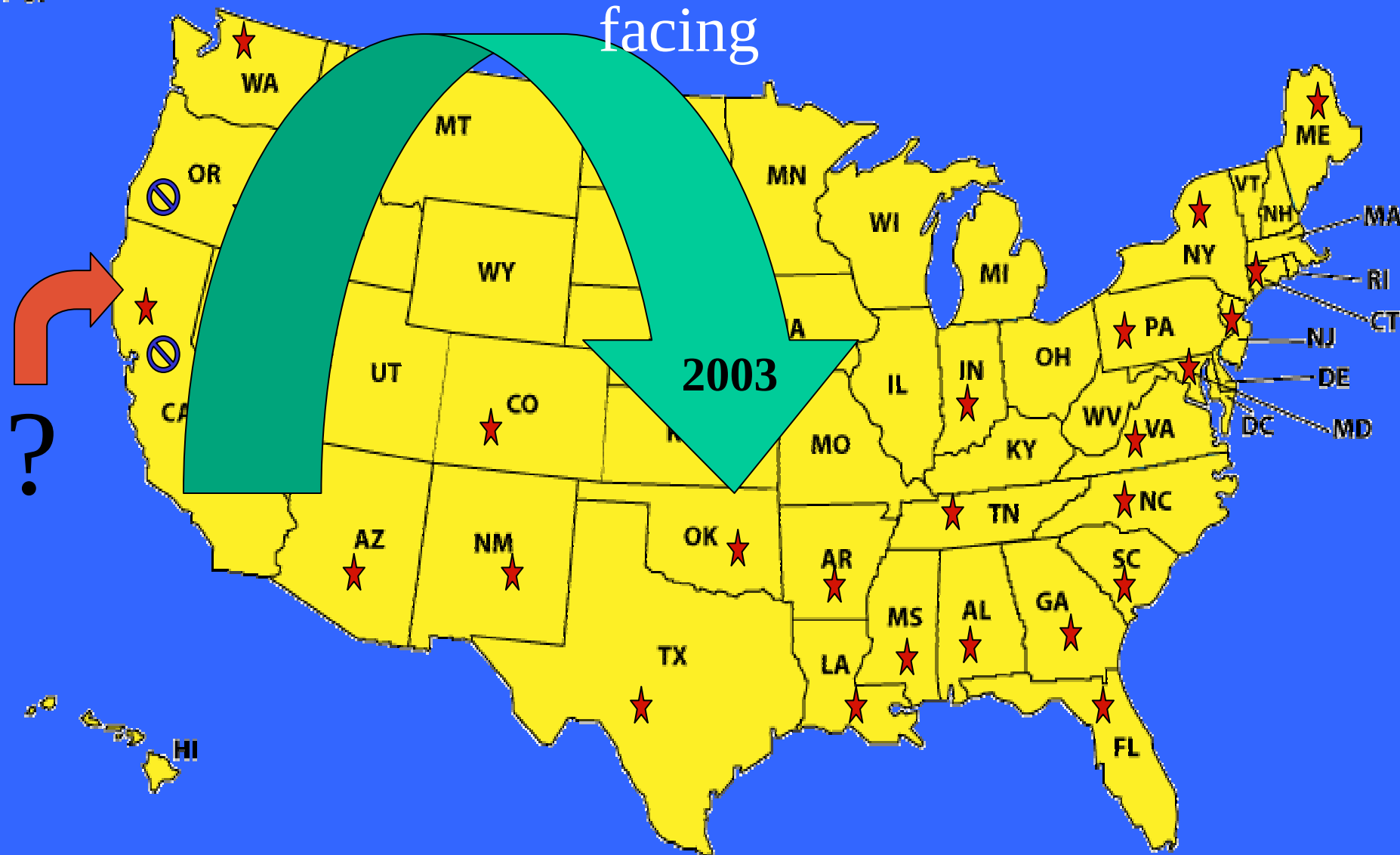


The rapid expansion of global trade and human travel has greatly accelerated the introduction of non-endogenous pathogens and pests.

The global climate change influences pathogen communities both directly and indirectly

Sudden Oak Death

A good example illustrating the challenges we are facing



Disclaimers

A photograph of a chimpanzee in a thoughtful pose, with its hand resting on its chin. A bright green speech bubble is positioned above the chimpanzee's head, containing text. The background is a solid yellowish-brown color.

These messages were
paid for by the Swift Fungi
For Truth.

Challenge 1



Difficulties in accurately determining species/population identity ->

Accurate determination of species/population identity is critical for risk assessment and the implementation of regulatory measures and appropriate disease control strategies.

Issues in Molecular Identification

- ✓ **Molecular identification is not a panacea.**
 - Your results may be as good as what you compared with (legacy errors and problems).
 - Different genes may tell different stories.
- ✓ **What is species?**
 - Biological, morphological, and phylogenetic species concepts.
 - They overlap but not perfectly.
- ✓ **Biological/geospatial contexts are critical.**
 - Host and geographic origins of new isolates.
 - Pathological and morphological phenotypes.

Challenge 2

“There are known knowns. These are things we know that we know. There are known unknowns. That is to say, there are things that we know we don't know. But there are also unknown unknowns. There are things we don't know we don't know.”

- Donald Rumsfeld -



Limited understanding of pathogen diversity in nature ->

There exist many “known knowns, known unknowns & unknown unknowns” threatening agricultural and ecological systems.

Challenge 3



Limited efforts and mechanisms to support global cooperation and knowledge integration->

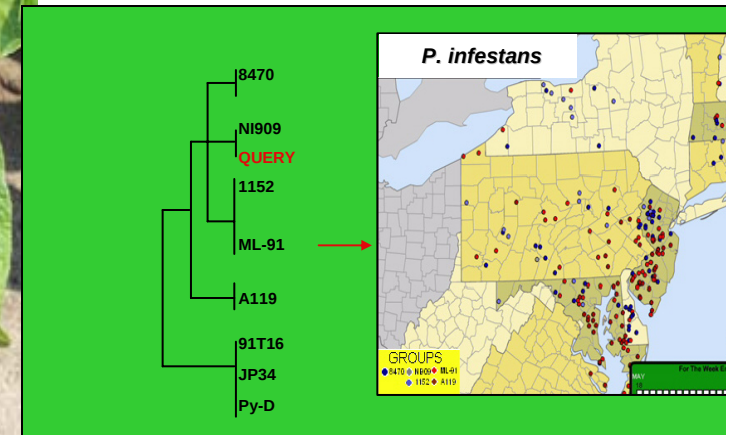
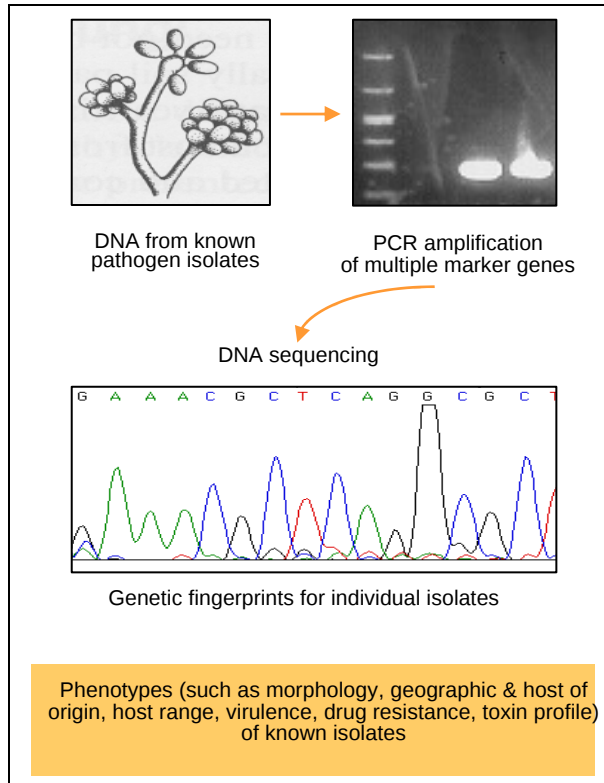
Mapping and documenting the diversity, distribution, and biology of major pathogens worldwide and sharing this information are essential to improve our ability to track and manage pathogens.

Issues in Molecular Identification

- ✓ **Molecular identification is not a panacea.**
 - Your results may be as good as what you compared with (legacy errors and problems).
 - Different genes may tell different stories.
- ✓ **What is species?**
 - Biological, morphological, and phylogenetic species concepts.
 - They overlap but not perfectly.
- ✓ **Biological/geospatial contexts are critical.**
 - Host and geographic origins of new isolates.
 - Pathological and morphological phenotypes.

Phytophthora Database

Cyberinfrastructure supporting identification and monitoring of *Phytophthora* species



www.phytophthoradb.org

Principal Investigators

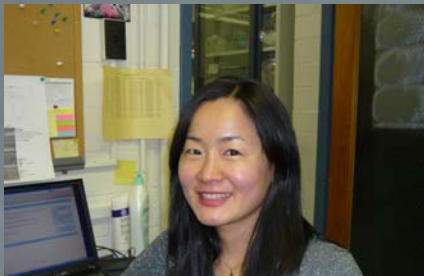
- **Penn State:** Seogchan Kang, David Geiser & Izabela Makalowska
- **UC-Riverside:** Mike Coffey
- **North Carolina State University:** Kelly Ivors
- **USDA-ARS:** Frank Martin & Kerry O'Donnell



USDA-NRI
Plant Biosecurity

THANKS to...

- **Penn State:** J. Blair, S. Park, N. Veeraraghavan, M. Mansfield & B. Park
- **UC-Riverside:** M. Peiman
- **NC State:** M. Green
- **West Virginia:** Y. Balci
- **PA Dept of Ag:** S. H. Kim & E. Nikolaeva
- **Seoul National University:** Y. Lee, K. Jung & J. Park
- **USDA-ARS SBML:** A. Rossman, D. Farr & E. Cline
- **APS Press:** D. Erwin & O. Ribeiro



Specific Objectives of the PD Project

- ✓ To establish a comprehensive phylogenetic framework for the genus *Phytophthora*.
- ✓ To build a cyberinfrastructure that archives the genotypes, phenotypes, and distribution of individual *Phytophthora* species/isolates and provides data analysis and visualization tools.
- ✓ To develop and optimize molecular diagnostic tools for detecting and identifying *Phytophthora* species.

Progress

- ✓ Development of new phylogenetic markers based on the genome sequences of *P. ramorum*, *P. capsici*, *P. sojae* and *P. infestans*.
- ✓ Conducted a genus-wide phylogenetic analysis using representative species/isolates.
- ✓ Genotypic characterization of ~3,000 isolates (>90 species) within the genus.
- ✓ Establishment of the *Phytophthora* Database.

Organization of the *Pytophthora* Database

WWW.PHYTOPHTHORA.DB.ORG

Home Introduction Database Search & Analysis

Species | Genetic Markers | Host | References



Phytophthora Database Login

Dear Seogchan Kang,
Welcome to Phytophthora Database.

» I want to **logout** this database.
» I want to **modify my login information**.

Run Wizard Easy to access work process

» Search the database
» How to use the database

Welcome to Phytophthora Database

» About the goals and utility of the database
» About sequence based search
» About submission of data
» Acknowledgements
» How to save and reuse your favorite data and result

Phytophthora Database News

Current Statistics of the Database

» 84 Species
» 1,266 Isolates
» 2,917 Sequences

Link to Contributors



Systematic Botany and

Park et al. Plant Disease 2008

Species Information Page

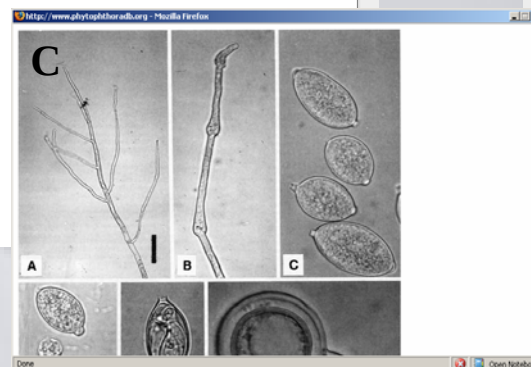
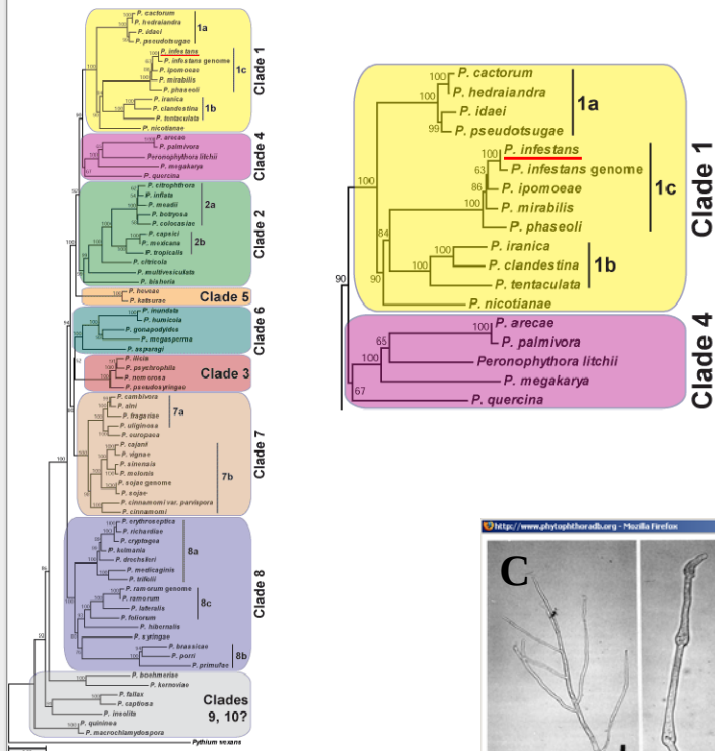


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- Introduction
- Database
- Search & Analysis
- Geographical Distribution

Phytophthora infestans

Phylogenetic Position within the Genus

This genus-wide phylogenetic tree contains 74 species, including *Pythium vexans* as the outgroup, and was built using sequences at seven loci (approximately 7700 nucleotides), including 60S Ribosomal Protein L10, Beta Tubulin, Enolase, Heat Shock Protein 90, Large Subunit rRNA, T1g gene fusion, and Translation Elongation Factor 1 alpha (Jaime Blair et al., unpublished data).



Phytophthora infestans (Mont.) de Bary 1876 (Oomycetes, Pythiales)

- = Botrytis infestans Mont. 1845
- = Peronospora infestans (Mont.) Cesp. 1854
- = Botrytis fallax Desm. 1846
- = Peronospora Hinkelmannii Cesp. 1052
- = Botrytis vallis Harting 1846
- = Phytophthora tholicti G.W. Wilson & Davis 1907
- = Phytophthora infestans (f. sp. Bialobli) (G.W. Wilson & Davis) G.M. Waterhouse 1963
- = Peronospora trifurcata Unger 1847

Notes: The original name applied in this oomycete was *Gangraena tuberosum solani*, by Montagne in 1842. After a period of debate (see Erwin & Ribeiro 1996), it was described by Montagne in 1845 and given the name *Botrytis infestans*. It has received much renown as the cause of the great Irish potato famine of the 1840s, and it is the type of the genus *Phytophthora*. The name *Botrytis devastatrix* (alternate spelling *vastatrix* or *devastatrix*) L.B. 1845 was published previous to *Botrytis infestans*, and has been listed as a synonym by various authors (e.g. Waterhouse 1963, Erwin & Ribeiro 1996). If this were true, the epithet *vastatrix* would have priority for this species. Waterhouse (1967) retained the name *Phytophthora infestans*, arguing incorrectly that *Botrytis devastatrix* was an invalid name because it was published in a newspaper, but this is permitted by the Code previous to 1953 (Art. 34.2). While it is in fact valid, *Botrytis devastatrix* is an illegitimate superfluous name; Libert published it as a replacement name for *Botrytis fallax* (Erwin & Ribeiro 1996). Therefore the name *Botrytis devastatrix* must be typified by *Botrytis fallax* (= *Peronospora fallax*), and refers to a different species than *Phytophthora infestans* (Art. 7.4).

Distribution: Cosmopolitan.

Substrate: Tubers, leaves, haulms of potato and tomato. Also stems, flowers, fruits, buds on other hosts.

Disease Note: Late blight of potato and tomato. Overwinters in tubers. Several races occur. Also causes leaf blights and, rarely, damping off, flower, and fruit blight in a wide range of hosts.

Host: Principal hosts are Solanaceae including *Solanum* spp. (potato) and *Lycopersicon esculentum* (tomato). Also occurs on hosts in its other genera and in ten other families (Erwin & Ribeiro 1996).

Supporting Literature:

Erwin, D.C., and Ribeiro, O.K. 1996. *Phytophthora Diseases Worldwide*. APC Press, St. Paul, Minnesota. 562 pages.

Kramer, L.P.N.M., Bakker, F.T., van den Bosch, G.B.M., Benard, P.J.M., and Flor, W.G. 2004. Phylogenetic analysis of *Phytophthora* species based on mitochondrial and nuclear DNA sequences. *Fungal Biol.* 110: 106-120.

Pullman, A. 1936. *Phytophthora infestans* a Uromycete which is the cause of the late blight of potatoes. *Phytophthora* (Mont.) de Bary. 1936: 1-12.

Shenoy, D.L. 1987. *Phytophthora infestans*. C.M.I. Descript. Pathog. Fungi Path. 339: 1-2.

Tucker, C.M. 1931. Taxonomy of the genus *Phytophthora* de Bary. *Univ. Missouri Agric. Exp. Sta. Bul.* 153: 1-208.

Updated on May 04, 2006

Characteristics

P. infestans is classified in group IV (Stamps et al. 1990). See Tables 4.2 and 4.3 for tabular keys and Appendix 4.9 for a dichotomous key (Hu 1992) in *Phytophthora Diseases Worldwide* (Erwin and Ribeiro 1996). Morphology is shown in [Figure 3](#) below and 1.L.1. in *Phytophthora Diseases Worldwide* (Erwin and Ribeiro 1996). See Hry et al. (1998) and Tucker (1931) for photomicrographs of spore structures.

**Phytophthora Diseases Worldwide*

Link to this site in a separate window: <http://ehpapp.apspress.org/42.L20.html>

1. Sporangia

Sporangia are ovoid, ellipsoid to limoniform, tapering at the base, pedicels (<3 µm), and semipapillate. Average size of sporangia ranges from 36 × 22 µm (Tucker 1932) to 29 × 19 µm (Waterhouse 1963). These dimensions are similar to those of *B. idaei* (38/6), *B. solanum* (29/1), *B. idaei* (31/1), *B. idaei* (31/1), *B. idaei* (31/1), and *B. idaei* (31/1). Sporangia are compound symmetrical (Figure 4.2 in *Phytophthora Diseases Worldwide* (Erwin and Ribeiro 1996)) with a small characteristic swelling just below the sporangium (Figure 1.5 in *Phytophthora Diseases Worldwide* (Erwin and Ribeiro 1996)).

2. Hyphal Swellings and Chlamydospores

Neither hyphal swellings nor chlamydospores have been reported, except in a paper from Russia by Petrakjeva (1979), who noted chlamydospores with a thin layer wall after incubation for 4 to 9 months on oatmeal agar at 19°C.

3. Sex Organs

P. infestans is heterothallic. Antheridia are amphigynous; oogonia are 31 to 51 µm in diameter (average 46 µm); oospores formed in plant tissues are aplanic, 24 to 35 µm in diameter (average 31 µm); in artificial culture they measure 24 to 31 µm in diameter. Until the early 1960s, A1 was the only mating type found in most of the world, but in central Mexico both A1 and A2 isolates coexisted at a 50:50 ratio (Niederwieser 1991). Infection of a leaf with an A2 isolate of *P. infestans* (A1) induced oospore production (Siddons et al. 1964). Whether or not unique biotypes could arise from unrelated species is unknown. Most likely, formation of oospores results from stimulation by hormone-like substances emitted by the opposite mating type (see Chapter 3 in *Phytophthora Diseases Worldwide* (Erwin and Ribeiro 1996)).

4. Growth Temperatures

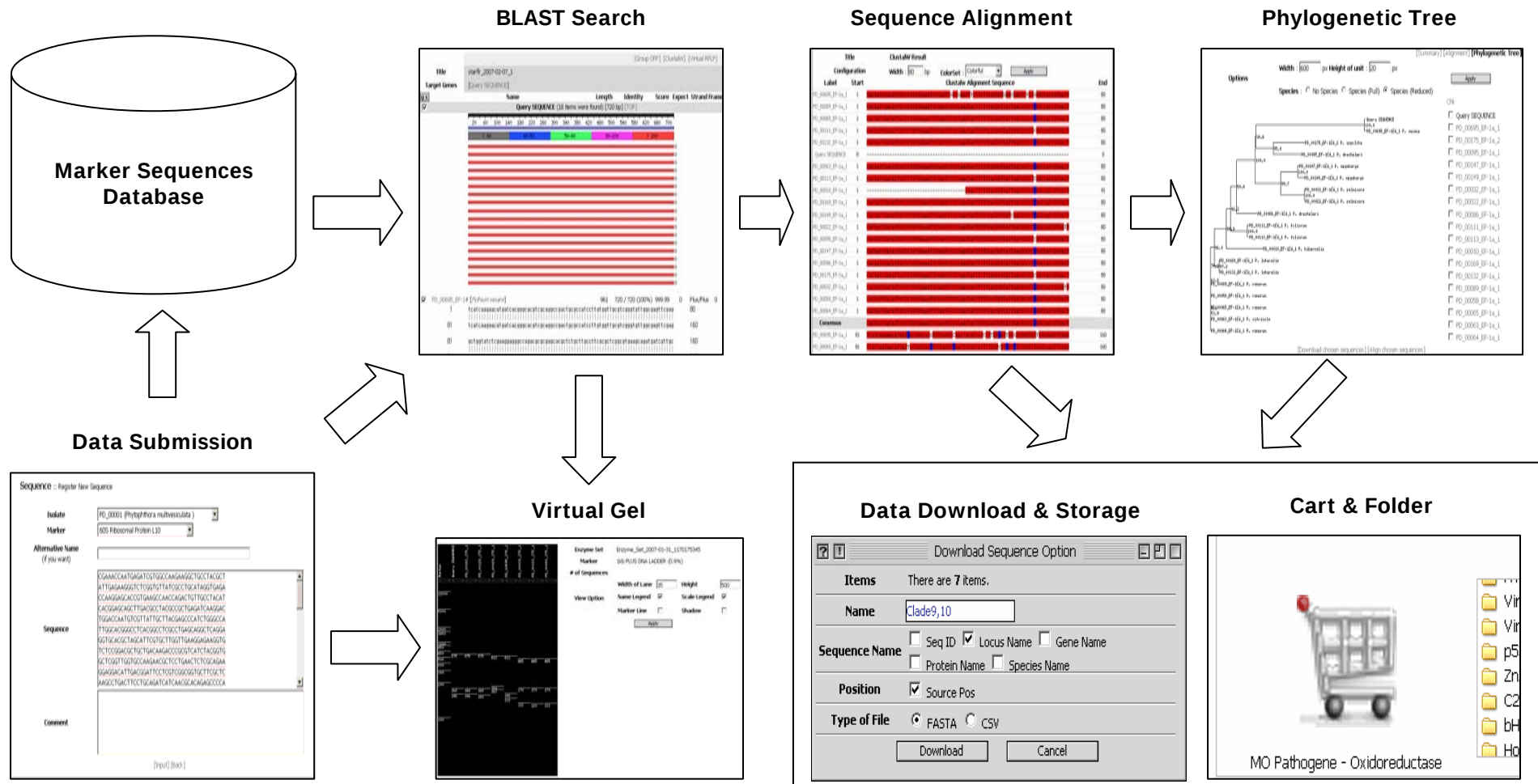
The minimum temperature for growth is 4°C, optimum 24°C, and maximum 26°C.

Diseases

P. infestans affects several hosts in the nightshade family (Solanaceae). It is a severe pathogen of potato (*Solanum tuberosum*) and tomato (*Lycopersicon esculentum*) and can lead to 100% crop loss under conditions favorable for disease development and in the absence of fungicides (Fig. 1).



Functionality of the *Pytophthora* Database



Functionality of the *Pytophthora* Database

Phytophthora DATABASE
WWW.PHYTOPHTHORADB.ORG

Home Introduction Database Search & Analysis

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[Summary] [Alignment] [Phylogenetic Tree]

Options

Width : 600 px Height of unit : 20 px

Species : ☐ No Species ☐ Species (Full) ☒ Species (Reduced)

Select All

Query SEQUENCE

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68.3 PD_00936_ITS P. cactorum

2.6 PD_00959_ITS P. cactorum

PD_00948_ITS P. cactorum

PD_00947_ITS P. cactorum

PD_00946_ITS P. cactorum

PD_00941_ITS P. cactorum

PD_00958_ITS P. cactorum

26.4 PD_00956_ITS P. cactorum

11.3 PD_00955_ITS P. cactorum

31.3 PD_00951_ITS P. cactorum

PD_00939_ITS P. cactorum

16.9 PD_00938_ITS P. cactorum

PD_00610_ITS P. cactorum

37.3 PD_00478_ITS P. cactorum

34.3 PD_00427_ITS P. cactorum

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PD_00437_ITS P. cactorum

0.0 PD_00435_ITS P. cactorum

PD_00512_ITS P. cactorum

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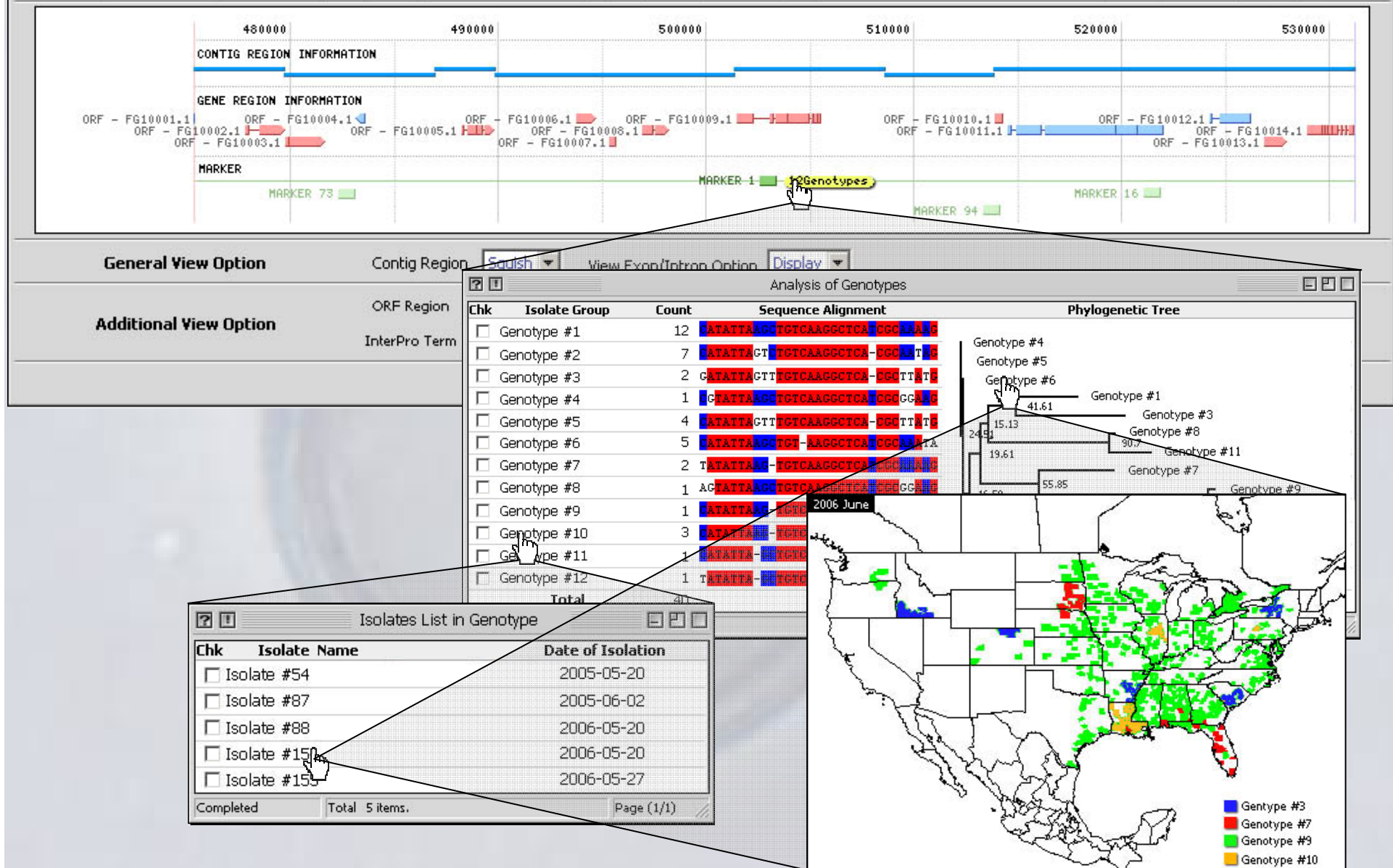
PD_00512_ITS

[Download available marker sequences] [Download chosen sequences] [Align chosen sequences]

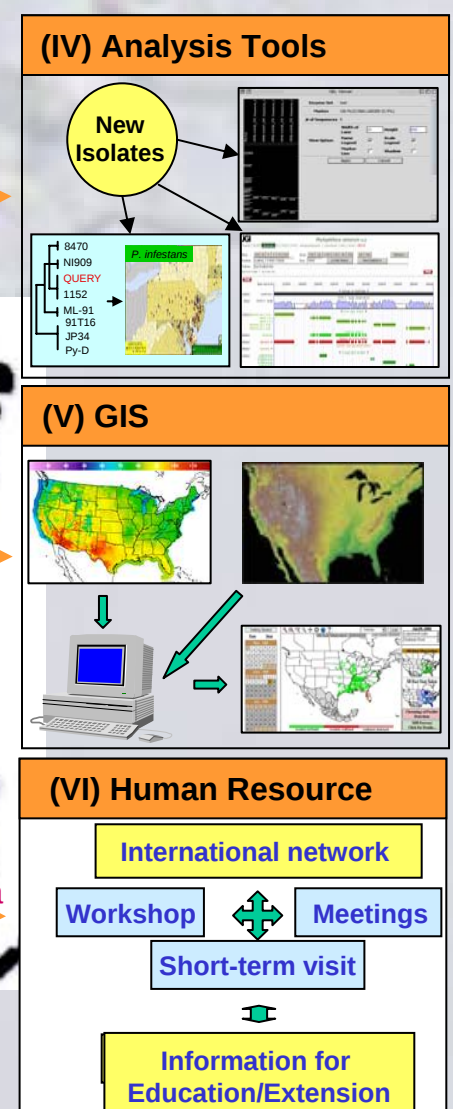
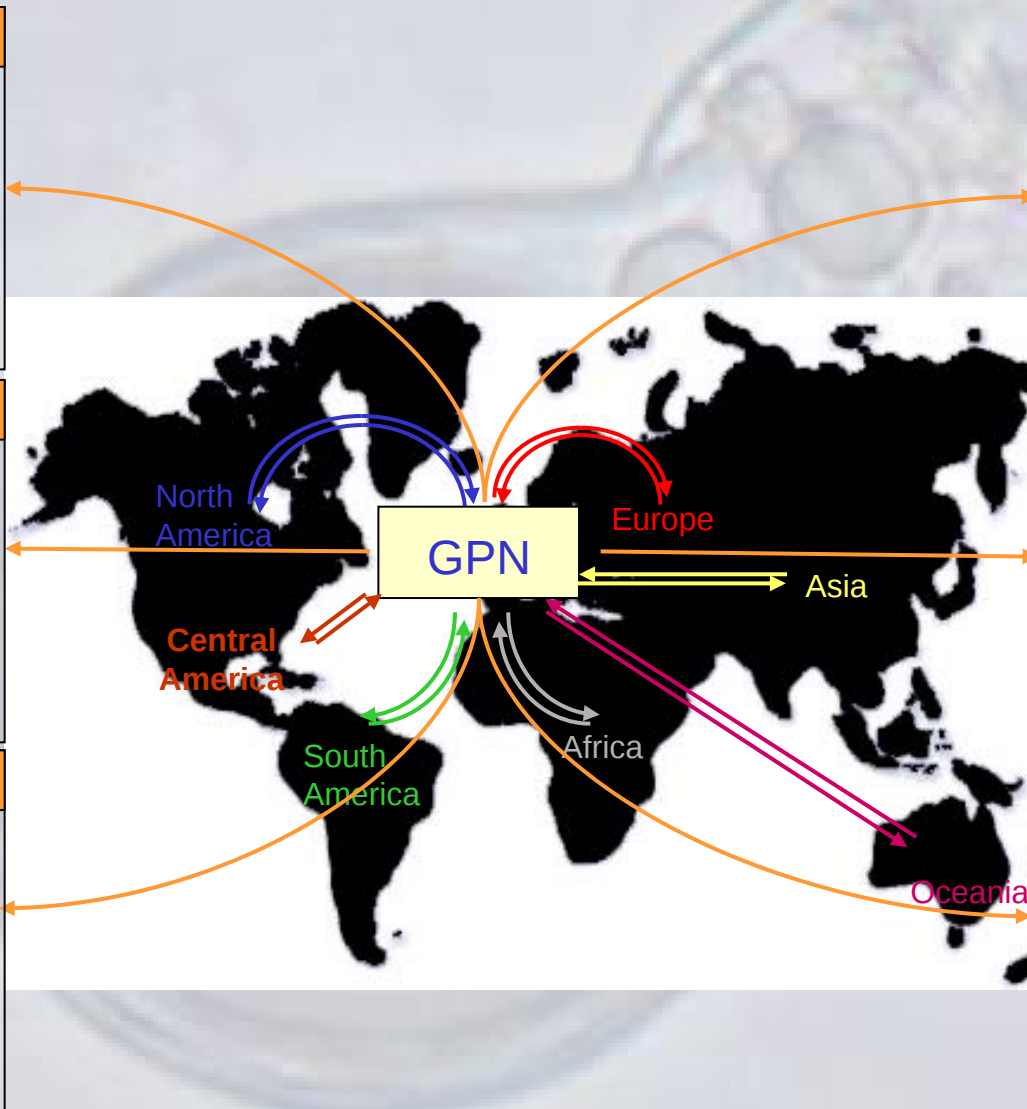
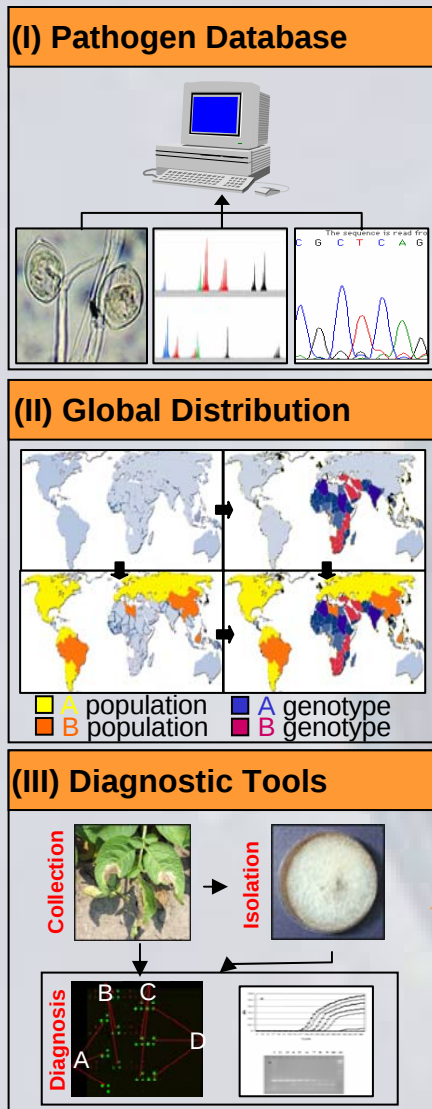
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On-going Work

Linking isolate data from genome to ecosystem



Global Virtual Network of Plant Pathologists



Cyberinfrastructure linking data, 'e-tools' and global human capital to support the management of new or reemerging pathogens.