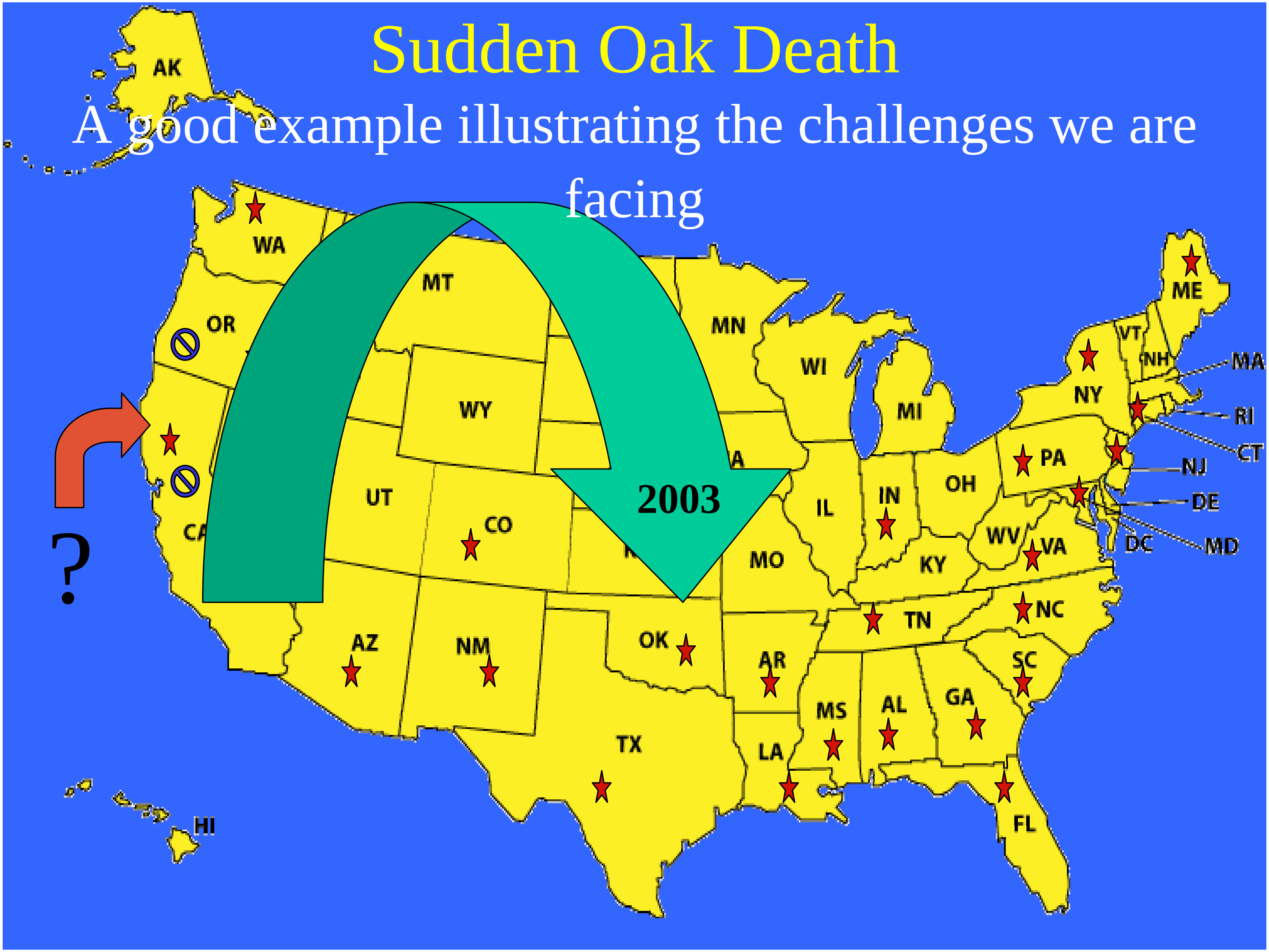
The rapid expansion of global trade and human travel has greatly accelerated the introduction of non-endogenous pathogens and pests.

The global climate change influences pathogen communities both directly and indirectly

Sudden Oak Death

A good example illustrating the challenges we are facing



Disclaimers

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->

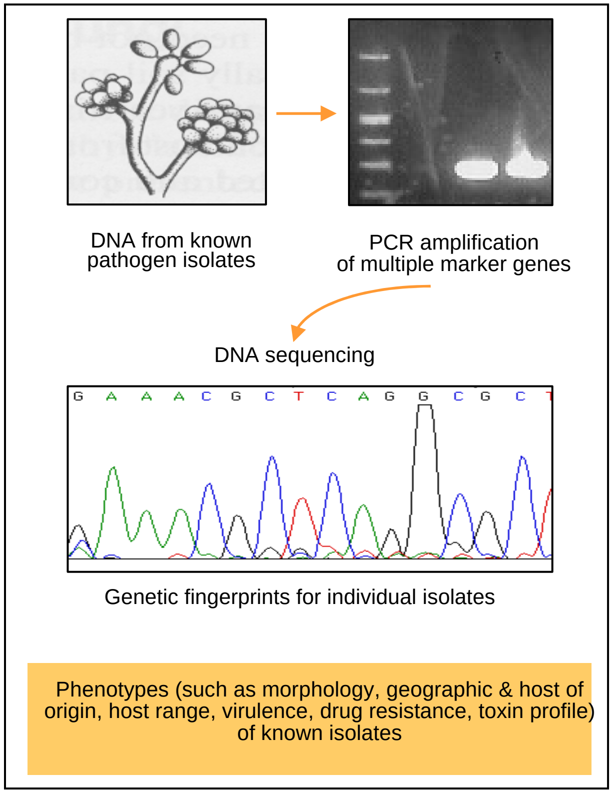
Mapping and documenting the diversity, distribution, and biology of major pathogens worldwide and sharing this information are essential to improve our ability to track and manage pathogens.

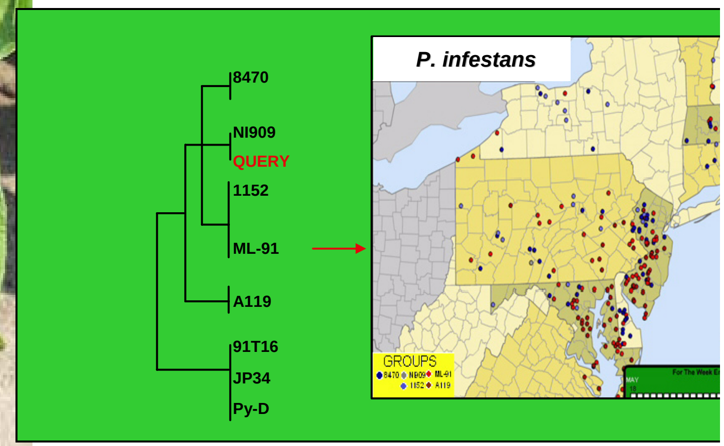
Issues in Molecular Identification

- ✓ **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

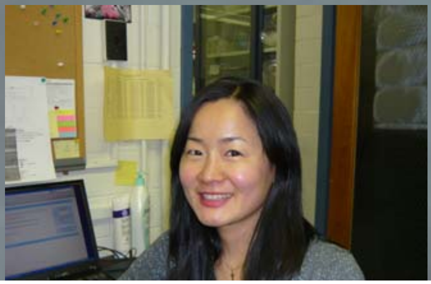
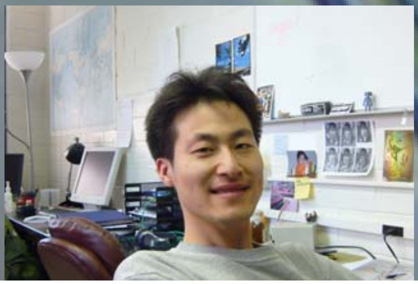
- **Penn State:** Seogchan Kang, David Geiser & Izabela Makalowska
- **UC-Riverside:** Mike Coffey
- **North Carolina State University:** Kelly Ivors
- **USDA-ARS:** Frank Martin & Kerry O'Donnell

CSREES

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

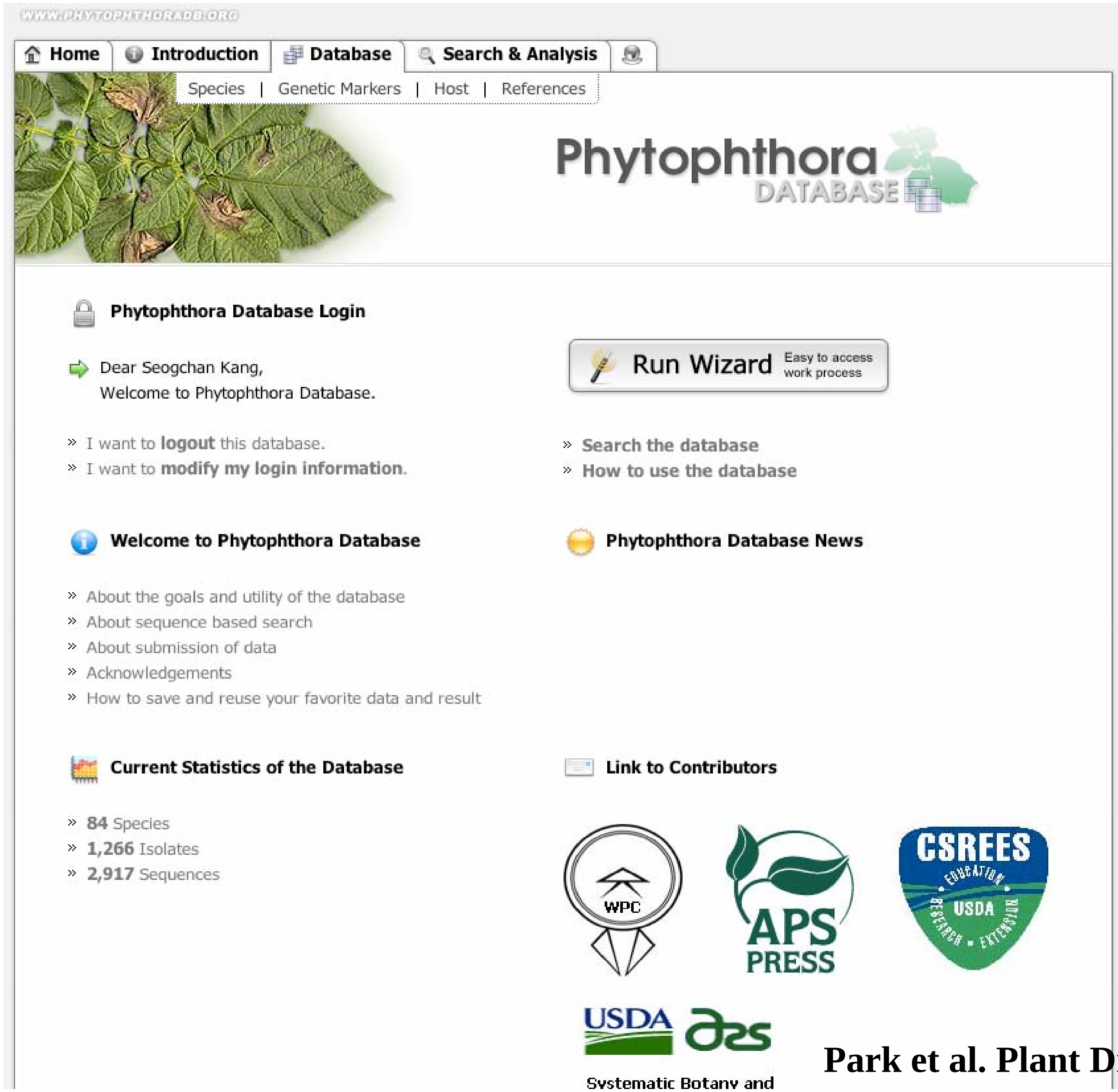
✓ Development of new phylogenetic markers based on the genome sequences of *P. ramorum, P. capsici, P. sojae* and *P. infestans*.

✓ Conducted a genus-wide phylogenetic analysis using representative species/isolates.

✓ Genotypic characterization of ~3,000 isolates (>90 species) within the genus.

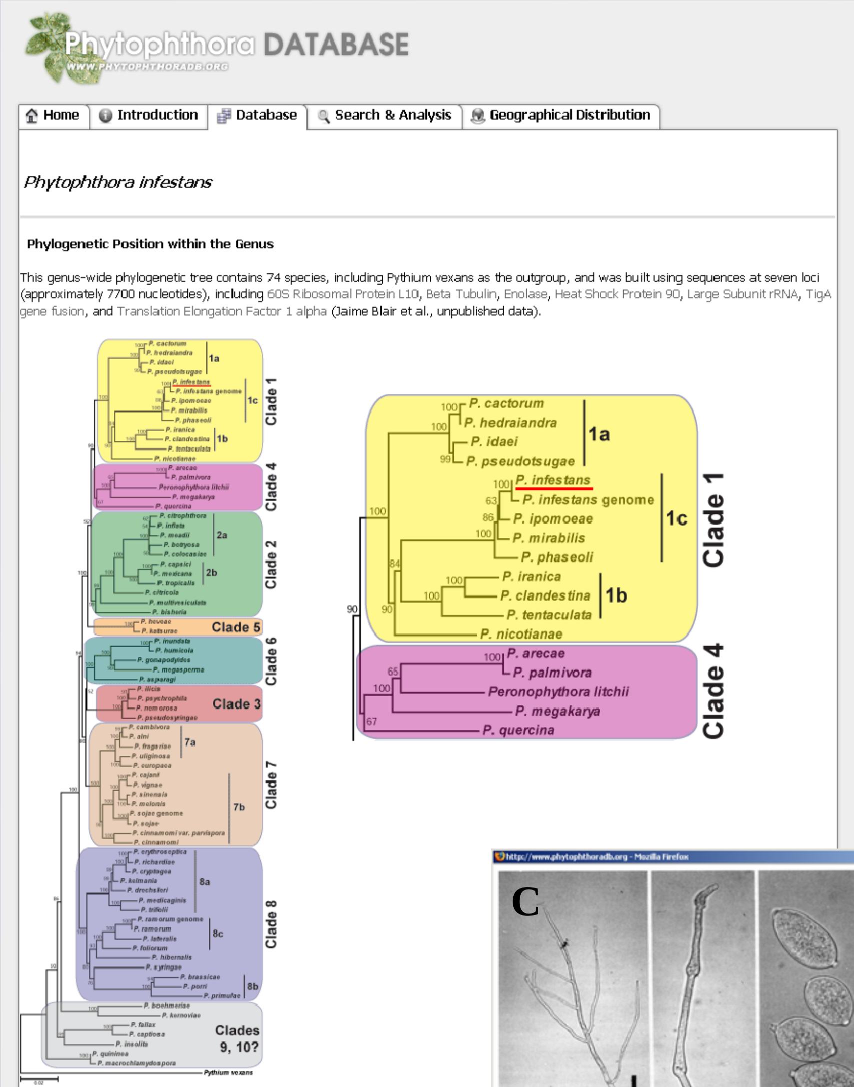
✓ Establishment of the *Phytophthora* Database.

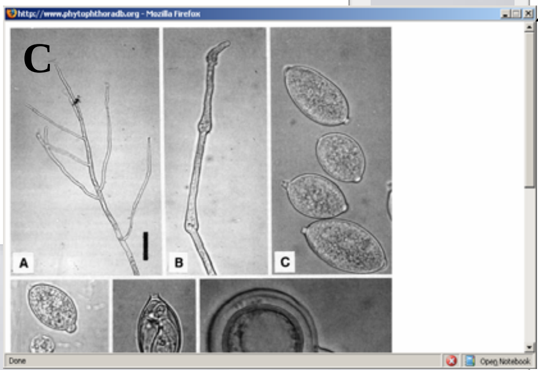
Organization of the *Pytophthora* Database

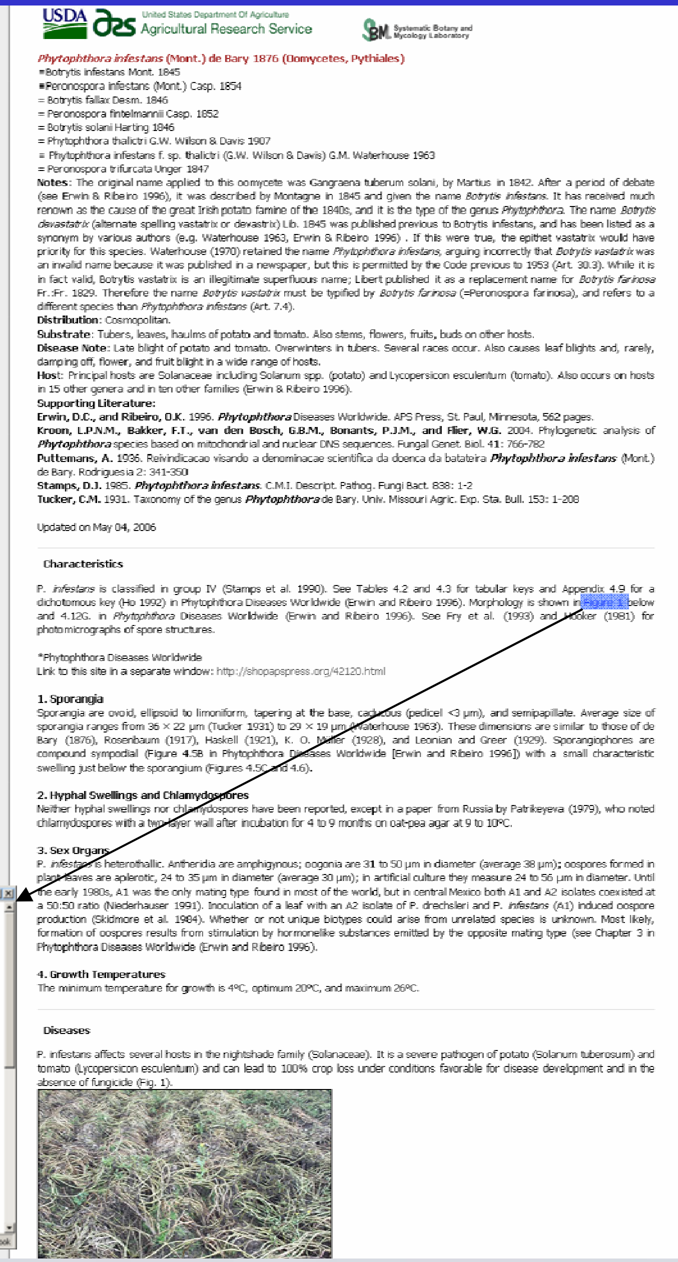


Park et al. Plant Disease 2008

Species Information Page







Phytophthora infestans (Mont.) de Bary 1876 (Oomycetes, Pythiales)
≡Botrytis infestans Mont. 1845
≡Peronospora infestans (Mont.) Casp. 1854
= Botrytis fallax Desm. 1846
= Peronospora fintelmannii Casp. 1852
= Botrytis solani Harting 1846
= Phytophthora thalictri G.W. Wilson & Davis 1907
≡ Phytophthora infestans f. sp. thalictri (G.W. Wilson & Davis) G.M. Waterhouse 1963
= Peronospora trifurcata Unger 1847

Notes: The original name applied to this oomycete was Gangraena tuberum solani, by Martius 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 devastrix) Lib. 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 (1970) retained the name *Phytophthora infestans*, arguing incorrectly that *Botrytis vastatrix* was an invalid name because it was published in a newspaper, but this is permitted by the Code previous to 1953 (Art. 30.3). While it is in fact valid, Botrytis vastatrix is an illegitimate superfluous name; Libert published it as a replacement name for *Botrytis farinosa* Fr.:Fr. 1829. Therefore the name *Botrytis vastatrix* must be typified by *Botrytis farinosa* (=Peronospora farinosa), 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 15 other genera and in ten other families (Erwin & Ribeiro 1996).

Supporting Literature:

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

Kroon, L.P.N.M., Bakker, F.T., van den Bosch, G.B.M., Bonants, P.J.M., and Flier, W.G. 2004. Phylogenetic analysis of ***Phytophthora*** species based on mitochondrial and nuclear DNS sequences. Fungal Genet. Biol. 41: 766-782

Puttemans, A. 1936. Reivindicacao visando a denominacae scientifica da doenca da batateira ***Phytophthora infestans*** (Mont.) de Bary. Rodriguesia 2: 341-350

Stamps, D.J. 1985. ***Phytophthora infestans***. C.M.I. Descript. Pathog. Fungi Bact. 838: 1-2

Tucker, C.M. 1931. Taxonomy of the genus ***Phytophthora*** de Bary. Univ. Missouri Agric. Exp. Sta. Bull. 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 (Ho 1992) in Phytophthora Diseases Worldwide (Erwin and Ribeiro 1996). Morphology is shown in Figure 1 below and 4.12G. in *Phytophthora* Diseases Worldwide (Erwin and Ribeiro 1996). See Fry et al. (1993) and Hooker (1981) for photomicrographs of spore structures.

*Phytophthora Diseases Worldwide
Link to this site in a separate window: http://shopapspress.org/42120.html

1. Sporangia
Sporangia are ovoid, ellipsoid to limoniform, tapering at the base, caducous (pedicel <3 µm), and semipapillate. Average size of sporangia ranges from 36 × 22 µm (Tucker 1931) to 29 × 19 µm (Waterhouse 1963). These dimensions are similar to those of de Bary (1876), Rosenbaum (1917), Haskell (1921), K. O. Müller (1928), and Leonian and Greer (1929). Sporangiophores are compound sympodial (Figure 4.5B in Phytophthora Diseases Worldwide [Erwin and Ribeiro 1996]) with a small characteristic swelling just below the sporangium (Figures 4.5C and 4.6).

2. Hyphal Swellings and Chlamydospores
Neither hyphal swellings nor chlamydospores have been reported, except in a paper from Russia by Patrikeyeva (1979), who noted chlamydospores with a two-layer wall after incubation for 4 to 9 months on oat-pea agar at 9 to 10ºC.

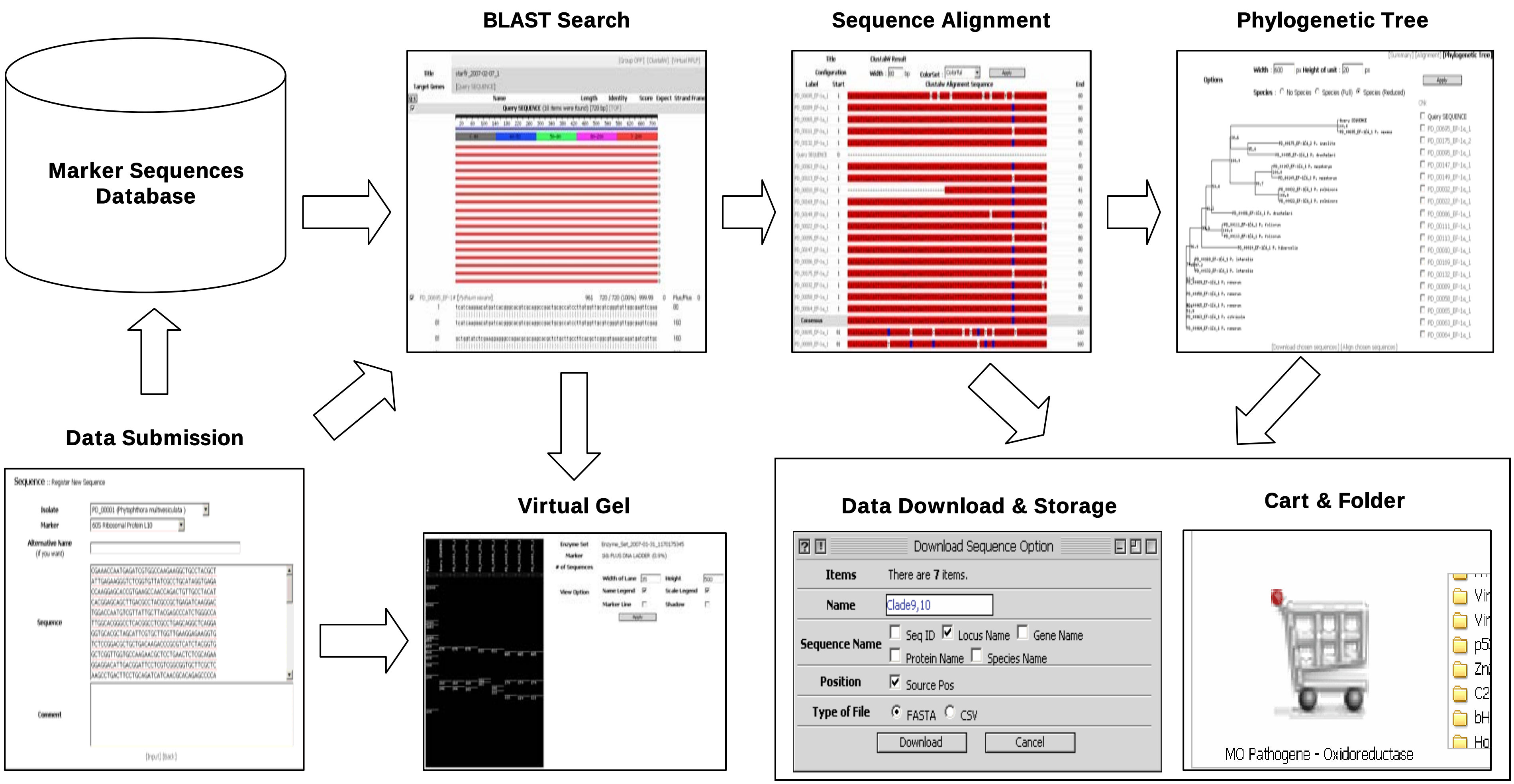
3. Sex Organs
P. *infestans* is heterothallic. Antheridia are amphigynous; oogonia are 31 to 50 µm in diameter (average 38 µm); oospores formed in plant leaves are aplerotic, 24 to 35 µm in diameter (average 30 µm); in artificial culture they measure 24 to 56 µm in diameter. Until the early 1980s, A1 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 (Niederhauser 1991). Inoculation of a leaf with an A2 isolate of P. drechsleri and P. *infestans* (A1) induced oospore production (Skidmore et al. 1984). Whether or not unique biotypes could arise from unrelated species is unknown. Most likely, formation of oospores results from stimulation by hormonelike 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 4ºC, optimum 20ºC, and maximum 26ºC.

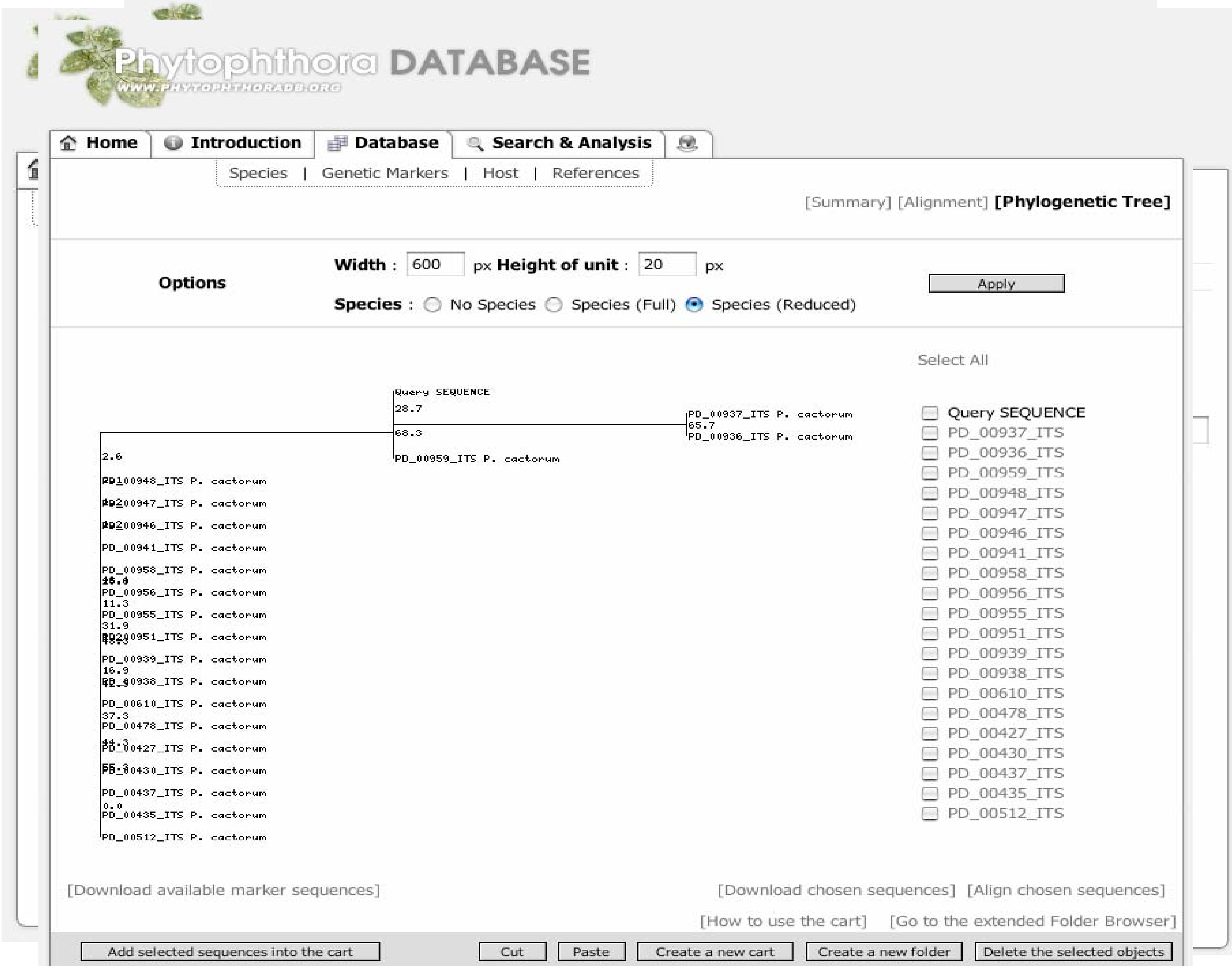
Diseases

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 fungicide (Fig. 1).

Functionality of the *Pytophthora* Database

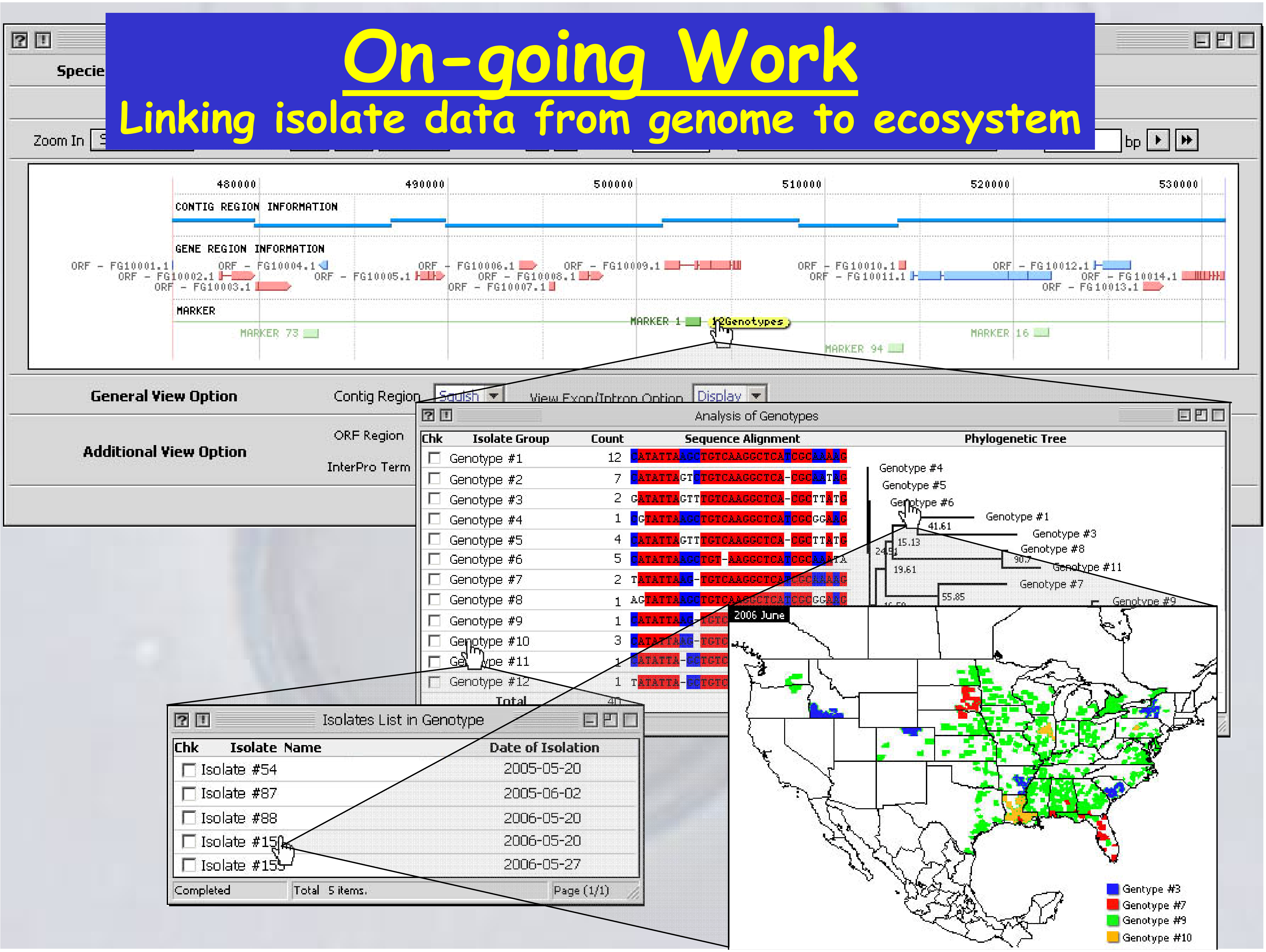


Functionality of the *Pytophthora* Database

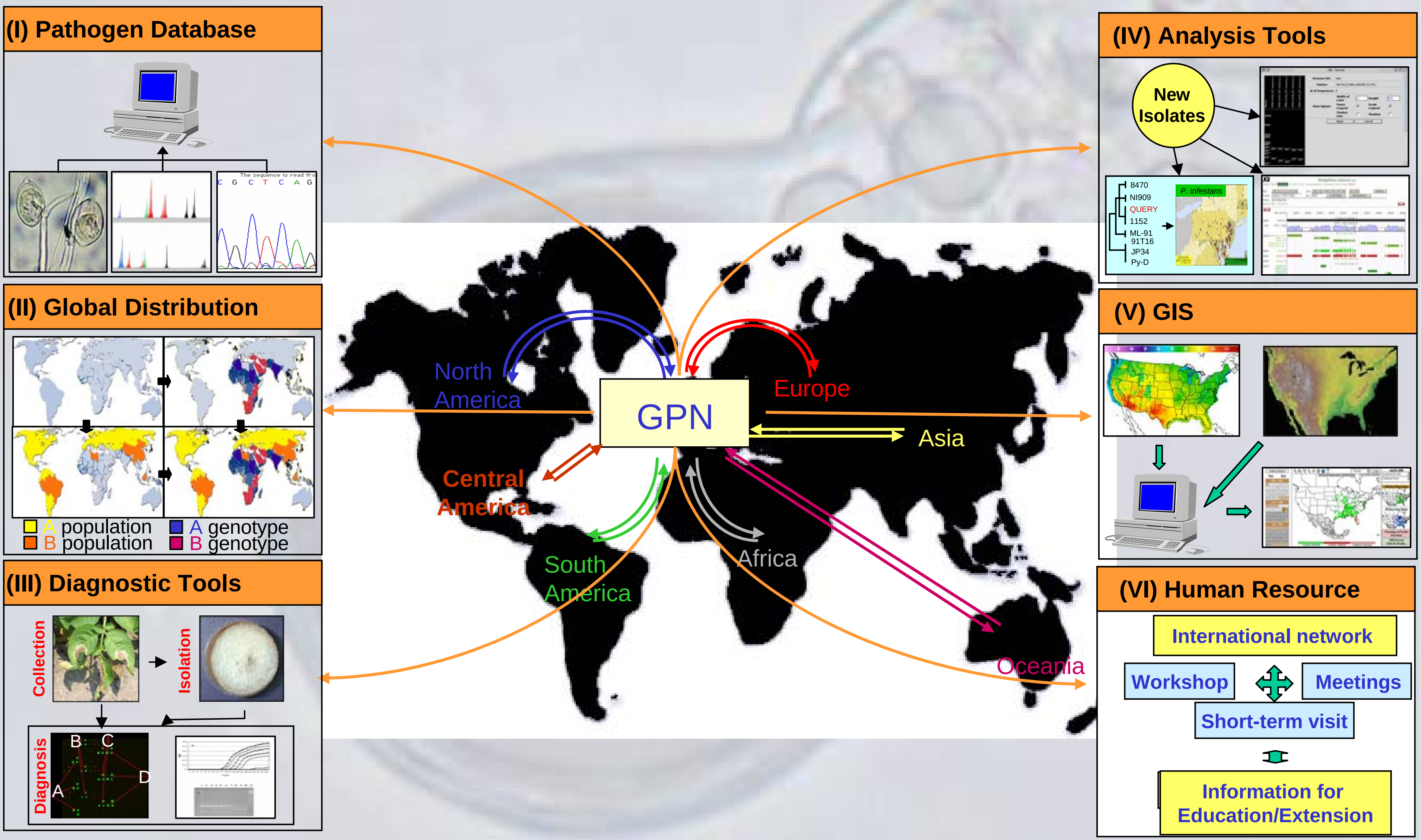


On-going Work

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.