

E²M²: Ecological and Epidemiological Modeling in Madagascar

Ecology Meets Epidemiology

Centre ValBio

Ranomafana National Park, Madagascar

6 – 14 January, 2020

Thanks to our sponsors!



Mahaliana
IT ALWAYS STARTS WITH A QUESTION



International Clinics on Infectious
Disease, Dynamics, & Data



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**MMED: *Clinic on the
Meaningful Modeling of
Epidemiological Data***

May-June 2019, Cape Town,
South Africa





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South African Center for Epidemiological Modeling and Analysis (SACEMA), Director

Dr. Juliet Pulliam
University of Stellenbosch

ICI3D, Program Director
Dr. Steve Bellan
University of Georgia



International Clinics on Infectious
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www.ici3d.org

Goals for this lecture

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 - Madagascar

All course materials are available at:

E2M2.org

Saturday/Sunday: R Bootcamp

- Intro to R Studio
- Exploring and Visualizing Data in R
- For-loops, Functions, and If-Else Statements
- Data Cleaning
- Intro to Spatial Visualization & Plotting

Monday: Travel

Tuesday: "Understanding Your System"

- Data and Models
- Reviewing Concepts in Mathematics
- Student Introductions & Presentations
- Formulating Research Questions
- Study Design and Data Collection
- Designing Studies in R

Wednesday: "Building Simple Models"

- Linear Regression and Simple Statistics
- Statistical Modeling in R
- Dynamical Fever
- Intro to Compartmental Models
- Building Mechanistic Models in R
- Refining Research Questions for Modeling

Thursday: "More Complicated Models"

- Intro to Mixed Modeling
- Mixed modeling in R
- Introduction to Occupancy Modeling
- Occupancy modeling in R
- Compartmental Modeling Extensions
- Intro to Network Modeling
- Model Telephone

- Programming
- Lectures
- Activities
- Research Development

Saturday: "Putting it All in Perspective"

- Modeling in Practice: The Lifecycle of a Modeling Project
- Mentor Research Presentations
- Looking Back

Sunday: Travel

Tuesday: "Sharing Your Work"

- Final student presentations

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What is an -ology?

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- “the study of”
- “the science of”

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- “the study of”
- “the science of”
- goal: to *explain*

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 - **Ecology**
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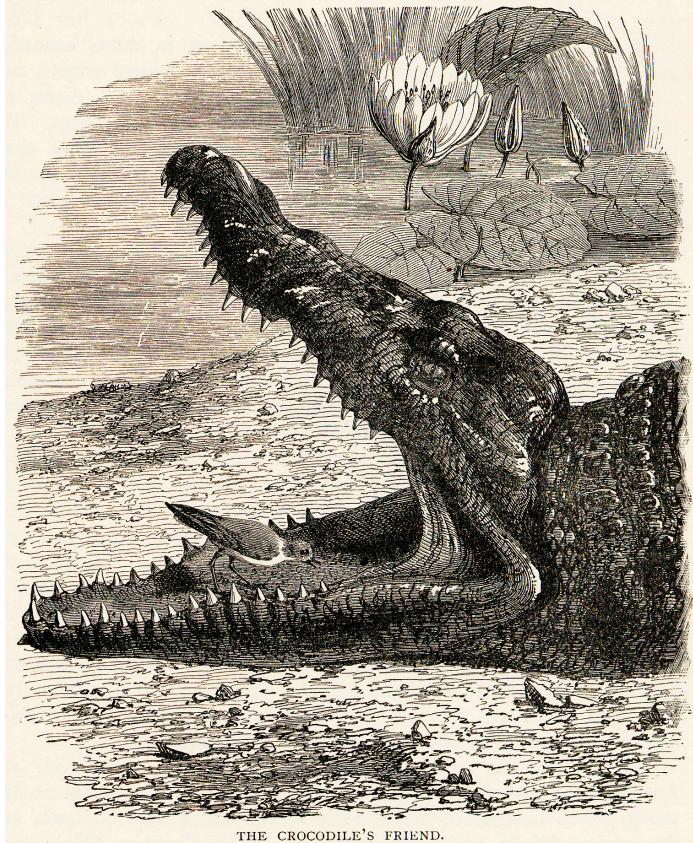
What is Ecology?

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- The study of the **interactions** of **organisms** and their **environment**

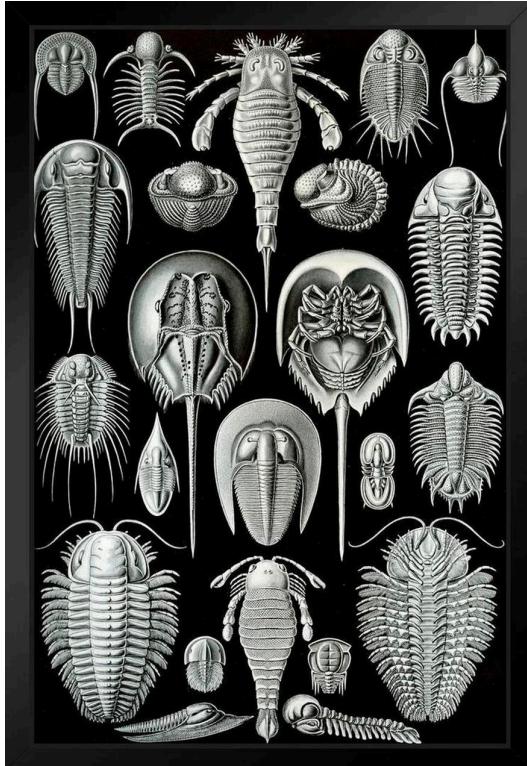
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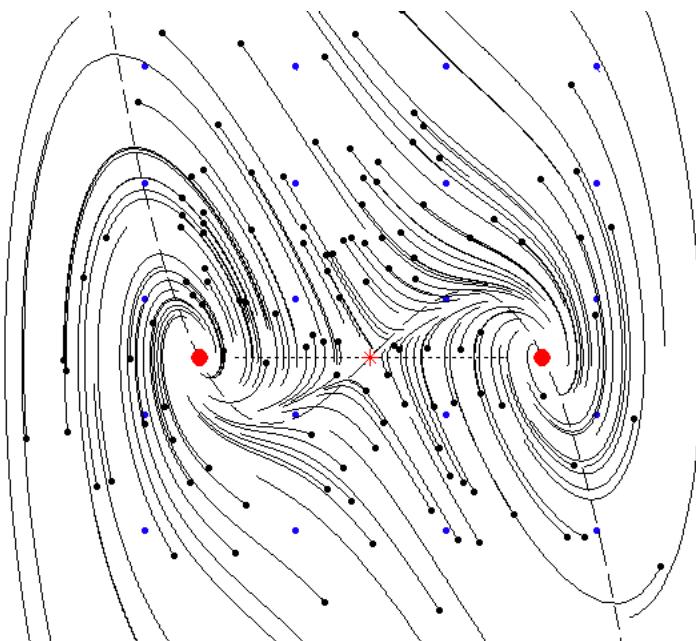
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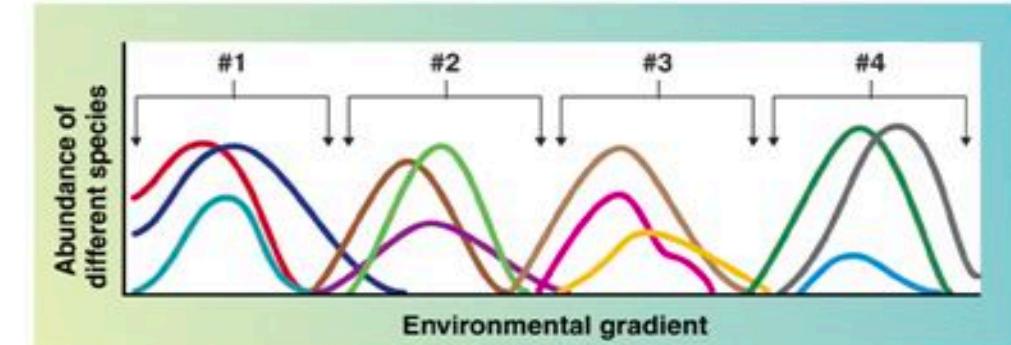
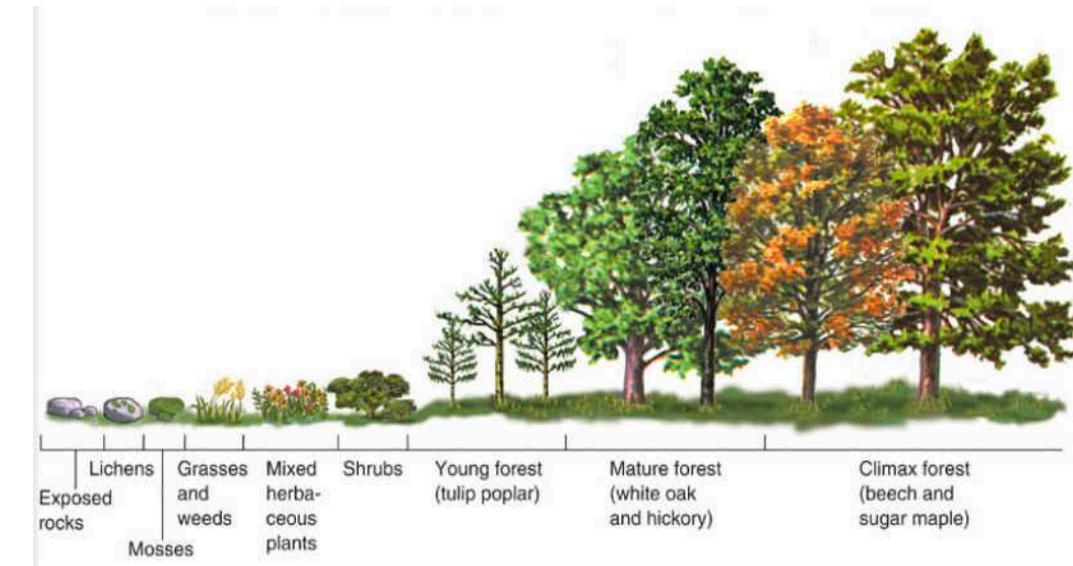
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- Emphasis on explaining **dynamical processes** in nature



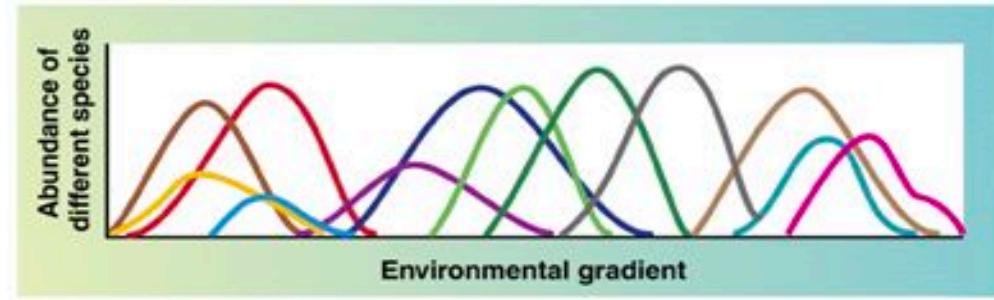
A Brief History of Ecology

1. Plant Biology

- Clements (1905): 'superorganism'
- Gleason (1918): individualistic ecology



(a) Organismic model



(b) Individualistic model

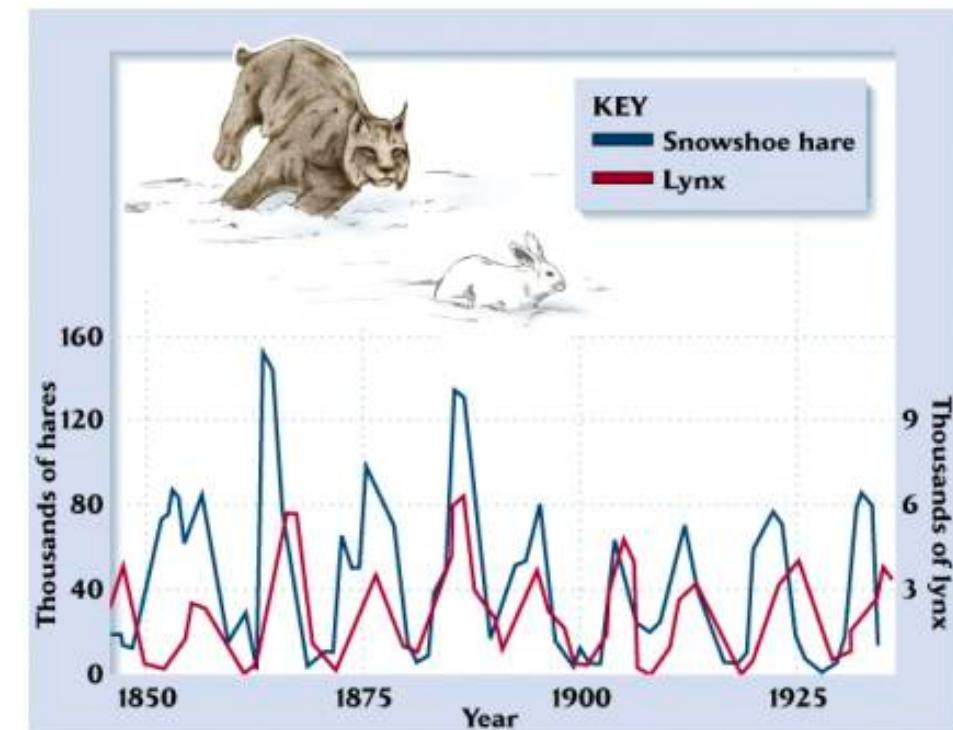
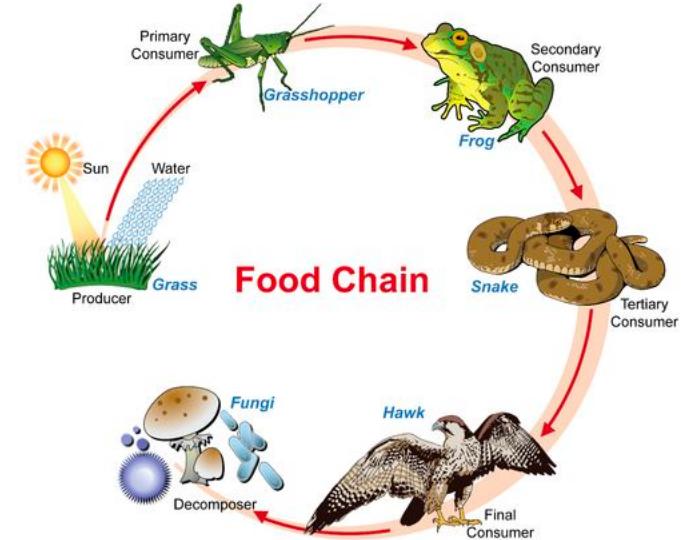
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2. Population Biology

- Charles Elton (1920s): food webs
- Lotka-Volterra (1920s): predator-prey models



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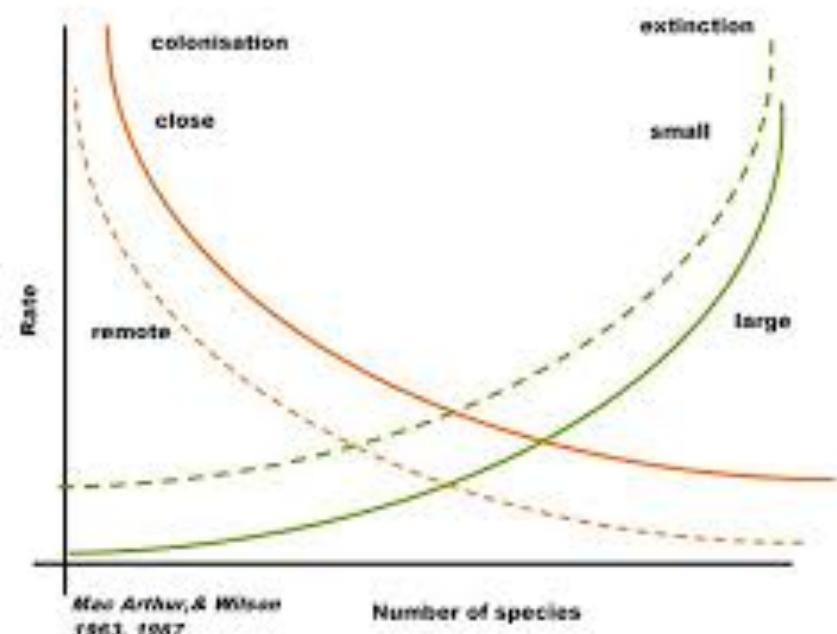
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3. Mathematical Ecology

- MacArthur (1950s): island biogeography



Island biogeography



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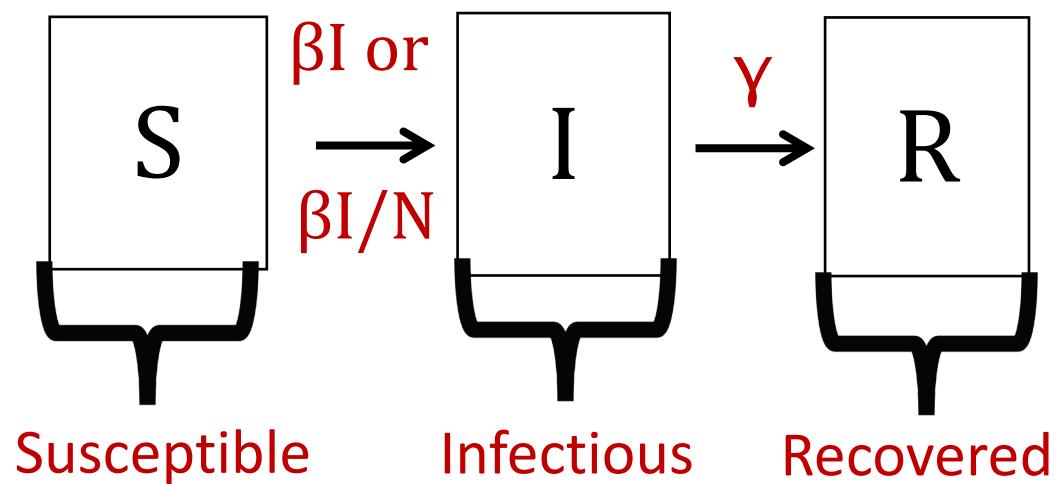
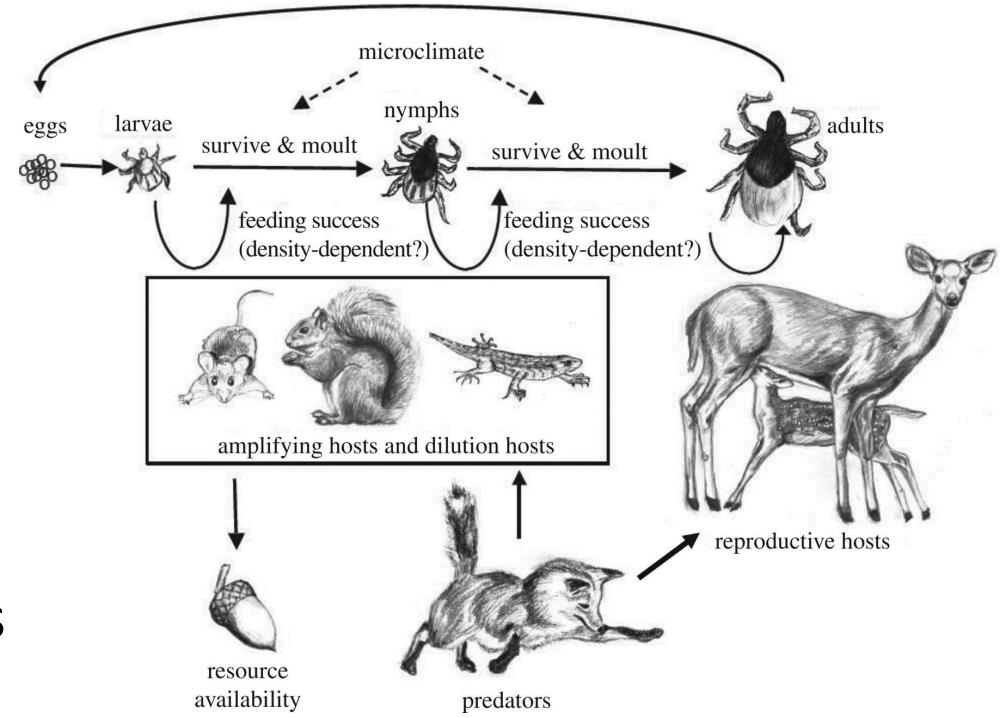
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3. Mathematical Ecology

- MacArthur (1950s): island biogeography

4. Disease Ecology

- Anderson and May (1980s)



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 - **Epidemiology**
 - Modeling
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What is Epidemiology?

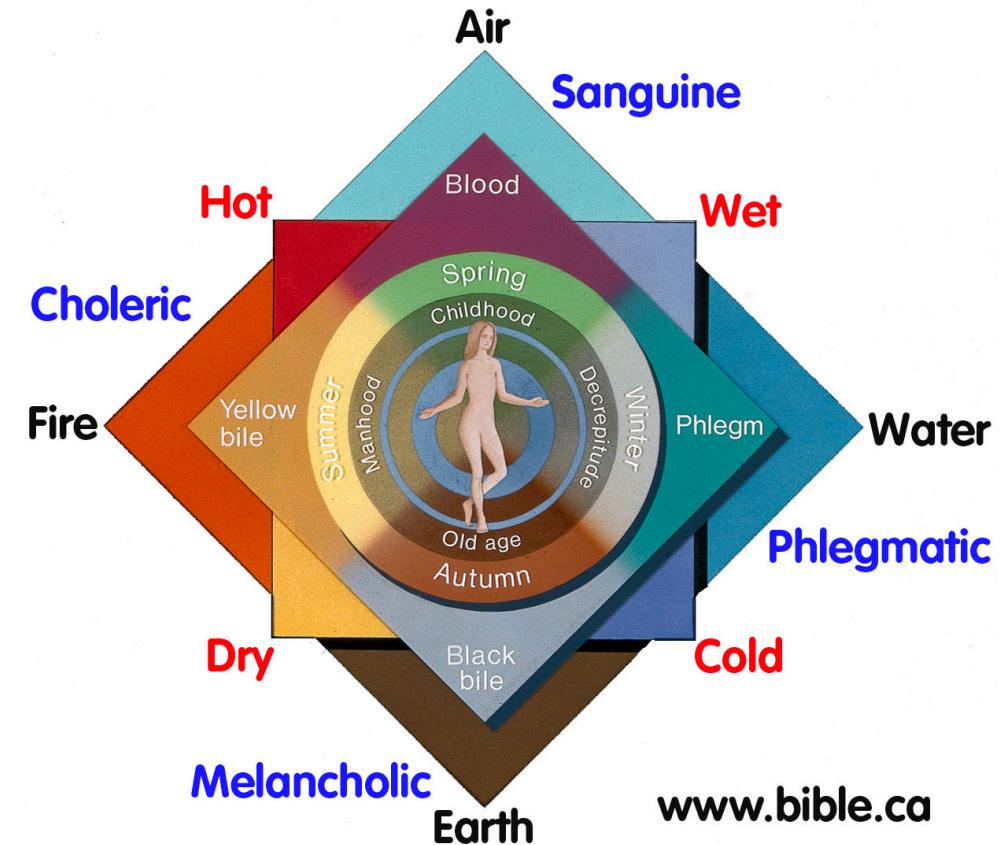
- “the study of **what** is on the people”
 - coined by Spanish physician Villalba in 1802
- Emphasis on the study and analysis of the distribution and determinants of health and disease (“risk factors”)

A Brief History of Epidemiology

1. Four Humors

- Disease results from imbalance
- Hippocrates (c. 400 BC)

The Four Humors of Hippocratic Medicine
450 BC - 1858 AD
Melancholy Blood (depression)



A Brief History of Epidemiology

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2. Miasmatic Theory of Disease

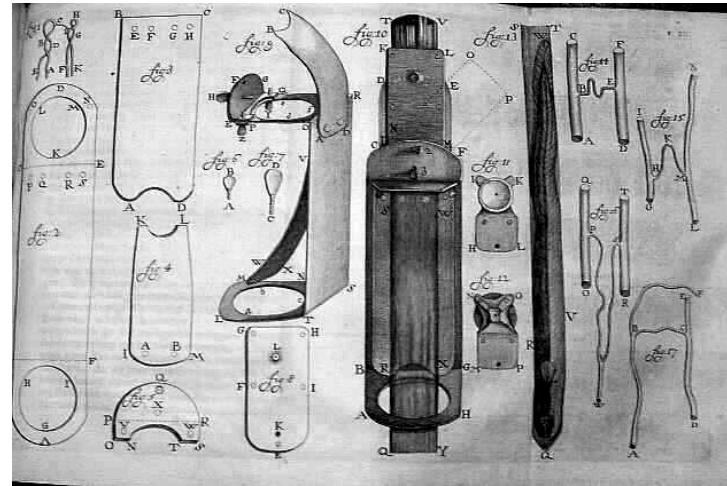
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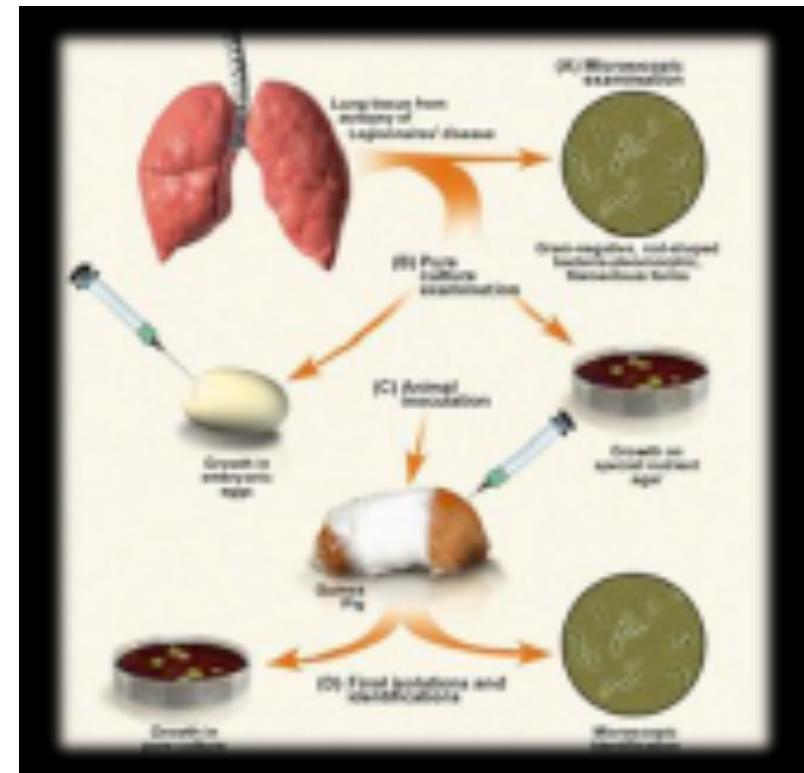


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3. Germ Theory of Disease

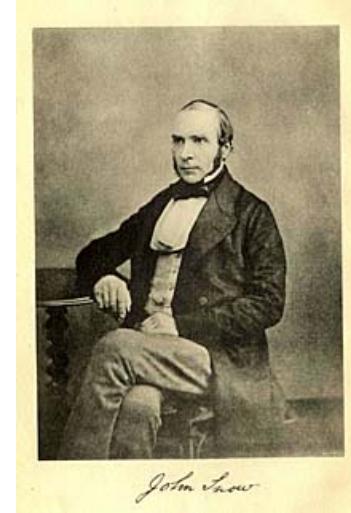
- Disease results from 'germs'
- Leeuwenhoek's microscope (1675)
- Koch's postulates (1890)



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3. Germ Theory of Disease

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4. Classical epidemiology

- 'Risk factors'
- John Snow and London cholera (1854)



Applying Ecology and Epidemiology

- Applied Ecology = **Conservation Biology**
 - **Goal:** protect **populations** from **extinction**

Applying Ecology and Epidemiology

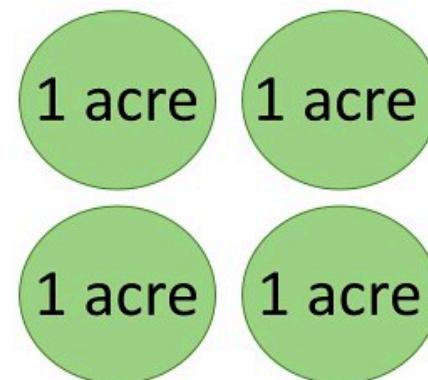
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 - **Goal:** protect **populations** from **extinction**
 - **Approach:** protected area reserves

Single Large



or

Several Small



Applying Ecology and Epidemiology

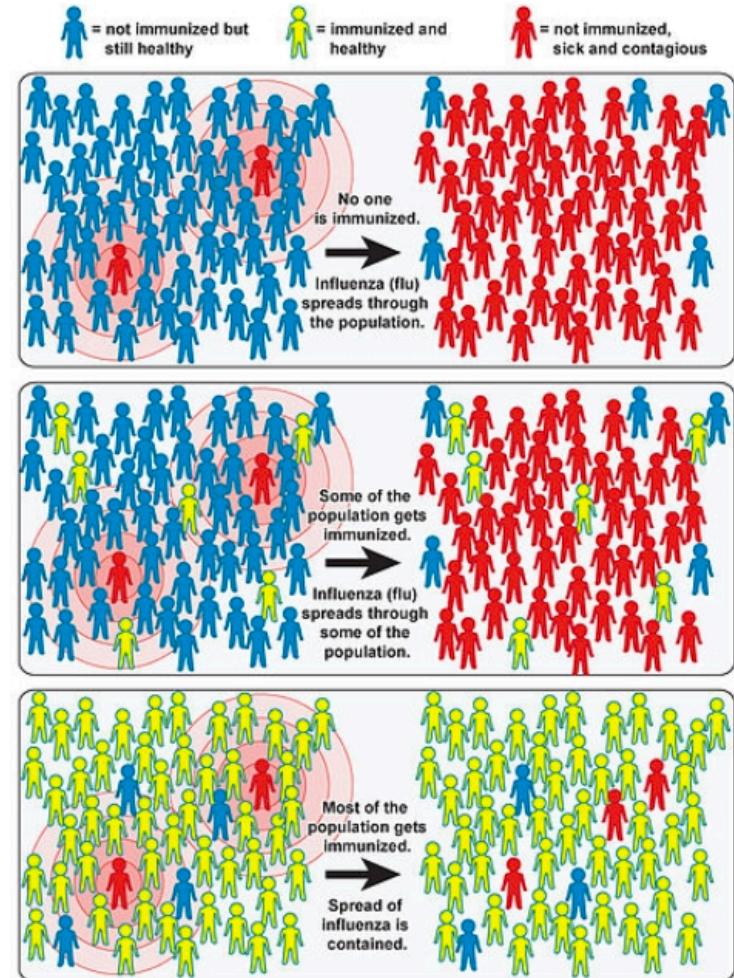
- Applied Ecology = **Conservation Biology**
 - **Goal:** protect **populations** from **extinction**
 - **Approach:** protected area reserves
 - **Key Terms:**
 - **Minimal Viable Population (MVP):** minimum number of individuals sufficient to sustain 99% of population in 100 yrs
 - **Intrinsic growth rate** = r
 - **Finite population rate of increase** = λ

Applying Ecology and Epidemiology

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Applying Ecology and Epidemiology

- Applied Epidemiology = **Public Health**
 - **Goal:** protect **populations** from disease via pathogen **extinction**
 - **Approach:** sanitation, quarantine, vaccination
 - **Key Terms:**
 - **Critical Community Size** (CCS): minimum number of hosts sufficient to sustain a pathogen indefinitely
 - **Basic Reproduction Number** = R_0

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Misaotra!