"Chemical industry and plant breeders have forged fine technical weapons, but only epidemiology sets the strategy."

Vanderplank (1963)

More specific objectives (see syllabus):

a. To gain an understanding of how plant disease epidemics occur in nature and how they can be monitored and analyzed.
b. To learn how plant diseases cause crop losses, how these losses are quantified, and how losses are predicted.
c. To learn how epidemiology is used to set the strategy of plant disease control.
d. To learn how to use some statistical procedures for quantifying and comparing and predicting epidemics.
Lecture Topics (from syllabus):

1) **Introduction**
   Terminology,
   History
   Guide to course

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**Epidemic:**

"Change in disease intensity in a host population over time and space."

*Change:* often *increase* -- a *dynamic process*

*Disease:* dealing with *diseases,* not just the pathogen (or plant/crop)

*Host:* Organism infected (or potentially infected) by another organism

*Population:* a *population phenomenon*

*Time and space:* two *physical dimensions* of interest.
Epidemiology
"Science of disease in populations"
Vanderplank (1963)

System
Community
Population
Individual
Organ
Tissue
Cellular
Molecular

Populations:
host and pathogen (and ....)

Note:
Epidemic does **not** mean widespread
and/or high level of disease!

We use *pandemic* for widespread, high disease
level ("major epidemic")

Why this definition?
Answer with an example.

Consider an epidemic of potato late blight, caused by
*Phytophthora infestans*...
Scenario (potato late blight)

A large field with 4 million plants (4x10^6)

1 lesion/plant: 0.1% severity (that is, y = 0.001 or 1/1000 of the leaf surface covered by lesions)

Disease progress curve

\[
\begin{align*}
  t=0 & \quad y = 0.001 (or 0.1\%) & \quad \text{1 lesion/field} \\
  t=44 & \quad y = 0.001 (or 1 \text{ lesion/plant}) & \quad \text{(or 1 lesion/plant)} \\
  t=83 & \quad y = 0.999 (or \sim100\%) & \quad \text{4 million-fold increase}
\end{align*}
\]

<table>
<thead>
<tr>
<th>t</th>
<th>y</th>
<th>Lesions</th>
<th>Rate Parameter = 0.246/day</th>
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<tr>
<td>80</td>
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</table>
1) No obvious place to "draw the line between epidemic and no epidemic
2) Same biological processes occur over entire time (or disease) range

Thus, a change in disease intensity (in a population) is an epidemic

Other definitions:
1) increase instead of change;
2) drop space from definition (focus on time)

Other name for epidemic: epiphytotic
Unger (1833)
Whetzel (1920's)

Epidemic: "what is among people" (Greek origin)

However, equally valid meaning from Greek:
"what is in (or among) a population" ("demio")

"Epidemic" used for plants for a long time.....
1728: Duhamel 1691,1842: book titles <
1858: Kuhn 1901: Ward

Thus, no valid reason to use "epiphytotic"
Epidemiology:

- Study of epidemics.
- Science of disease in populations.
- Ecology of disease.
- Study of the spread of diseases, in space and time, with the objective to trace factors that are responsible for, or contribute to, epidemic occurrence.
- The science of populations of pathogens in populations of host plants, and the diseases resulting therefrom under the influence of the environment and human interferences.

Epidemiology:

Involves the disease triangle, but at the population level

- Some efforts have been made to extend the disease triangle to encompass the dimensions of time and space (and other factors). This become awkward since we are limited to pseudo-3-dimensions.
- See APSnet Education Center (Teaching Articles) for interesting article by Francl on disease triangle.
NOTE:
If one used *epiphytotic* (instead of epidemic), then one should use *epiphytotiology* instead of epidemiology!
-(Epiphytology is the study of epiphytes).

**History (ancient to modern times):**

Hippocrates (~400 BC)
  First use of "epidemic", widespread disease (human diseases)

Theophrastus (~340 BC)
  Plant diseases in fields
  Environmental influences

Pliny (~50 AD)
  Plant diseases; soil; climate

Duhamel de Monceau (1728 AD)
  *Rhizoctonia* sp. infecting saffron crocus
  Disease progress curves
  Comparison of plant and animal epidemics
**Late 19th Century and forward…**

**Kuhn** (1858) - 1st textbook of plant pathology

**Ward** (1901)  
- book "Diseases in Plants" emphasized ecology (populations) of disease

**Jones** (1913) - role of the environment

**Gaumann** (1946) - "Principles of Plant Infection"  
- Disease spread  
- Conditions leading to an epidemic  
- 'Infection Chain' (= disease cycle)  
- compare with medicine (diseases of humans)  
- theory (initial, in words)

**Large** (1952, and others)  
- Disease progress curves  
- Crop losses  
- Disease assessment (measurement)

**Horsfall & Dimond** (1960)- "Plant Pathology, Volume 3"  
- Populations  
- Inoculum density:disease relations  
- Spore dispersal  
- Analysis (mathematics)  
- Forecasting, prediction  
- *Traditional* definition ---* Modern* definition

**Gregory** (1963, 1973)  
"The Microbiology of the Atmosphere"  
- Spore dispersal, disease spread  
  **Aerobiology**
**Vanderplank** (1963) (used to be **van der Plank**)  
"**Plant Diseases: Epidemics and Control**"  
- Populations  
- Rates (dynamic processes)  
- Analysis, mathematics  
- Models, theory  
- Link epidemiology and control  
- Established the science of plant disease epidemiology

Other pioneers:  
Zadoks (1960-1995), The Netherlands  
Kranz (1968-1995), Germany  
Waggoner (1960-mid --1980s), USA

Note: many developments in other fields…  
Ecology, medical epidemiology,  
Biomathematics, etc.

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**Guide to the course…..**

1) **Introduction**  
Terminology,  
History  
Guide to course

2) **Monitoring epidemics**  
Host measurement  
Disease measurement  
Severity-incidence

3) **Analysis of epidemiological data**  
Models  
Regression (introduction)  
MINITAB/SAS

4) **Disease progress over time**  
Disease progress curves  
Models and analysis  
Advanced topics  
asymptotes  
thresholds  
components  
controls
**Guide (continued)…**

5) **Disease spread in space**  
   Dispersal gradients  
   Models, analysis  
   Spatio-temporal

6) **Spatial patterns (dispersion)**  
   Concepts of aggregation  
   Analysis  
   Spatial scale  
   Sampling

7) **Crop loss assessment**  
   Concepts  
   Models  
   Prediction

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**Grading:**

Two tests (65%) + Assignments (35%)

**Readings from:**

- Chapters from *The Study of Plant Disease Epidemics*,  
  - by L. V. Madden, G. Hughes, and F. van den Bosch (2007)  
- Various book chapters and journal articles.

*Students are expected to have access to a personal computer, and either Minitab or SAS statistical software.*
Reading assignment #1:

- Chapter 1 Madden, Hughes, and van den Bosch (MHV)
- Chapter 2 MHV -- for next two classes

Updated lecture notes will be posted to the course website after each class.

Classes are recorded, and should be available for viewing within a few hours of each class.

Assignments, and other items, available on the website.