantitative polymerase chain reaction (qPCR), based on the change in qPCR response due to increased target cell populations during accelerated culturing as a measure of viable spore presence. Current development is focused on targeting a broader set of bacterial pathogens. Protocols are also being developed to target pathogen mRNA using reverse transcriptase qPCR as a direct indication of viability. Interns would gain valuable experience in molecular biology, microbiology and robotics as they help develop capabilities for characterizing and restoring facilities contaminated with biothreat agents.
Contact: Staci Kane (925-422-7897; kane11@llnl.gov)

Assessment of Forensic Signatures of Single Bacterial Spores by High-Resolution Atomic Force Microscopy

Spore surface structures determine important physico-chemical properties, such as hydrophobicity, adhesion, dispersal, and ecological response to the environment. Microbial forensics is challenged by the prospect of having to establish the origin, means and methods of production, processing, stabilization, and dispersal through the analysis of extremely small quantities of evidence. There is a need to evaluate entirely new analytical technologies that are capable of interrogating single cells and spores. Atomic force microscopy (AFM) allows direct and rapid visualization of micro-quantities of crude samples at molecular resolution in air or fluids. AFM is highly efficient in visualizing objects in the size range of tens of nanometers to tens of microns covering the entire spectrum of pathogenic agents, from small agricultural viruses to engineered human or animal cells.

The objective of this project is to investigate forensic signatures associated with the architecture, structure, and hydrophobicity of single bacterial spores through a systematic high-resolution in-vitro AFM characterization of spore samples. The experimental approach uses AFM in conjunction with ensemble techniques including immunochemical and nanogold chemical labeling. AFM will be utilized as a forensic tool to obtain spore structural signatures that identify agent preparation, purification, and formulation procedures. The student supporting this project will provide data and a knowledge base for understanding the structure and biophysical properties of bacterial spores and for the analysis of collected sample by reconstruction of sporulation, purification, and formulation signatures.
Contact: Alex Malkin (925-423-7817; malkin1@llnl.gov)

Ultra-Uniform, High-Throughput Sieve for Rapid Microbe Identification

An important challenge for the identification of unknown biothreats is separating the harmful microbe (bacteria or virus) from the larger background of nonthreat microbes. To do this, it is necessary to know what constitutes the background microbial composition—only then can the novel microbe be distinguished. A promising method for identifying novel microbes is to first separate them as particles by their defined physical properties (e.g., size, density, charge, other property) and then enumerate the particles separated that have a common physical property (e.g., similar size). Once this is accomplished, the particles' nucleic acid can be further characterized by detecting the presence of conserved nucleic acid sequences that are unique to microbial families that constitute the same physical size as the unknown pathogen. (This method was used successfully to identify a novel Corona virus obtained from a SARS patient.) Determining the physical size and abundance of the particle before conducting a nucleic acid similarity search would allow the search to be much faster and more accurate.

This project explores a novel method for laser fabrication of an ultra-uniform silicon-based sieve that will sort microbes into key size bins rapidly and efficiently. Current technology (e.g., polycarbonate track-etched membranes) lacks uniformity or throughput efficiency to perform this task effectively. We make use of very uniform silicon substrates and other processes designed for the microelectronics industry and precisely integrate these to create large-area filters. Specific issues to be addressed include fabrication paths toward nanometer-scale uniformity for pore diameter, determination of mechanisms necessary for efficient microbe transport through pores, and surface coatings to control interaction between microbes and pores. To examine some important application characteristics, fluid flow experiments with benign microbes can be performed. Goals for the summer project will be defined based on the student's experience and interests.
Contact: Joe Tringe (925-422-7725; tringe2@llnl.gov) or Ray Lenhoff (925-424-4034; lenhoff2@llnl.gov)

Nuclear Countermeasures

Emergency Preparedness Architecture

Decisions and actions taken by responders and community leaders in the first few hours of a radiological or nuclear attack have the greatest potential for reducing exposure and saving lives. The national laboratories support the Department of Homeland Security by providing technical understanding, modeling, and integration of radiological and nuclear terrorism effects into preparedness programs. Models can calculate the effects of the blast wave and the dispersal of fallout. However, emergency responders also need information about the expected physical and psychological effects on populations, the expected degree and types of injuries and the response system's ability to handle them, the expected effects on infrastructure and their influence on response capabilities, and guidelines for response organizations and the public in the event of radiological or nuclear terrorism. This technical information must be synthesized into effective community preparedness campaigns. Depending on student interests, project activities include effects modeling aimed at improving preparedness, facilitating workshops and interviews with emergency response experts, and drafting of white papers and other documents to help inform policy development for radiological and nuclear

emergency response.
Contact Brooke R. Buddemeier (925-423-2627; buddemeier1@llnl.gov)

Advanced Light-Emitting Materials and Devices

Our multidisciplinary research group is developing new scintillator materials for multiple applications in homeland security. Efforts range from growth of large scintillator transparent ceramics to photonic device integration. Scintillators are materials that emit light when excited by electrons (e.g., in a cathode ray tube in a television) or other high-energy radiation. Transparent ceramics are prepared from nanocrystalline particles, sintered to the transparent shape and size of choice. We are working on integrating our new scintillator materials into improved scintillator detectors with optimized performance through detailed analysis of the optics, photodetector and electronic noise. Students with background and interest in optics, device engineering, inorganic synthetic chemistry, ceramics processing, or optical spectroscopy are invited to participate.
Contact: Nerine Cherepy (925-424-3492; cherepy1@llnl.gov)

Contextually Aware Expert System for Automated Threat Assessment

Gamma-ray and neutron measurements alone are often insufficient to discriminate benign sources of radiation from those that pose a weapon threat. Most spectroscopic gamma-ray detection systems presently in use, or likely to be in use in the next few years, are based on scintillators such as NaI (T1) and CsI (T1) that provide only modest resolution and thus further compound the discrimination problem. This project aims to combine gamma-ray and neutron measurements with nonradiation and contextual information to vastly improve threat/nonthreat discrimination and radiation alarm resolution capability. This project will develop a decision analysis expert system (DAES), supported by an information architecture developed specifically for this application. The functioning system will enable nuclear and radiological threat-detection operations with higher detection probability and lower false-alarm rates at reduced operating costs.
Contact: Simon Labov (925-423-3818; slabov@llnl.gov)

Ultrahigh-Energy-Density Isotopic Power Sources for Advanced Microsystems

Microelectronic circuits and microelectromechanical systems (MEMS) are potent tools for computation, navigation, and sensing. With every successive generation, circuits and sensors have become smaller and increasingly capable. However, the traditional batteries that power these systems in the field cannot be scaled down because of fundamental limitations associated with the energy density of the power source. For example, a lithium ion battery has an energy density of about 0.3 milliwatt-hours per milligram (mW-h/mg). For a power supply, therefore, smaller is definitely not better. As a result of this scalability difference between the system’s computational and/or sensing component and its power supply, the size and weight of the system as a whole is increasingly limited by the power supply itself.

Ultrahigh-energy-density materials, such as radioactive isotopes, are being considered as a way to solve this problem for advanced Microsystems. Polonium-210, for example, emits alpha particles and has an energy density of 57,000 mW-h/mg, which is almost 200,000 times greater than that for a lithium ion battery. Due to the very high energy density of the isotope source, the total amount of isotope needed to power a microsystem could be less than that used in a standard smoke detector.

This project will explore critical aspects of conversion efficiency and longevity associated with microscopic isotope power sources. Specific issues to be addressed include mechanisms for extending the lifetime of the battery by using thin-film scintillators and photovoltaic cells. Goals for the summer project will be defined depending on the student participant's experience and interests.
Contact: Joe Tringe (925-422-7725; tringe2@llnl.gov)

Mathematics, Computations, and Simulations

Multiscale Epidemiological/Economic Simulation and Analysis (MESA) Decision Support System

The MESA decision support system is a DHS project to develop a coupled foot-and-mouth disease (FMD) epidemiological model and economic impact model. The national-scale system provides an environment to explore various scenarios for the intentional introduction of FMD. Users are able to assess the efficacy of response options and countermeasures (e.g., diagnostics, vaccines, therapeutics) in controlling the extent and duration of simulated outbreaks. MESA is an individual-based model, with each agricultural facility representing a herd, stockyard, etc., modeled as a discrete entity. The Java-based framework includes components for scenario definition and setup, data analysis, and visualization, including linkages to a geographical information system. MESA is designed to run on supercomputers or large clusters and can be extended to simulate other foreign animal diseases. The MESA project is looking for a computer science candidate with an interest in scientific data analysis or geographical information systems. The candidate will participate in the development of algorithms and software to analyze MESA output.
Contact: Tom Bates (925-423-3055; twbates@llnl.gov)

Video- and Radar-Based Detection and Tracking of Fast Moving Objects

In a number of DHS related problems, there is a need to develop distributed sensor network system where multiple sensor nodes are used to detect and track objects of interest. For example, there is a need to detect and track intrusions using outdoor video and LLNL's micropower impulse radar (MIR) technology. Track characteristics together with biometric measurements from advanced radar and other sensors can be used to further discern higher level information for surveillance and real-time analysis. This project involves the use of signal processing methods, in particular advanced Kalman tracking and radar signal processing methods. Strong interest in signal processing and algorithm development is the main requirement in this project. Students must be fluent in programming in MATLAB, C, and basic signal processing.
Contact: Farid Dowla (925-423-7705; dowla1@llnl.gov)

Computational Analysis of Structural Vulnerabilities

In order to better understand the potential vulnerabilities to both civil and defense industrial base (DIB) infrastructure, LLNL engineers are applying first-principle-physics hydrocode modeling to risk and safety studies. The level of fidelity provided by these analyses can be critical for determining asymmetric threats and the risk of intolerable consequences on U.S. soil. The assessments can used by stakeholders to design mitigation strategies.
Project opportunities are available with the Defense Systems Analysis Group (DSAG) and Structural and Applied Mechanics Group (SMG) of LLNL's Engineering

directorate. Working as part of a team, students will have access to LLNL's world-class supercomputing resources and engage in numerical/computational studies to validate experiments and perform sensitivity and parameter studies on structural materials and mechanical systems. This work may also include performing trade-off studies to determine the appropriate level of fidelity required for a particular risk scenario. A background in mechanical and/or civil/structural engineering is required, with basic course work in mechanics of materials, statics, dynamics, and continuum mechanics recommended.
Contact: Doug Faux (925-423-9705; faux1@llnl.gov)

BAMS Data Analysis and Algorithm Development

Real-time data processing and analysis is vital to turning real-time data obtained with a Bioaerosol Mass Spectrometry (BAMS) instrument or an Enhanced Bioaerosol Detector System (EBADS) into protective action. The problem of identifying a bioagent from the measured single particle properties (size, charge, fluorescence, mass spectrum) has many layers. In its simplest incarnation, it is necessary to perform pattern recognition on multidimensional data and mass spectra as they are acquired to identify threat agent spectra and to give a confidence level for the identification. While this will be prototyped in software, ultimately the algorithm must be amenable to implementation in an embedded system. The problem becomes even more interesting when ones considers that the identification of a mass spectrum should also take into account the tentative identities of other spectra that have been acquired at the same time and in the same place. Suspicious new spectra need to be data-reduced and reported to a central location where they can be compared with suspicious particles from other locations. The definitions of suspicious particles must be constantly updated to reflect new information and particles identified at nearby instruments. Obviously, these are just a few of the issues that confront the establishment of a distributed biodefense grid using many networked BAMS or EBADS instruments. There is considerable depth to this field to be pursued by an innovative computer scientist, electrical engineer with a strong background in algorithm development, or applied mathematician with an interest in pattern recognition.
Contact: Matthias Frank (925-423-5068; frank1@llnl.gov) or Paul Steele (925-422-5239; psteele@llnl.gov)

Simulating the Dispersion of Hazardous Materials in Urban Environments

This research team is developing a new incompressible finite-element flow solver for the simulation of the dispersion of hazardous materials in urban environments. The new solver includes an adaptive mesh refinement capability and it is designed to provide high performance on a wide range of computational platforms. The urban dispersion modeling capability will be integrated into the operational modeling system of the National Atmospheric Release Advisory Center (NARAC) to support DHS and DOE in vulnerability studies, emergency planning and response, and post-event assessments. Data from the Salt Lake City Urban 2000 and Oklahoma City Joint Urban 2003 field experiments are used to validate and improve aerosol physics and turbulence parameterizations in the urban dispersion model. The student participant would be involved in the development, improvement, and evaluation of this new urban dispersion model. The student should have basic knowledge of fluid mechanics, some training in computational methods, and relevant computer skills. Basic knowledge of atmospheric boundary layer dynamics would be a plus.
Contact: Branko Kosovic (925-424-4573; kosovic1@llnl.gov)

Source Characterization for Modeling the Dispersion of Hazardous Materials

A recent report by the National Research Council of the National Academies identified source characterization as a crucial topic that must be addressed in order to improve dispersion modeling: "To accurately predict atmospheric dispersion of hazardous materials it is first necessary to answer the critical questions: What was released? How much material was released? When and where?" Researchers at LLNL are developing an atmospheric release event reconstruction capability with source characterization as one of its key components. Source characterization represents a difficult inverse modeling problem where initial conditions are estimated based on sparse, degraded, or conflicting data and additional uncertainties arise from observations of meteorological conditions.

This project uses a stochastic methodology based on Bayesian inference. For source characterization, a wide range of forward dispersion models, from simple Gaussian puff models and Lagrangian particle dispersion models to computational fluid dynamics codes, for the prediction of dispersion in urban areas. The student participant will be pursuing an undergraduate or graduate degree in statistical analysis, atmospheric science, physics, mathematics, or computer science. The student will work with team researchers to develop and test the methodology using field observations of releases of passive tracers and variable atmospheric dispersion models.

Contact: Branko Kosovic (925-424-4573; kosovic1@llnl.gov)

Nondestructive Evaluation (NDE) to Defend the Homeland

Making sure that explosives do not get on airplanes and other mass transit modes and interdicting weapons of mass destruction at our borders requires several different types of detection technologies. The NDE team at LLNL is researching and developing x-ray methods to increase the probability of detection for explosives and to reduce the false alarm rate caused by nonthreat materials. The LLNL team specifically is looking for students to reduce the x-ray radiographic and tomographic images and to experimentally evaluate the x-ray attenuation properties of explosives and nonthreat materials in a controlled laboratory environment. For border protection applications, we are also looking students interested in analyzing high-energy (9-MeV bremsstrahlung) x-radiographs.

Contact: Faranak Nekoogar (925-423-3148; nekoogar1@llnl.gov)

Analysis of Software for Detection of Security Flaws

This project is focused on the detection of security flaws through the analysis of both source code and binary forms of software. Work includes both the compile-time analysis of C and C++ applications as well as the direct analysis of binaries. Work also includes program analysis and transformations supporting the detection and repair of software security flaws in existing software. Within this project, novel techniques are being developed to identify and quantify levels of security for existing software. A specific focus of this project is on handling the requirements of large-scale software and the precise analysis of large-scale software using parallel computational resources to support aggressive forms of analysis and software verification.

Contact: Daniel Quinlan (925-423-2668; dquinlan@llnl.gov)

Pathogen Bioinformatics

The Pathogen Bioinformatics team at LLNL is determining unique DNA and protein diagnostics for microbial pathogens of bioterrorism concern. Over the past few years, with enormous help from summer students, we have built the world's most efficient automated pipeline for designing such diagnostics. The requirements of our customers (e.g., DHS, CDC, USDA) are driving the development and implementation of additional functions to this system. We are

also conducting several complex analyses of pathogen genomes to develop signatures for bioforensics and next-generation biodetection technologies. All student positions in the project require an ability to program in Perl or a demonstrated ability to learn Perl rapidly on the job. Although in-depth biological knowledge is not required, prior exposure to DNA and/or protein sequence analysis is desirable. Individual assignments will be based on the participant's level of programming and analysis capabilities.
Contact: Tom Slezak (925-422-5746; slezak1@llnl.gov)

Research area: Chemical and Biological Threats and Countermeasures

Title: Virtual PCR
Description: Computational modeling of PCR reaction kinetics, in order to predicatively optimize PCR protocols by simulation
Required skills: Advanced C++ programming required. Familiarity with bioinformatics and polymerase chain reaction (PCR) is desired.
Expected from student: The student is expected to program several alternative formulations of a particular kinetic rate, which will be called by an existing suite of software. The student will then compare predictions of the software with empirical data, to determine the most appropriate formulation.
Funding: No DHS funding
Contact: Peter L. Williams (phone: 925-296-5789; email: williams95@llnl.gov) or Shea Gardner Shea N. Gardner (phone: 925-422-4317; email: gardner26@llnl.gov)

Research area Explosives Detection, Mitigation and Response

Title: Superconducting ultra-high energy resolution Gamma spectrometer arrays
Description: The Advanced Detector Group at LLNL is developing ultrahigh energy-resolution Gamma and fast-neutron spectrometers for national security and fundamental science applications. They are based on thermistors operated at the transition between the superconducting and normal state, and they measure Gamma-ray energies from the temperature rise upon absorption. They have achieved an energy resolution of 50 - 90 eV FWHM at 100 keV, which exceeds that of conventional high-purity Germanium detectors by an order of magnitude. This can increase the precision of non-destructive isotope analysis of nuclear samples accordingly by removing statistical errors due to line overlap and by reducing systematic errors due to baseline subtraction and efficiency variations. One current challenge for this detector technology is to increase their sensitivity by building pixilated detector arrays and the associated readout electronics. For this, we are fabricating large Mo/Cu detector arrays by photolithography, and are collaborating with Prof. Adrian Lee's group in the Physics Department at UC Berkeley on the development of a multiplexing technique to read out these arrays with an acceptably small heat load into the detector cold stage. The second challenge is to increase the user-friendliness of these superconducting spectrometers by automating detector operation at 0.1 K without the use of cryogenic liquids. We are working with VeriCold Technologies on adapting their mechanical pulse tube refrigerator technology to cool down our superconducting sensors without introducing additional noise due to vibrations.
Expected from student: The DHS students will work with members of the Advanced Detector Group on implementing the frequency-multiplexed readout for the gamma-detector arrays. They will also test the compatibility of these sensors with operation in a liquid-cryogen-free pulse tube refrigerator. They will then use the cryogen-free gamma-spectrometer for novel precision measurements of nuclear materials.
Funding: No DHS funding
Contact: Stephan Friedrich, 925-423-1527; and email <friedrich1@llnl.gov>

Title: Pillar Structured Thermal Neutron Detector
Description: For certain homeland security applications, radiation detectors must be inexpensive and robust, operate at ambient temperature, provide high efficiency, and be small enough to be used in covert operations. Current detector technology is limited in its ability to meet all of the requirements. For example, many of the gamma-ray detectors operate properly only at liquid-nitrogen temperature, which significantly increases the overall system size. Neutron detectors used in the field typically operate with tubes filled with helium gas. These instruments are large, require high voltage to operate, and are sensitive to vibration. Applying micro and nano technology methods may revolutionize improvements in these devices. A team will hopefully demonstrate that microscale materials can be fabricated to produce a high efficiency thermal neutron detector. The Pillar Detector promises to achieve more than twice the efficiency of conventional thermal neutron detectors used in the field, without the field issues that challenge detectors using helium tubes. Instead of helium, the Pillar Detector relies on a carefully constructed platform of etched silicon pillars that are interspersed with boron, which converts incoming neutrons to alpha particles. The 3D structure maximizes the capture of neutrons. Incoming neutrons interact with the boron, producing alpha particles that interact with the semiconductor and create the current that provides the electronic signal.The group is collaborating with the University of Nebraska at Lincoln, which is applying the chemical vapor deposition of boron.
Expected from Student: The DHS students will work with members of the Pillar Detector team on materials integration, processing and testing as well as device silicon PIN diode characterization. Prior clean room experience is desired but not required.
Funding: No DHS funding
Contact: Rebecca Nikolic, 925-423-7389, nikolic1@llnl.gov
Research area: *Explosives Detection, Mitigation and Response*

Title: LLNL Foreign Animal Disease (FAD) Modeling and Risk Assessment Program
There are several USDA and DHS funded projects that involve foreign animal disease modeling and risk assessment. Our project is focused on developing a national scale decision support system (DSS) to be used for planning and policy analysis in preparation for the introduction of foreign animal diseases (FADs). The initial coupled epidemiological and economic model (MESA) was developed for analysis of foot and mouth disease (FMD) epidemics and is now being adapted to model other foreign livestock or poultry diseases (HPAI, END, and CSF). MESA is then used as a tool to execute a systems studies analysis on intentional FMD introduction and evaluation of the impacts of various countermeasures employed along the line of the HSPD-10 pillars of defensive architecture. Current work is focused on FMD and HPAI, but will be expanding into Classical Swine Fever (CSF) in 2008.
Student skills/Expectations: Background in animal science, agriculture, or segments of the livestock industry preferred. Interest in infectious disease or epidemiology. Will contribute to ongoing projects in FAD modeling.
Funding:Fully funded by DHS.
Contact: Pam Hullinger, 925-423-7083, hullinger2@llnl.gov
Research Area: Chemical and Biological Threats and Countermeasures

Title: **Protein Pipeline: Reagents for Protein-based Detection & Thermal-Fluidic System for the Manipulation of BioMolecules and Viruses**

The goal of this project is to develop an increasingly efficient and productive pipeline of high affinity, selective, low cost reagents and protein-based molecular recognition assays for bioagent identification. These reagents and assays will eventually become the gold-standard complements to the genetic-based assays. We will develop 'multi-loci' protein recognition reagents for Select Agents with a focus on the list of top 20 threat agents identified by the Biological Threat Characterization Center (BTCC). Reagents will be produced using a pipeline approach with a major reduction in labor and operational costs ($0.05/signature; $0.50/agent test). Pipeline reagent discovery work will focus on looking for those NNAA ligands present in the libraries that bind to surface proteins. For organisms or proteins that are refractory to the HTP discovery methods, a focused computations guided approach will be used to produce synthetic ligand (SL) reagents. Recombinant antibodies will be generated for a subset of targets that exhibit unique structural features (loops, mobile domains) that cannot be targeted by small molecules.

ENGINEERING OVERVIEW: The rapid detection and identification of genetically engineered or naturally occurring viruses is important for current and future national security concerns. An often overlooked, yet critical, aspect in the general bio-detection space is the need for rapid, automated sample preparation instruments, of which, very few techniques and capabilities exist to manipulate viral samples. The project described here will use a new microfluidics separation and concentration technique to characterize various physicochemical viral properties and determine the feasibility of using this microfluidic platform to process viruses in complex fluids. The proposed 10-week project will consist of two parts. First, the student will develop or acquire fluorescently labeled protein and viral samples. These samples will then be incorporated into a "real world" biological matrix (such as saliva, urine, nasal pharyngeal fluid, etc.) and characterized to determine protein and viral electrophoretic mobilities by optically tracking the concentrated focused band of fluorescent protein and/or virus. It is anticipated that all results will be published in a scientific journal.

Temperature gradient focusing (TGF) is a promising technique for the manipulation of charged biomolecules. Successful incorporation of this technology into an automated, reproducible system requires the precise control of exceedingly small volumes of liquid (pico-to microliters). The precise manufacturing capabilities only offered by micro/nanofabrication techniques are required to achieve this level of fluidic control. Therefore, during a 10 week internship, students will be involved in the design, fabrication and characterization of a glass based microfluidic chip to perform TGF on-chip and have the capability for extraction of concentrated sample for off-chip biochemical analysis.

Contact: Kevin Ness 925-423-1856; email ness5@llnl.gov

Category: Chemical and Biological Threats and Countermeasures

Title: Shape-memory behavior of novel highly-crosslinked polyurethanes.

A series of novel shape memory polymers (SMPs) were developed at LLNL, based on highly idealized urethane network structures. These new SMPs are highly crosslinked amorphous polymers displaying excellent optical clarity, sharp and controllable thermal transitions, high shape recovery forces, low mechanical hysteresis, and good biocompatibility. As such they have potential for use in a variety of applications including components in MEMs based devices for chemical detection and biodetection, among others. More recently, low density polymer foams have been made from these same materials.

In this project the shape-memory behavior of both bulk SMPs and low density SMPs foams will be determined by a variety of techniques. Thermal transition temperatures for actuation will be determined by differential scanning calorimetry (DSC) and dynamic mechanical thermal analysis (DMTA). Recoverable strain and recovery rate will be determined by optical methods on specimens deformed in a circular manner. Additionally, an MTS tensile tester will be used to determine recovery forces, recoverable strain, and recovery during combined thermal-mechanical cycling. These results will be interpreted with regard to polymer structure. Finally, if time permits, the mechanical results will also be used to evaluate current constitutive models for predicting shape-memory response. This fundamental materials work will facilitate the use of these new SMPs in the applications described above.

Contact: Thomas S. Wilson; Phone: 925-422-5519; E-mail: wilson97@llnl.gov
Funding: Not DHS funded
Research areas:
* Explosives Detection, Mitigation and Response
* Chemical and Biological Threats and Countermeasures