



CENTER FOR  
INFERENCE & DYNAMICS  
OF INFECTIOUS DISEASES



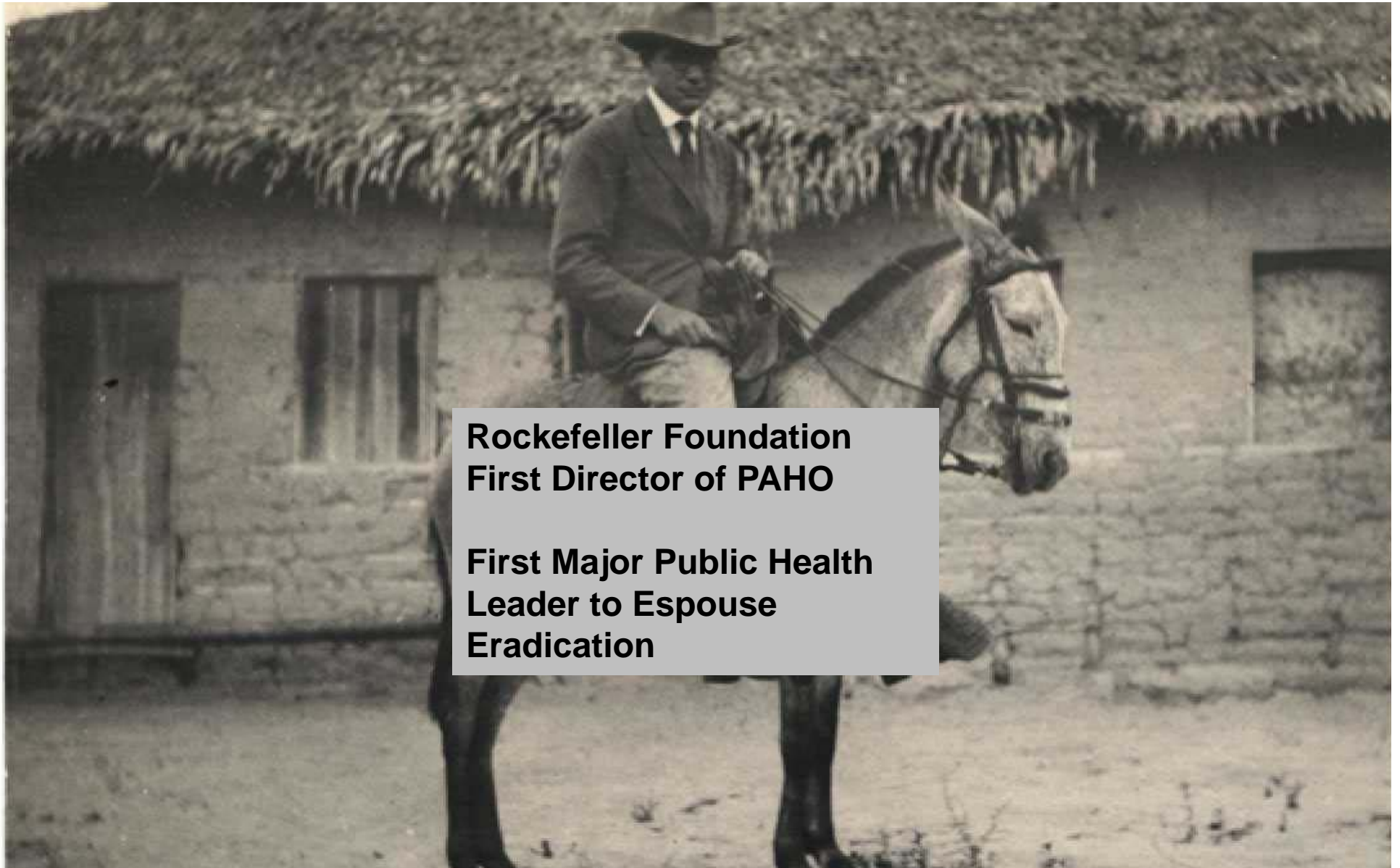
# **Lessons of Disease Eradication Efforts for Invasive Mussel Control**

**Jim Koopman MD MPH, Professor Emeritus**

# Talk Organization

- Antecedents to Smallpox Eradication philosophy
  - Yellow fever and Malaria
- Smallpox, why and how it was eradicated
- Polio eradication, why we are in year 28 of a 12 year program and consuming annually a billion dollars a year more than the total original program was to cost
- Collaborative modeling to set and achieve goals

# **Fred Soper's Quest to Eradicate Aedes Aegypti for Yellow Fever Control**



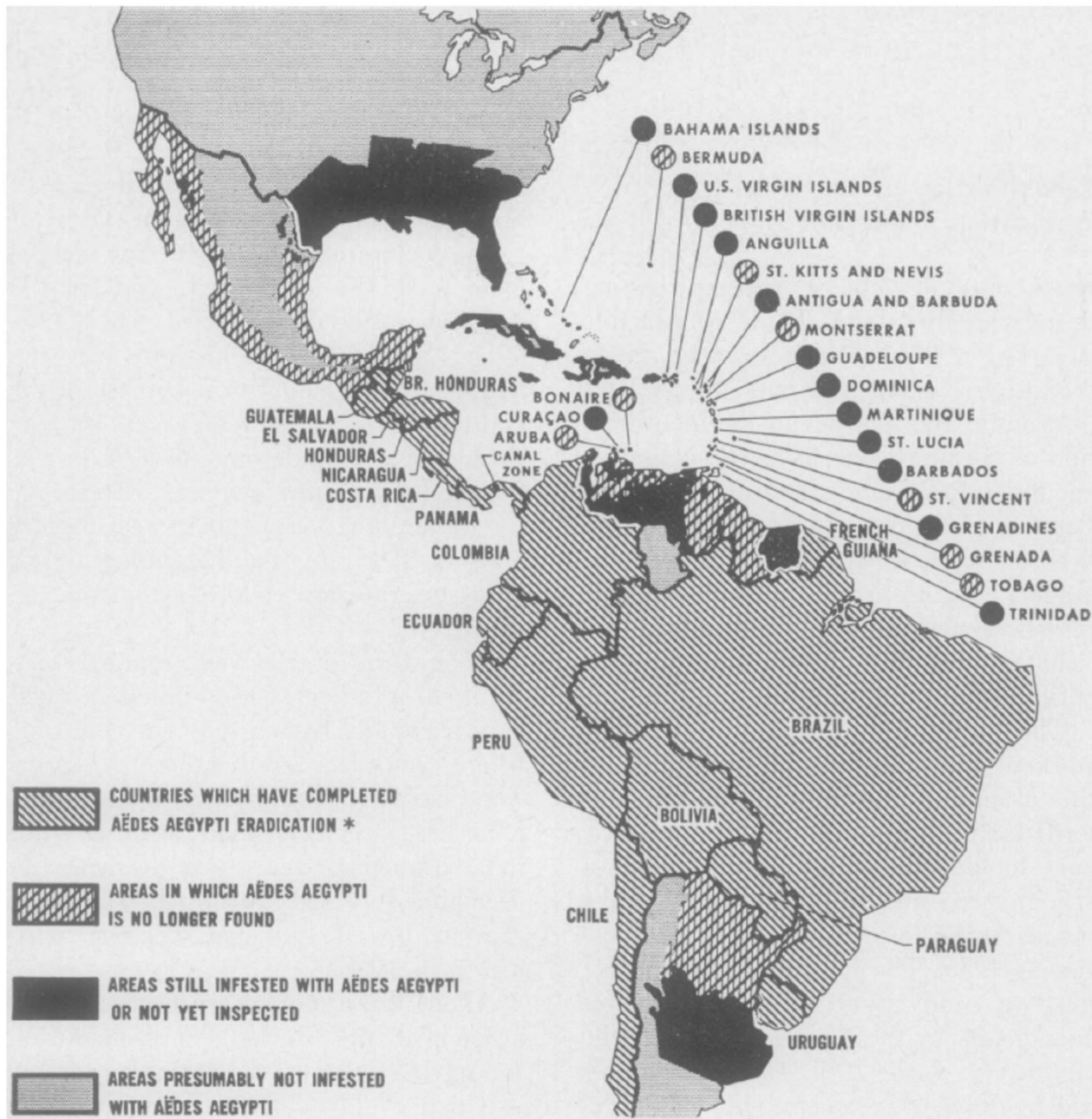
**Rockefeller Foundation  
First Director of PAHO**

**First Major Public Health  
Leader to Espouse  
Eradication**

# Yellow Fever Eradication Program

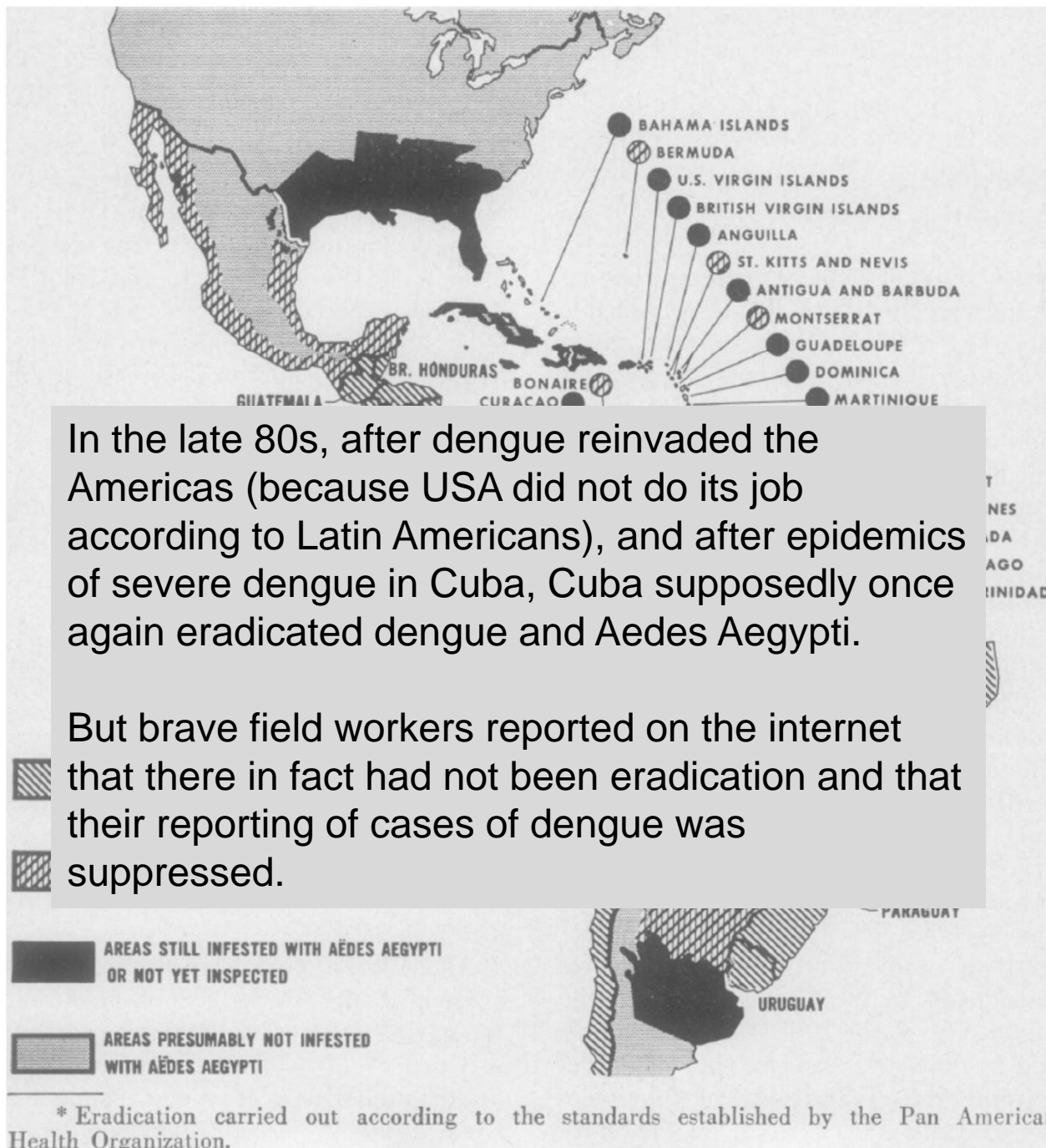
- Successes in *Aedes aegypti* control and discovery of monkey hosts changed program objectives from yellow fever eradication to *Aedes aegypti* eradication
- Focus was on rigid program implementation without much exploration of new approaches or scientific investigation of the biological or social processes that led to success or failure
- Philosophy was almost all resources had to be put into field work with checking on the work of all field workers

**Map 1—Status of the *Aedes aegypti* Eradication Campaign, June, 1961**



\* Eradication carried out according to the standards established by the Pan American Health Organization.

**Map 1—Status of the *Aedes aegypti* Eradication Campaign, June, 1961**



# What the World Learned From Yellow Fever

- Strong, thorough, meticulous, detailed (dictatorial) leadership can knock down health threats
- Lack of knowledge about transmission routes and dynamics can lead one to pursue a fools errand
  - Monkey host made eradication unpalatable
  - Mosquito population dynamics allow Aedes to spring back full force from undetectable levels of infestation (Concept of stable vs. unstable eradication)

# What the World Needed to Learn

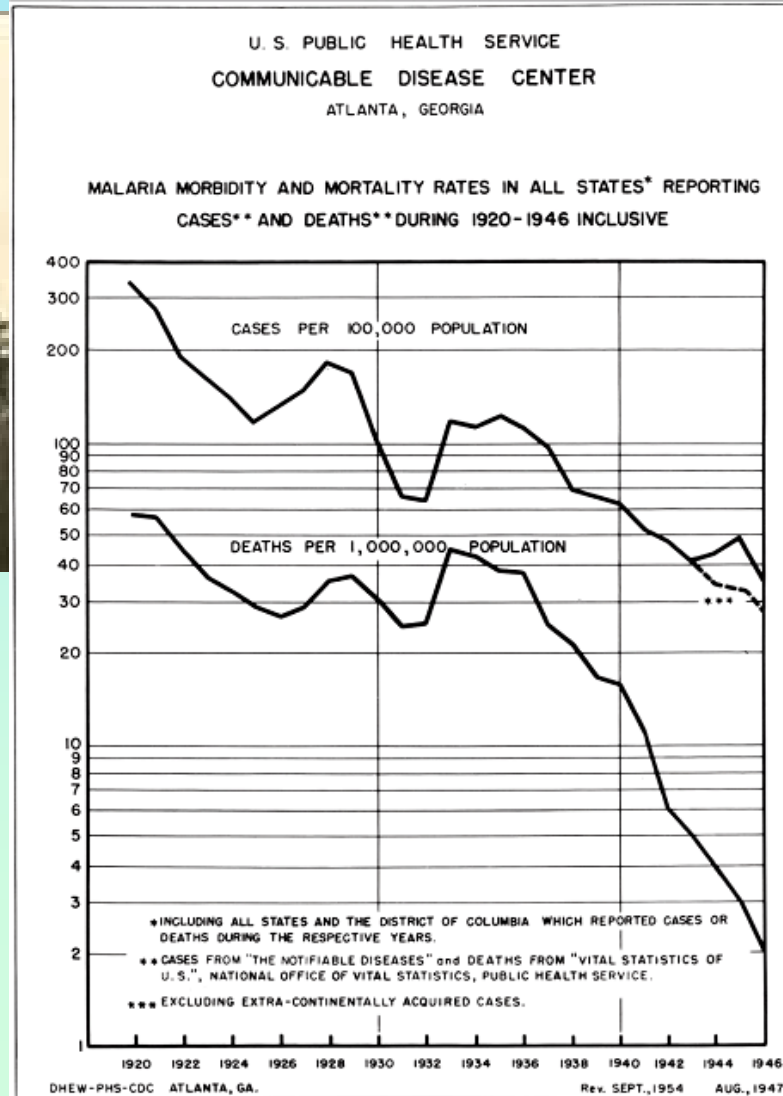
- Initial empirical success is a weak base on which to build an eradication program
- Eradication programs need a wide community of scientists to work openly on understanding what is involved in successes and failures
- Basic science and technological innovation should be built into big eradication programs
- Programs should be prepared to shift from eradication to control objectives in a manner that maintains progress



# CDC is Founded on Malaria Elimination Success



DDT

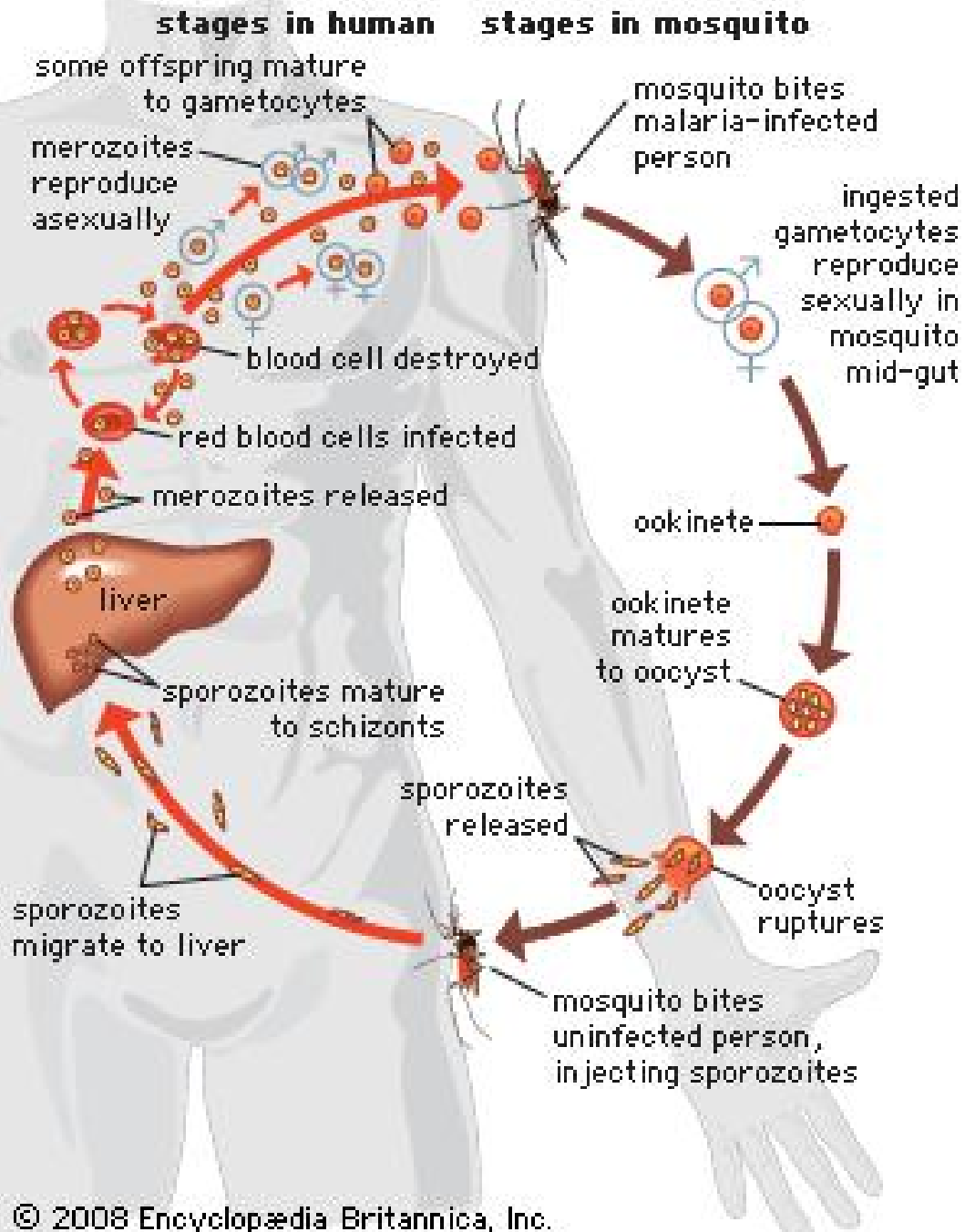


Chloroquine

# The First Malaria Eradication Effort

- 1955 WHO begins a Global Malaria Eradication Campaign based on DDT spraying & chloroquine Rx
- Same philosophy of putting all resources into fieldwork and evaluation of fieldwork quality
- Success in developed countries & India but by 1969 resistance to DDT and Chloroquine lead to surrender
- Reasons for failure were never completely understood
  - Inadequate understanding of biology (esp. gametocytes)
  - Inadequate efforts to understand transmission dynamics:
    - Effects of simplifying model assumptions never fully explored
    - Little modeling of evolution of resistance
    - WHO modelers involved, but modeling was underdeveloped in 1955

## Malaria's life cycle



A knowledge gap that deserves more attention is the frequency and causes of asymptomatic gametocytemia.

# Melinda Gates Revives Malaria Eradication

- Some effort to make data more available to a wide community of collaborative scientists but data is still too restricted to attract a broad community of modelers
- Some successes with insecticide impregnated bednets
- Search for key technical innovations that will make rigid program implementation successful
- Vaccine faces very fast waning of immunity problems
- Gates establishes company to do the needed modeling
- Still not enough basic science to understand how problems will arise as program changes transmission dynamics

# Smallpox eradication

- Administrative structure similar to yellow fever & malaria
  - WHO maps made for malaria serve smallpox
  - DA focuses all efforts outside WHO to skirt bureaucracy
- A flexible leadership changes directions
- A grand success on an easy target
- Rudimentary modeling was enough to guide decisions
- Morally questionable decisions helped success



# Flexible Leadership

- Believed initially
  - that infection was highly contagious, vaccine immunity was short lived, high coverage needed reach transmission threshold
- Discovered that
  - 150% vaccine coverage was insufficient in places due to counting repeat vaccinations as new vaccinations, transmission was very slow, vaccination lasted
- Program initially based on mass vaccination but lack of vaccine led to discovery that a few key vaccinations could stop transmission
- Logic of simple model convinced leadership to change to ring vaccination



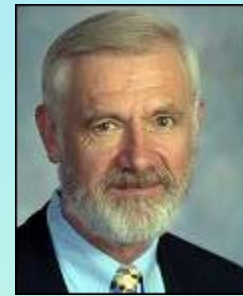
# An Easy Target

- Usually just looking at a face is enough to diagnose
- Vaccination after exposure to a case can prevent an infection and a subsequent transmission
- Vaccination is easy
- Lyophilized vaccine stable
- Two weeks to find exposed individuals
- Rewards for reporting cases highly effective



# Only Rudimentary Modeling Needed

- Mostly mathematicians doing modeling back then
- Modeling was highly disparaged
- Bill Foege did thought experiment
  - After stumbling on low vaccine use strategy
- Foege leadership: know and inspire workers

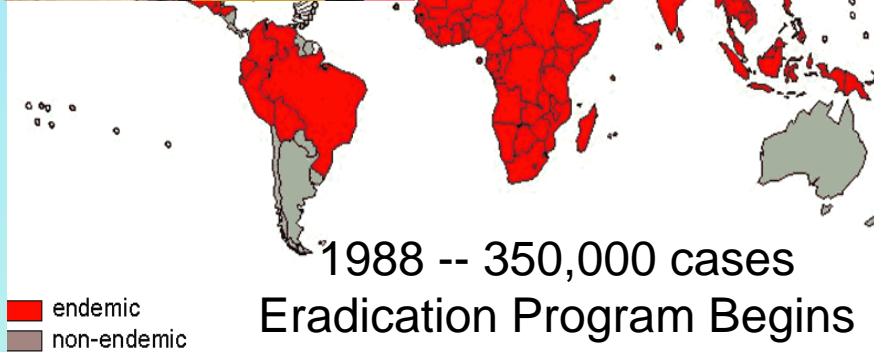
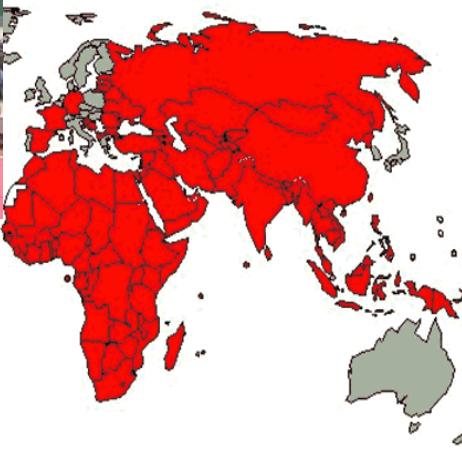






# Choose a virulent vaccine just to better insure success

- Russian vaccine had much higher complication rate but also a little higher take rate.





1988 -- 350,000 cases  
Eradication Program Begins

 endemic  
 non-endemic



# Polio Eradication

- The greatest global communitarian effort ever
- Year 28 of a 12 year program consuming every year more than original 12 year program was to cost
- Success needed now so we can pursue easier targets
- Biggest problems I see are
  - Lack of understanding of transmission dynamics
  - Program data constrained to 3 modeling groups
    - Theorists who could best use data don't get data
  - No local theorists generating new approaches
- The Taliban and Boko Haram blamed for failure
  - True, but we could have eradicated by now despite their actions

# Program organization

- Inherited from yellow fever, malaria, smallpox
- More research but
  - mainly implementation operations research and vaccine research. Not transmission dynamics
- WHO, UNICEF, CDC, Rotary International form GPEI
- Gates Foundation joins
  - New diagnostic, monitoring, mapping, and modeling tools are allowing faster and more accurate tracking of polio cases and transmission patterns
  - But basic science on transmission dynamics not pursued

# The Polio Endgame Problem

- High transmission countries that quickly reached high vaccination levels eradicated quickly
  - Helped by transmission of the vaccine boosting immunity
- Those who took a long time let immunity wane in older age groups let older age groups maintain transmission
- WHO and the GPEI have so longed stressed that only children need to be vaccinated that they fear changing their story

# The Global Polio Eradication Initiative Strategy



Only in the polio game the mole gains an ability to pop up and spread unseen as time passes

## **Ways for invasive mussel control to avoid mistakes made controlling epidemics**

- Get modelers, program people, & outside groups working together so they are continually mapping what we do and do not know while they are mapping mussels
- Use collaborative modeling software like Nova (Numerus) modeler
- Involve citizen scientists not only in gathering data, but in conceptualizing spread and control
- Make all data open so that smart people are attracted to analyze it

**Thank You**