NCTR:
A National Resource for Counterterror/Homeland Security Research

Innovative Tools and Novel Approaches for Assuring a Secure Homeland

Biosafety Level 3 (BSL-3) Laboratory

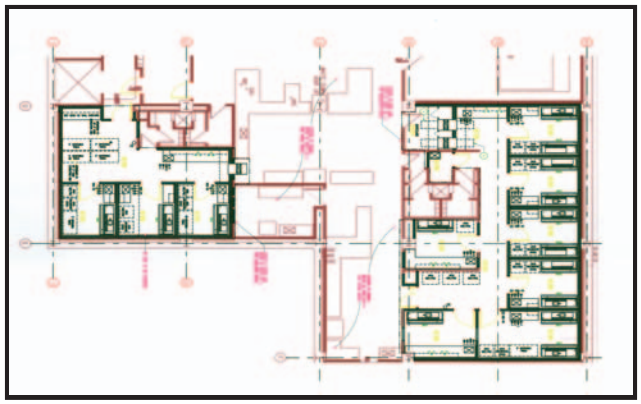
Isolation and Identification of Microbial Pathogens and Toxins

Rapid Inexpensive Sensor Technologies

Carbon Nanomaterials for Rapid Detection

NCTR is the Food and Drug Administration's (FDA's) key laboratory for research addressing multiple homeland security issues. A leader in the FDA's food safety research program, NCTR scientists developed rapid and specific detection technologies for food decomposition and biological pathogens. These methods are readily adaptable to counterterrorism activities involving either chemical or biological agents and are being deployed to address the rapid isolation and identification of microbial pathogens and toxins and to detect explosives. A Biosafety Level Three (BSL-3) Laboratory provides a national resource for hazardous agent research.

BSL-3 Laboratory



Basic floor plan

NCTR's animal toxicology, microbiological and chemistry expertise, and experience handling hazardous materials and agents, combined with its secure location, led the FDA to locate a specialty laboratory for handling and studying BSL-3 agents at NCTR. It offers a safe and efficient environment designed to address the nation's vulnerabilities to microbiological attack.

A) Class II Type A2 biological safety cabinet
B) Support laboratory

Methods to Detect and Identify Microbial Pathogens and Toxins

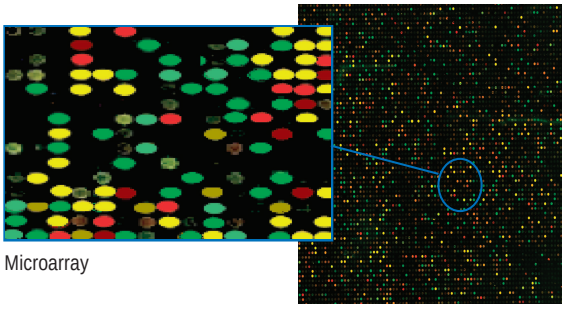
Identification using Traditional and Molecular Genetic Methods

NCTR scientists are internationally recognized for their expertise in the identification of foodborne microbial pathogens and toxins. NCTR uses a variety of highly-accurate, well-validated methods for the detection and identification of pathogens and toxins: 1) traditional culture; 2) multiplex polymerase chain reaction (PCR); 3) multiloccus sequence typing (MLST); 4) real-time PCR; and 5) pulsed field gel electrophoresis (PFGE).

The rapid identification of pathogenic bacteria and the characterization of foodborne hazards are essential to protect public health following a suspected bioterrorism attack. A team of microbiologists, geneticists, and chemists are comparing the usefulness of traditional culture methods with serological tests, molecular genetic methods, microarray technologies, rapid flow cytometric isolation, and mass spectrometric analysis.

Microarrays for Rapid and Accurate Microbial Identification

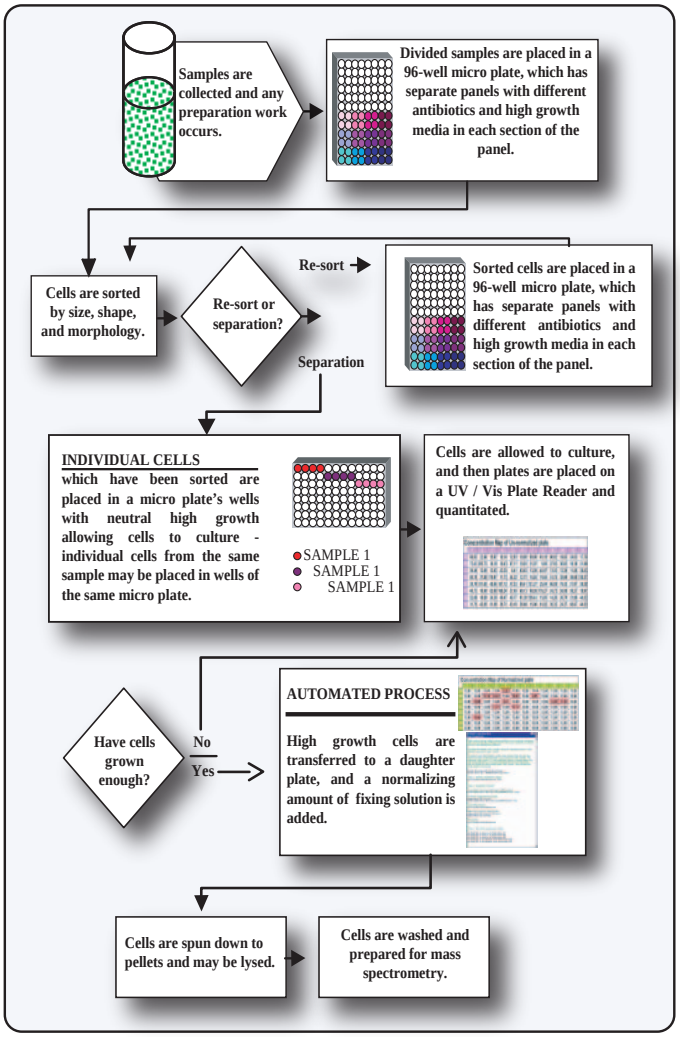
NCTR microbiologists and geneticists are developing custom microarrays for the rapid detection of pathogens, virulence genes, and antibiotic resistance determinants.



Microarray

Rapid Isolation of Microbial Pathogens Using Flow Cytometry

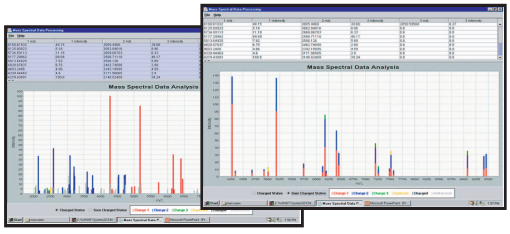
One of the unique capabilities housed in the BSL-3 Laboratory is a complex of instruments, including a flow cytometer, a centrifuge, and a liquid handling robot, aimed at reducing (by up to a week) the time required for isolating and propagating foodborne bacterial agents. Once isolated, the suspect microbes can be identified using either molecular, genetic, or newly developing mass spectrometric techniques.



Flow diagram illustrating the rapid isolation process.

Mass Spectrometric Bacterial Fingerprinting

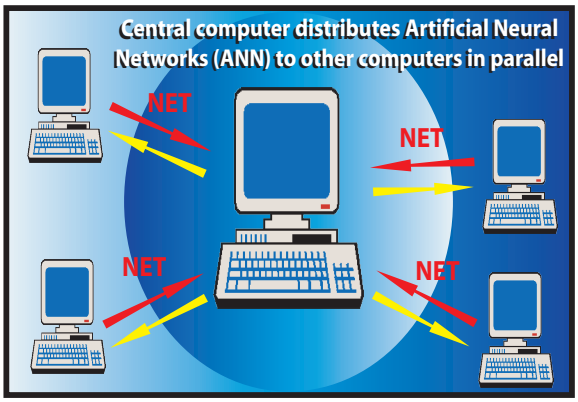
Using unique genetic bacterial fingerprints, scientists can identify bacteria. As an alternative to the traditionally used PCR-based and pulsed field gel electrophoresis methods, NCTR chemists generate bacterial fingerprints using two mass spectrometers, each equipped with an automated robot sampler. This approach, which provides the ability to grow a pure colony of cells in a few hours, facilitates rapid identification and characterization of bacterial agents. It is both fast and accurate.



Typical Matrix-Assisted Laser Desorption/Ionization (MALDI) mass spectrum for *Salmonella ser.* Anatum showing ion charge states by color code.

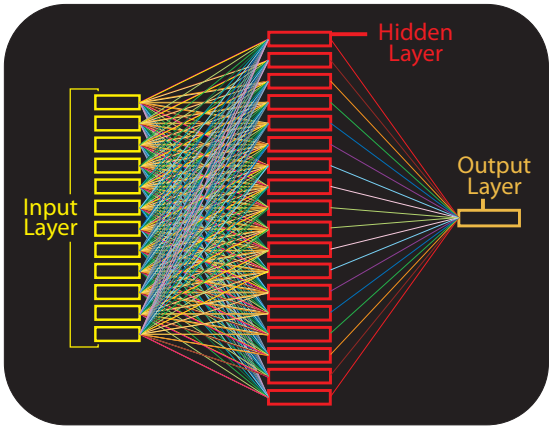
One of the mass spectrometers is capable of characterizing potential bioterror hoax materials and other nonbacterial samples. For example, compounds such as talcum powder, confectioners' sugar, corn, and flour can all be rapidly distinguished from pathogenic bacteria.

Pattern Recognition and Spectral Database Repository



Layout of the NCTR Parallel Distributed-Artificial Neural Networks

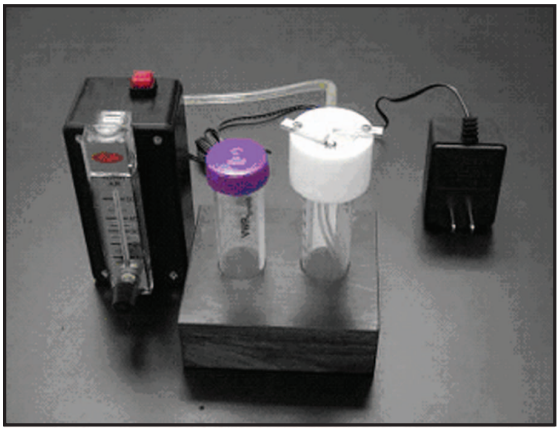
NCTR's pattern recognition system, consisting of specialty software and hardware, provides the unique computational capability to classify samples based on spectral fingerprints. Large quantities of spectral fingerprint data can be evaluated using this system and possibly stored in a spectral database repository. In addition to its on-site use, NCTR's computational capability is amenable to consultation from off-site, portable mass spectrometers, or other detectors. Therefore, NCTR, with a commercial partner, can sponsor a spectral database for a nationwide rapid bacterial characterization system. Such a system could be accessed by public health emergency first responders and would also be usable for more routine clinical diagnostic applications.



Layout of a fully interconnected ANN (Artificial Neural Network)

Rapid Inexpensive Sensor Technologies

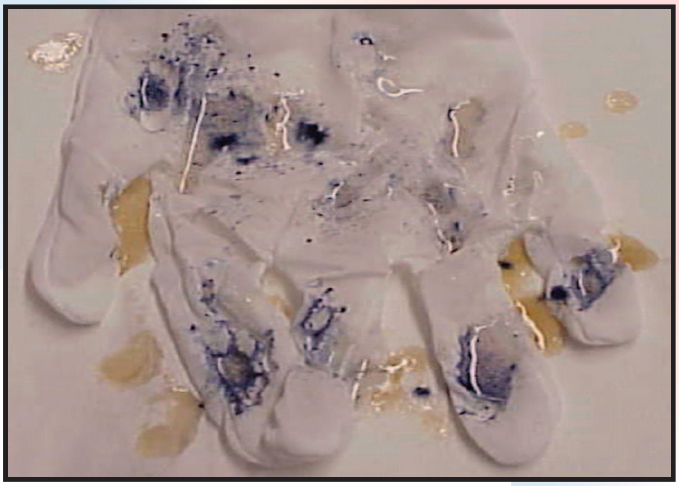
As part of its food safety initiative, NCTR offers a family of chemically sensitive spots, strips, laminated strings, and wafers that can be safely used inside clear food packages. These identifiers change color to indicate chemical events that affect food quality as well as the presence of bacterial decomposition of protein.



Food Quality Indicator Kit.

Blue (inside the package) = slightly spoiled; yellow (outside the package) = good

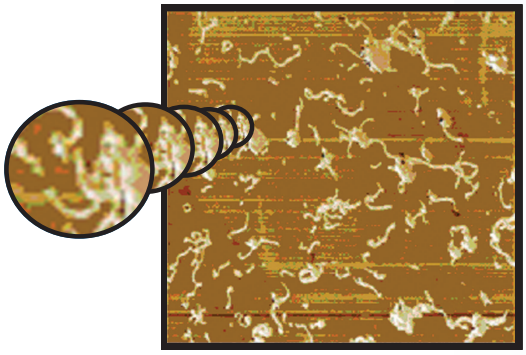
NCTR has developed a process where minute quantities of explosive residues can be detected using gloves impregnated with a sensing dye and sprayed with an acidic solution of diphenylbenzidene.



Colored spots on inspector's white glove indicate presence of explosives.

Carbon Nanomaterials for Explosives Detection

In collaboration with colleagues at the University of Arkansas at Little Rock (UALR) and Applied Nanotechnologies, Inc.., NCTR is developing novel and efficient methods for the synthesis and chemical modification of unusual nanomaterials. For example, NCTR is studying the use of nanofibers and polymer spots. When a polymer spot is embedded in a sniffer probe or wand, the probe or wand becomes an inexpensive and ultra-sensitive detector of vapors from explosives and is as easy to use as an ohmmeter.



Pure nanotubes generated using UALR/NCTR patented process

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