



September 15, 2009

National Institute for Microbial Forensics & Food and Agricultural Biosecurity

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Plant pathogens as bioweapons

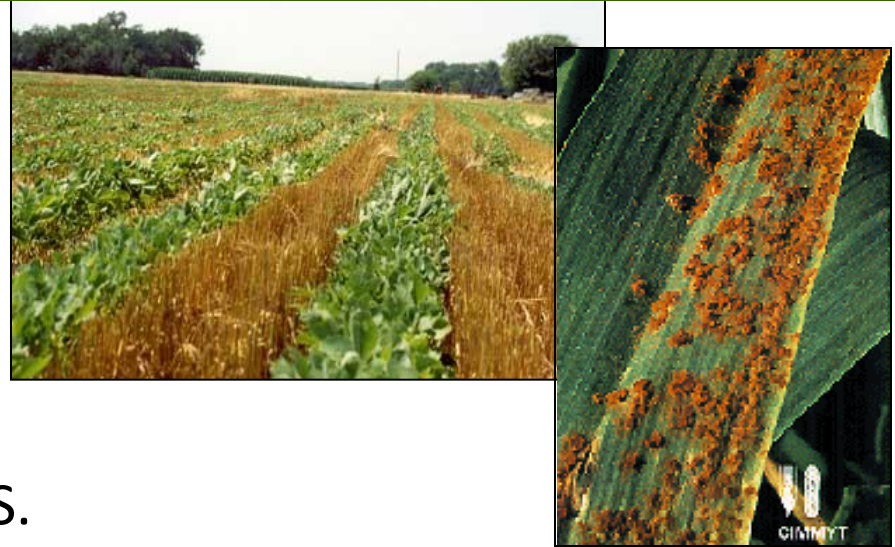
- Plant pathogens are easily available to those with nefarious intent
- Plant pathogens part of the biowarfare programs of several countries, including former USSR and the U.S.
- Notes on use of plant pathogens found in Afghani caves
 - Wheat rust
 - Rice blast
- Motives: Terrorism, economic gain, revenge, political/social statement (ELF, PETA, etc)



Wheat rust



Issues for forensic plant pathology



- Over 50,000 plant diseases in U.S.
- Generally, effort has *not* been made to eradicate pathogens of crops
- For any given crop, several pathogens do not *yet* occur in the U.S., but cause major losses elsewhere
- 2/3 of all U.S. cropland is planted to just 3 crops: wheat, corn and soybeans



Issues for forensic plant pathology



- 100s of plant species
- A number of pathogens uncultivable
- Culture collections scattered, inadequate & often lost with retirements
- Some diagnostics still based on time-consuming tests (e.g., reactions on host plant “differentials”, mating types)
- Plant pathogen entries in key databases (NCBI, GeneBank, BIOLOG, FAME, etc) very limited
- Lack of information on pathogen biology
- Lack of effective molecular detection tags: primers, probes and antibodies



Issues for forensic plant pathology

- Seeds and vegetative plant propagules are tiny samples
- Diagnostic and detection tools rarely standardized, validated
- Relative effectiveness of different technologies unknown in most cases
- “Best” test generally depends on the tools and databases available for that taxon and closely related taxa
- The “species” concept is becoming cloudy
- Funding for plant disease research is comparatively small



Corn stunt



Plants as food



AP Photo

Sep 17, 2006 LOS ANGELES (AP)
Spinach Pulled From Stores Across US



Getty Images

Sep 10, 2008 (CIDRAP News)
Unusual E. coli strain 0111 sickens 231 in OK



Plants as food

May 17, 2008
*Tomatoes suspect in
salmonella cases*



January 16, 2009

Peanut Butter Probe Expand; *Salmonella* at Georgia Plant



A strong national security plan should include:

- Early **detection and diagnostic** systems
- Epidemiological models for **predicting** pathogen spread
- Reasonable but effective **strategies and policies** for crop biosecurity
- Distributed physical and administrative **infrastructure**
- National response **coordination** plan and infrastructure
- ***Microbial forensic capability: Validated technology and investigative capability***



Is this something new?

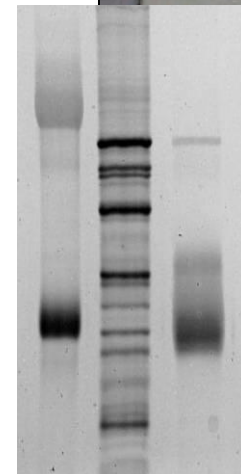


- Usual goals of an applied plant pathologist:
 - to identify the pathogen as needed for management strategies
 - to quickly and effectively manage a disease outbreak with optimal strategies
- **NEW :**
 - Discerning natural vs. intentional outbreaks
 - Attributing the crime
- The U.S. security community has identified **a need for enhanced capability in microbial forensics** (humans, animals and plants)



Is this something new?

- **The goals of a microbial forensics specialist:**
 - Collect very **specific** forensic (microbial and associated physical) evidence via tests that
 - Are standardized and **validated**
 - Have very high **confidence** levels
 - Are sufficiently **robust** to withstand rigorous adversarial review in a court of law
 - Attribution
 - Determination of biothreat agent **source**
 - Identification of the **perpetrators**
 - Criminal **prosecution**
 - Deterrence of future attempts





U.S. capability in microbial forensics

- 2002 – Study commissioned by US defense community found a need for greater capability in microbial forensics
- Included specific language with respect to plant pathogen forensics

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Plant Pathogen Forensics: Capabilities, Needs, and Recommendations

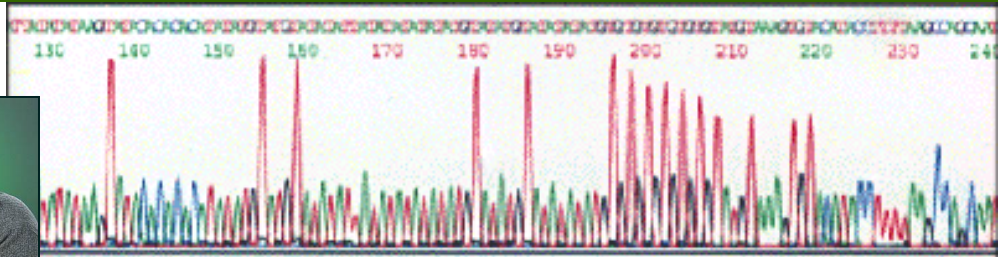
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Needs

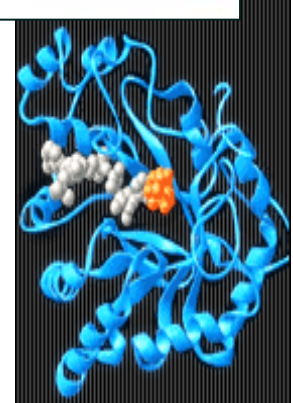
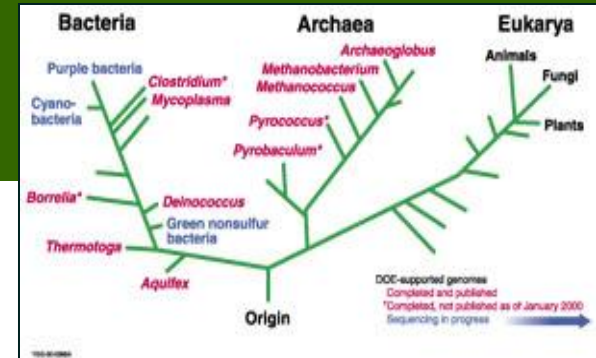


- Advances in genomics of microbial threat agents
 - **Complete** genome sequences known for only a few plant pathogens
 - Sequences of **multiple strains** very rare
 - Fungal genomes are **large and expensive**; nematodes even worse!
- Supporting info for molecular analyses
 - More specific tools (primers, probes, antibodies)
 - More multi-plex tests



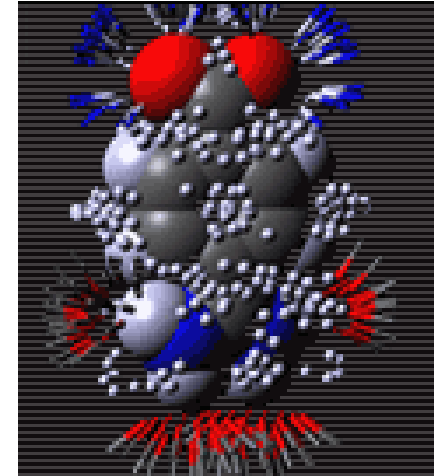
Needs:

- Non-nucleic acid components
 - More **specific antibodies**
 - Virulence factors in **secreted** fraction
 - Pathogen **gene expression** in plant and vectors
 - **Regulation** including signaling, quorum sensing, biofilms, secretion systems, virulence factors:
 - **Host plant defense** molecules
- Pathogen-pest population biology
 - Pathogen diversity and geographic location(s) of virulent biotypes
 - Knowledge of evolutionary biology and epidemiology



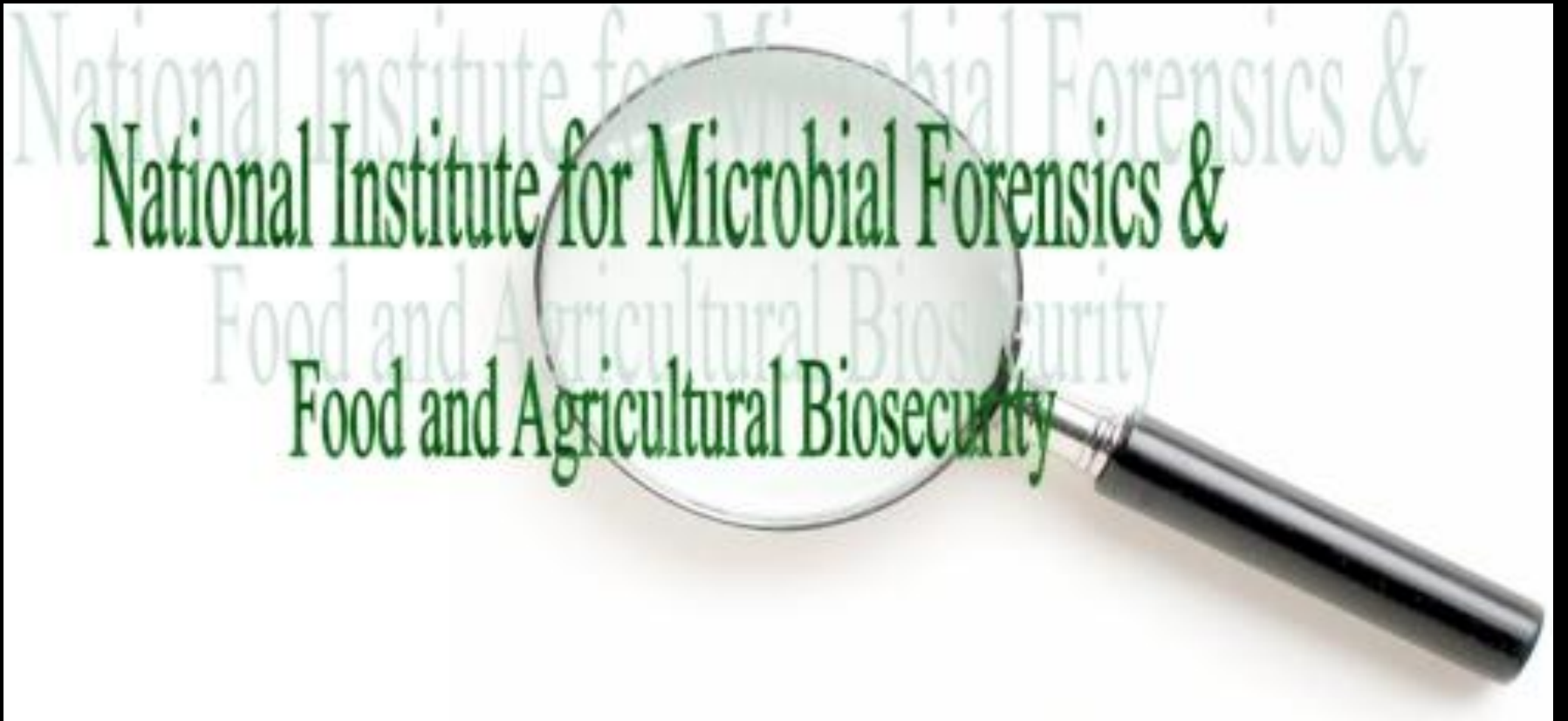


Needs: Other technologies



- Isotope analysis
- Presence of other signatures related to source location or perpetrators
- Generally not yet applied to plant pathogens
- *Need for targeted, goal-oriented research and development*
- *Need for more trained scientists (many positions restricted to U.S. citizens!)*

Design, Rick Grantham





NIMFFAB Mission

To **identify, prioritize, facilitate and conduct** research, education and outreach related to national needs in microbial forensic science with respect to pathogens of crops, forests, rangelands and food products.

*The **NIMFFAB** builds on, connects and enhances existing programs that support and address issues of crop and food security.*



NIMFFAB Objectives

- **Assess national capabilities** in microbial forensics related to plant pathogens and food safety.
- Provide **strategic planning**, a long-range **vision** and **prioritization** of needs and resources in forensic plant pathology.
- Conduct focused and outcome-oriented **research** in priority areas of microbial forensics.
- Establish a **coalition** of investigators conducting research on crop and food biosecurity and forensics issues.



NIMFFAB objectives, *continued*

- Serve as a link for **communication, cooperation** and **outreach** between the plant pathology and law enforcement/homeland security communities
- **Deliver outputs to end users** including the FBI, Department of Homeland Security, and USDA
- Develop and provide **educational and training** opportunities for students and stakeholders
- **Communicate** and **work in parallel**, locally and nationally, with programs related to animal and human pathogens



Oklahoma 'partners'

a) Oklahoma State University

- Experienced faculty
- Core facilities
- Graduate and undergraduate programs
- Cooperative extension



b) OSU Center for Health Sciences - Forensic Sciences

- Department of Forensic Sciences



c) OK Plant Disease & Insect Diagnostic Laboratory

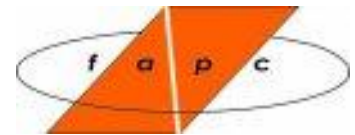
- OSU Department of Entomology and Plant Pathology
- Part of the **National Plant Diagnostic Network (NPDN)**
- Part of the **Great Plains Diagnostic Network (GPDN)**



Oklahoma resources

d) OSU Food and Agricultural Products Center

- Assists value-added food industry enterprises
- Expertise & research on microbiology of food safety



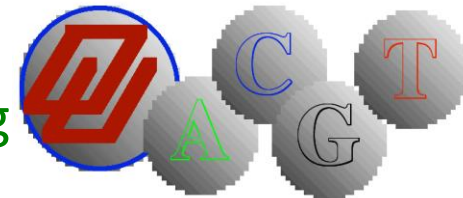
e) OSU Multispectral Laboratory, Ponca City

- Sensor technology development & applications



f) Advanced Center for Genome Technology, Norman

- University of Oklahoma
- Internationally recognized genome sequencing center





NIMFFAB people

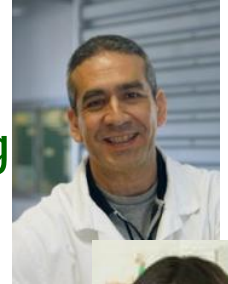


***Director** – Forensic plant pathology

***Asst. Director** – Insect transmission of threatening pathogens

***Plant Pathology** – Diagnostics & detection

***Food Safety** – Food contamination, human pathogens



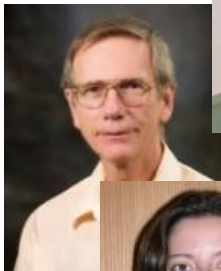
Associated Faculty

Forensic Sciences – Human DNA analysis

Forensic Sciences – Chemical signatures

Molecular Biology – Discriminatory assays

Water Quality – Microbial detection





Education

New Courses & Programs

- Undergraduate course
 - Global Issues in Agricultural Biosecurity and Forensics
- Graduate course
 - Microbial Forensics (Online D2L)
- Degree minor/specialization
 - Undergraduate: Entomology – Bioforensics, Pre-Med, Pre-Vet
 - Graduate: Specialization within majors
- Potential for distance education
- Potential for international courses



Education



USDA National Needs Graduate Fellowship Program



First graduate program to blend the fields of plant pathology & forensic sciences



3 M.S. (Forensic Sciences)

- Adaptation of human DNA detection technologies to plant pathogen detection (Jesse Carver, Charlene Beauman, Andrew Taylor)



Education



NNF Fellow Research Projects

3 Ph.D. (Plant Path; Biochem & Molec Biol)

- **Multi-locus variable number tandem repeats** for strain identification of *Pseudomonas syringae* pv, tomato (**Christy Baker**)
- **Microarrays for plant virus detection** and assessment of intentional introduction (**TeeCie West**)
- Development of “**decision trees**” for use by law enforcement personnel at a potential field crime scene (**Stephanie Rogers**)

– Internships at the FBI Laboratory





Research



Department of Homeland Security National Bioforensics Analysis Center



“NBFAC Spoke Laboratory” for Forensic Plant Pathology

Technology development & validation



Research

Microbial Rosetta Stone

Goals:

- Map the landscape of infectious agents
- Curate literature for high threat agents

Application:

- Assist forensic investigation & define attribution in case of a bioterror event

Sponsors:

- DARPA
- FBI
- DHS – NBFAC



NIMFFAB: Plant pathogen database



Outreach - Workshop

January 11-13, 2007

Plant Pathogen Forensics: Filling the Gaps

Oklahoma City, Oklahoma

Attendees included:

USDA: APHIS, ARS, CSREES

FBI Laboratory

Department of Homeland Security

National Laboratories: Los Alamos, Lawrence Livermore

Academic community – OSU & nationwide

Oklahoma agricultural security community



Outreach – Field Exercise

May 2008

Partnering for Success During a Plant Health Response

Stillwater, OK

Collaboration: NIMFFAB, OSU DASNR, FBI, DHS, CIA, USDA, NPDN

- Intentional plant pathogen introduction in a field setting
- Law enforcement interactions (FBI, APHIS, local police, etc)

– Issues

- Agency roles & interactions
- Determining what is evidence
- How to collect, store and transfer evidence
- What tests to use
- How to interpret them





Outreach – Tabletop Exercise

June 2009

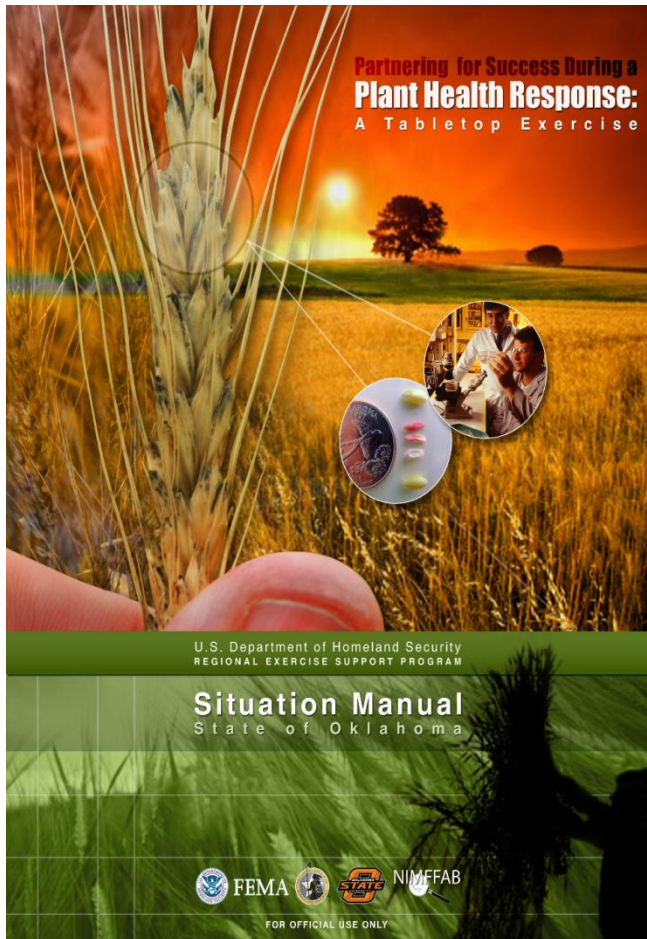
Partnering for Success During a Plant Health Response II

Oklahoma City, OK

Collaboration: NIMFFAB, OSU DASNR, FBI, DHS, CIA, USDA APHIS, USDA Off. of H.S., NPDPN

- Scenario practice
- Law enforcement interactions (FBI, APHIS, local police, etc)
- Issues

2010 – Full Scale Exercise





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OSU Provost

US Department of Agriculture

CSREES Competitive Grants

ARS Collaborations

Department of Homeland Security

Federal Bureau of Investigation

OK Office of Homeland Security

OK Center for the Advancement of Science & Technology

Fresh Produce Industry