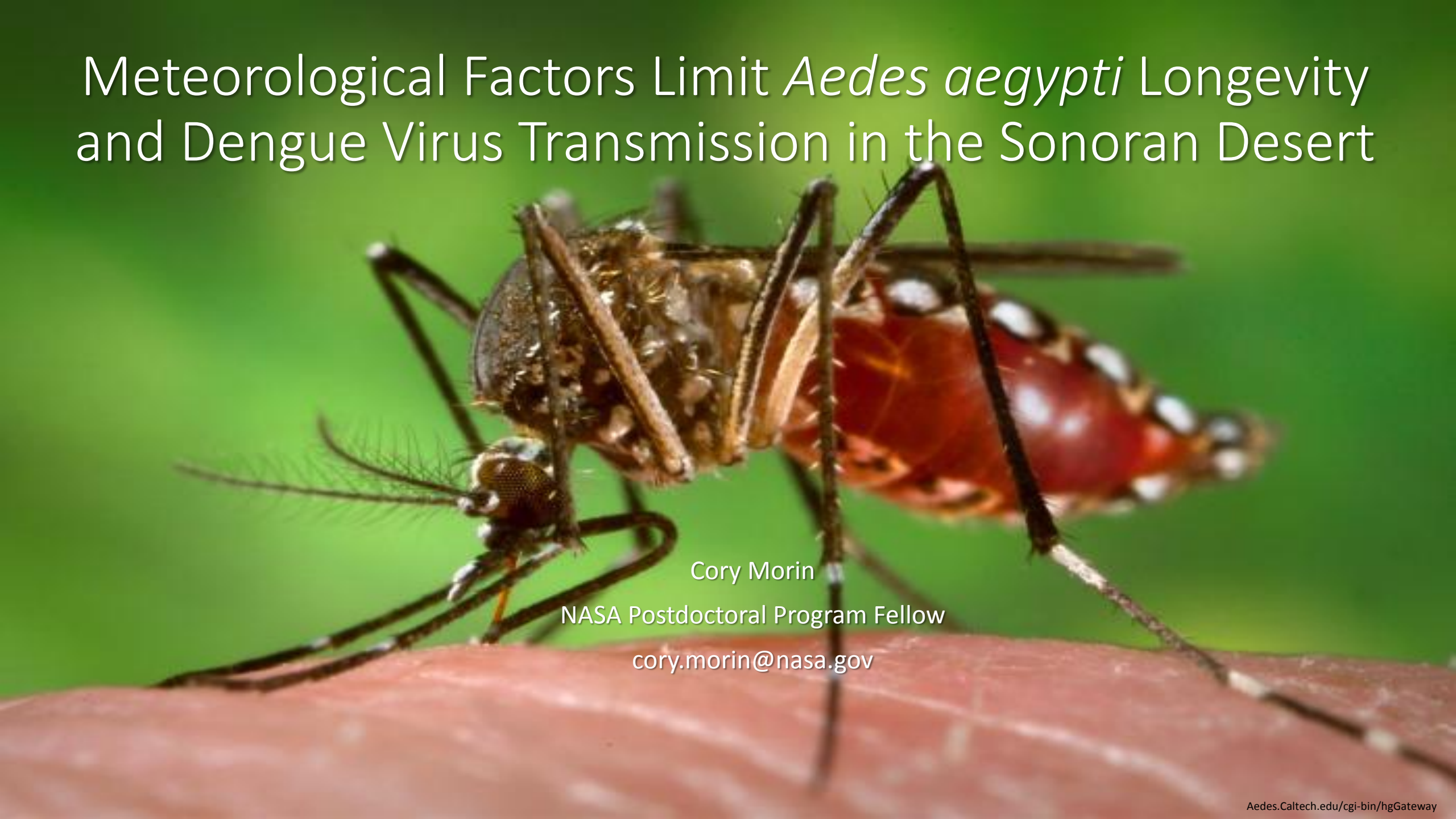
Meteorological Factors Limit *Aedes aegypti* Longevity and Dengue Virus Transmission in the Sonoran Desert



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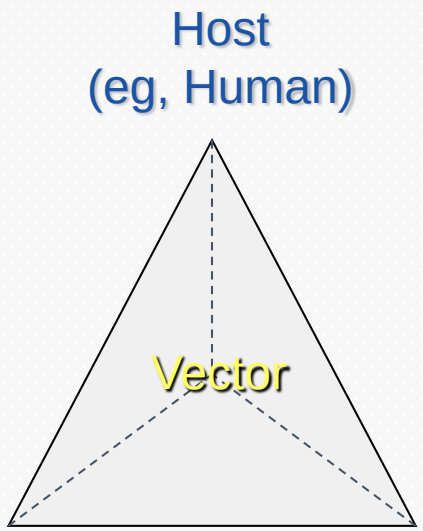
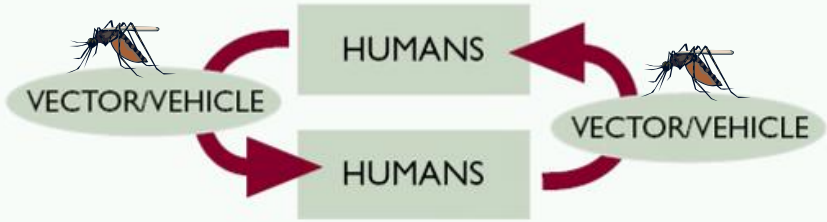
Aedes.Caltech.edu/cgi-bin/hgGateway

Vector-borne Disease Ecology

A *multi-factorial* relationship between hosts, agents, vectors and environment



Anthroponosis



National Research Council, 2001

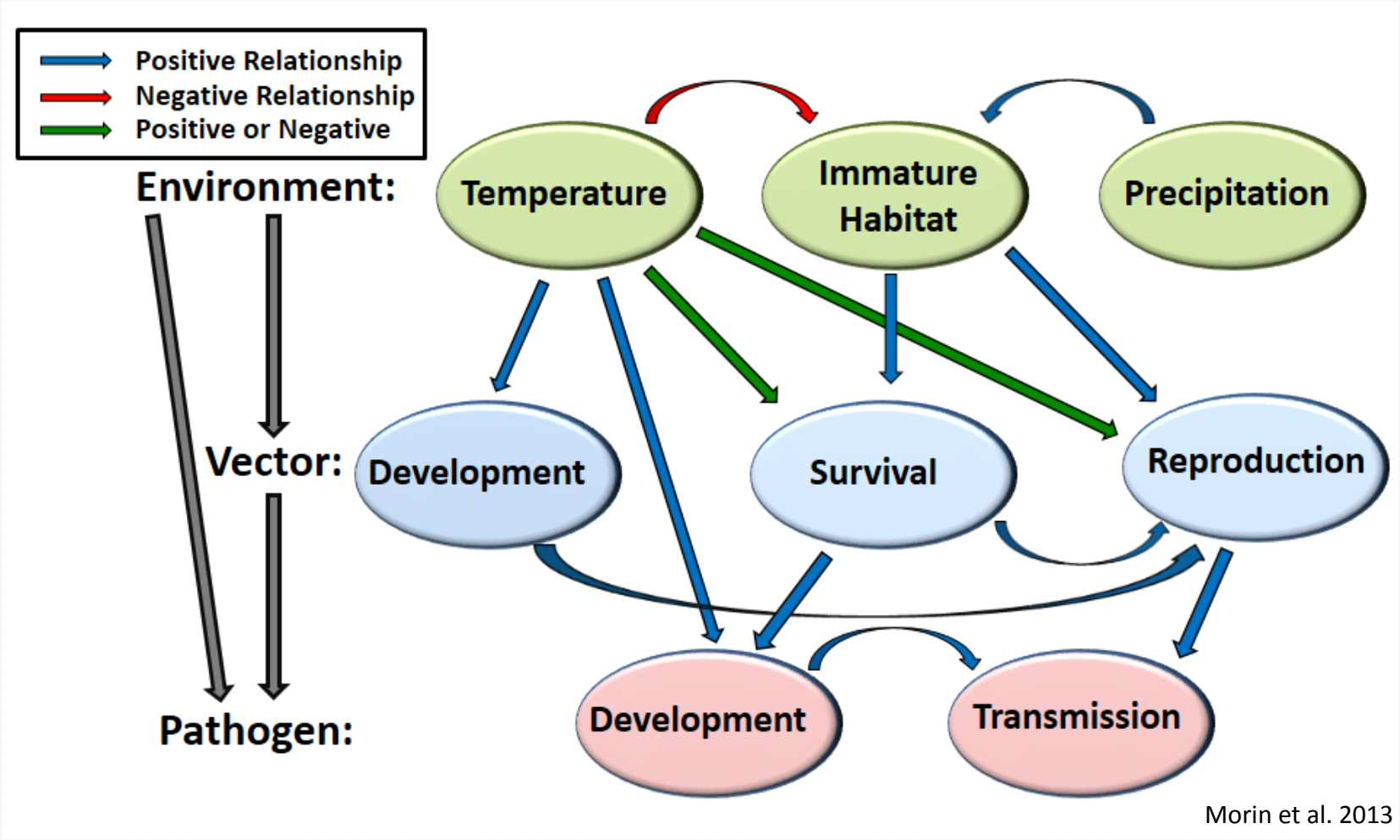
Dengue Viruses

- Annually ~ 96 million cases of symptomatic disease (WHO)
- Endogenous transmission in Texas and Florida
- Symptoms: muscle and bone ache, fever, and hemorrhagic manifestations in rare cases

Chikungunya Virus

- In 2013 first locally acquired cases reported in the Americas
- Symptoms include fever, joint pain, headaches, and rash

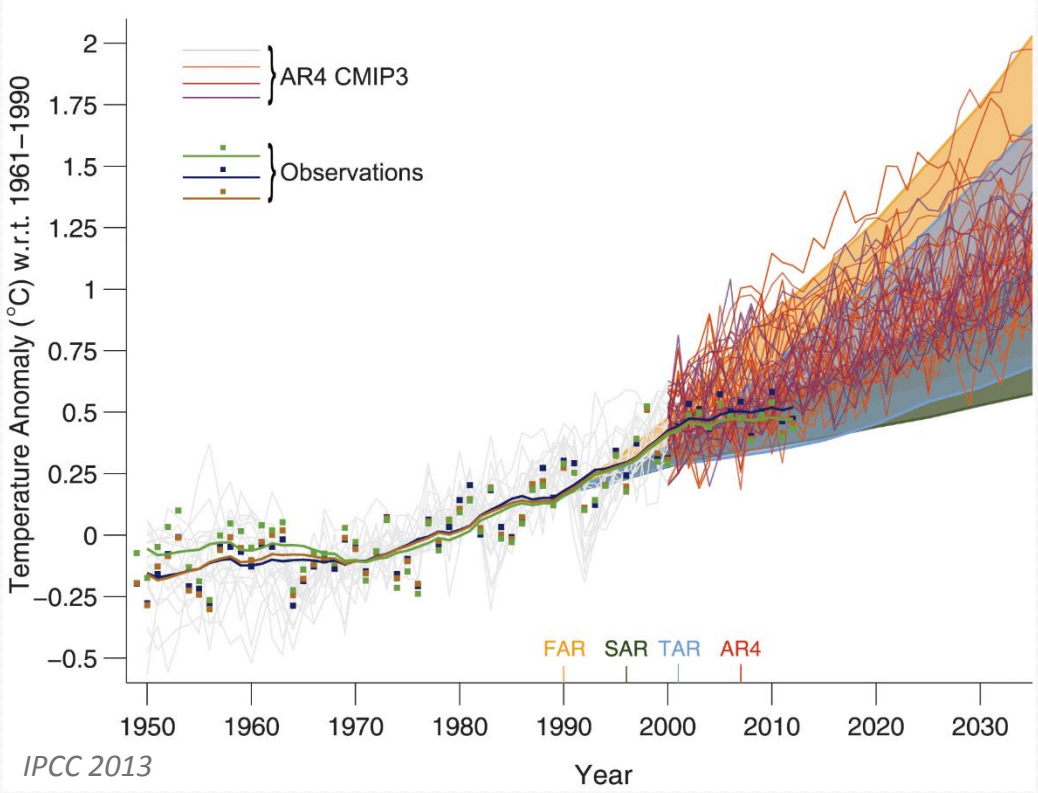
Weather/Climate Influences on Vector-borne Disease Ecology



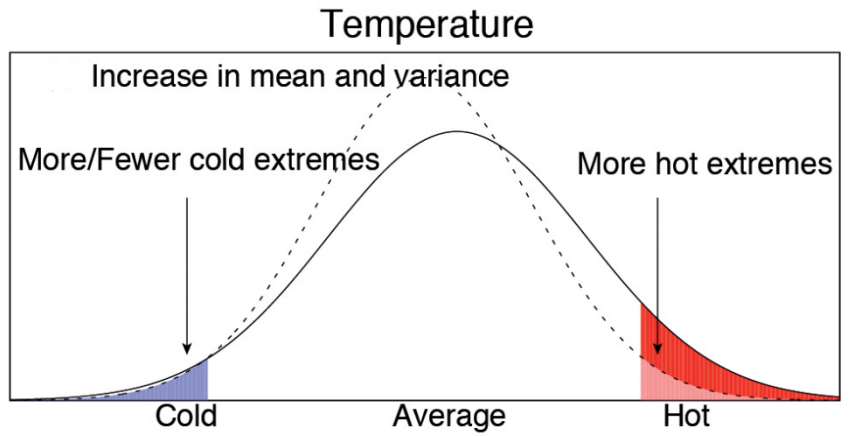
Morin et al. 2013

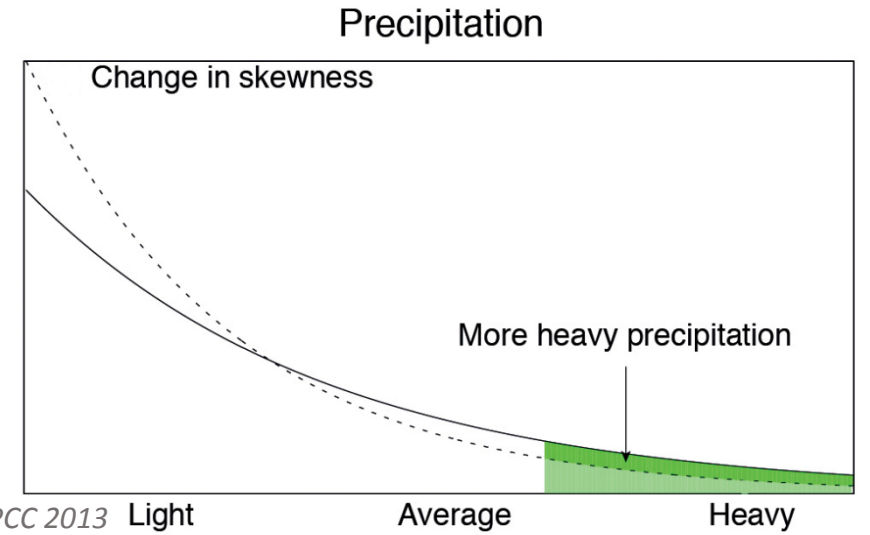
Climate Variability and Change

- Shift in mean and variance
- Increase in frequency of extreme conditions



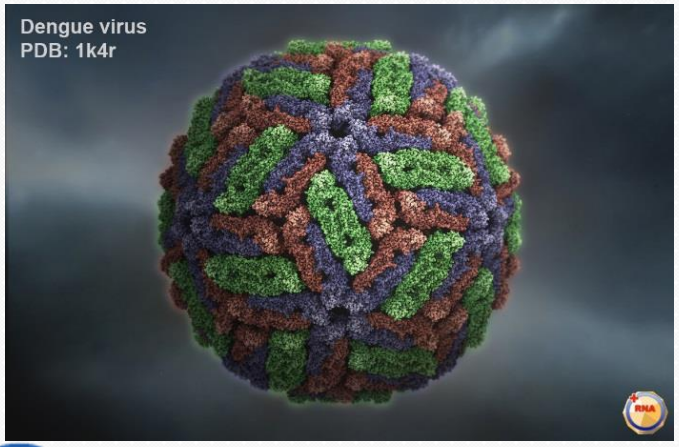
IPCC 2013





IPCC 2013

Challenges in Weather/Climate and Health Research (Vector-borne Diseases)



- Knowledge gaps
  - Vector population dynamics
  - Extrinsic Incubation Period (EIP)
  - Transmission probabilities
  - Evolution and adaption of virus and human immunity
- Reporting problems
  - Misdiagnosis
  - Subclinical cases
  - Reporting errors/bias
  - Availability of data

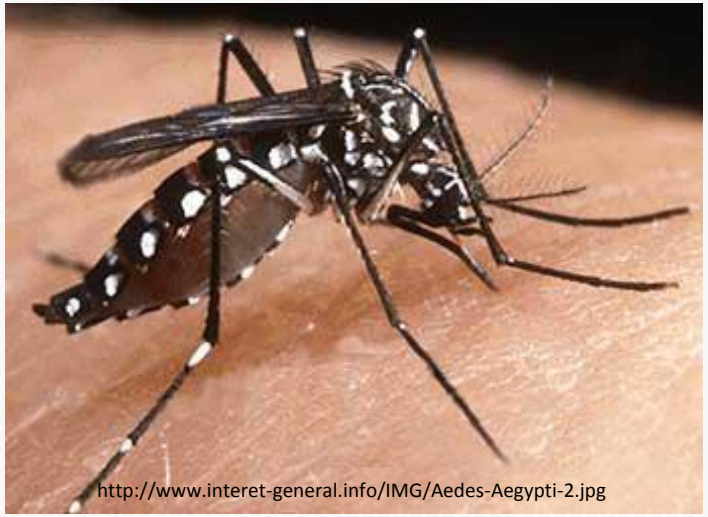
- Climate data
  - Availability/Reliability
  - Resolution
  - Predictability
- Human vs. climate influences
  - Socioeconomic status
  - Microclimatic influences
  - Human adaptions to climate

Investigating Dengue Transmission in Sonora, Mexico

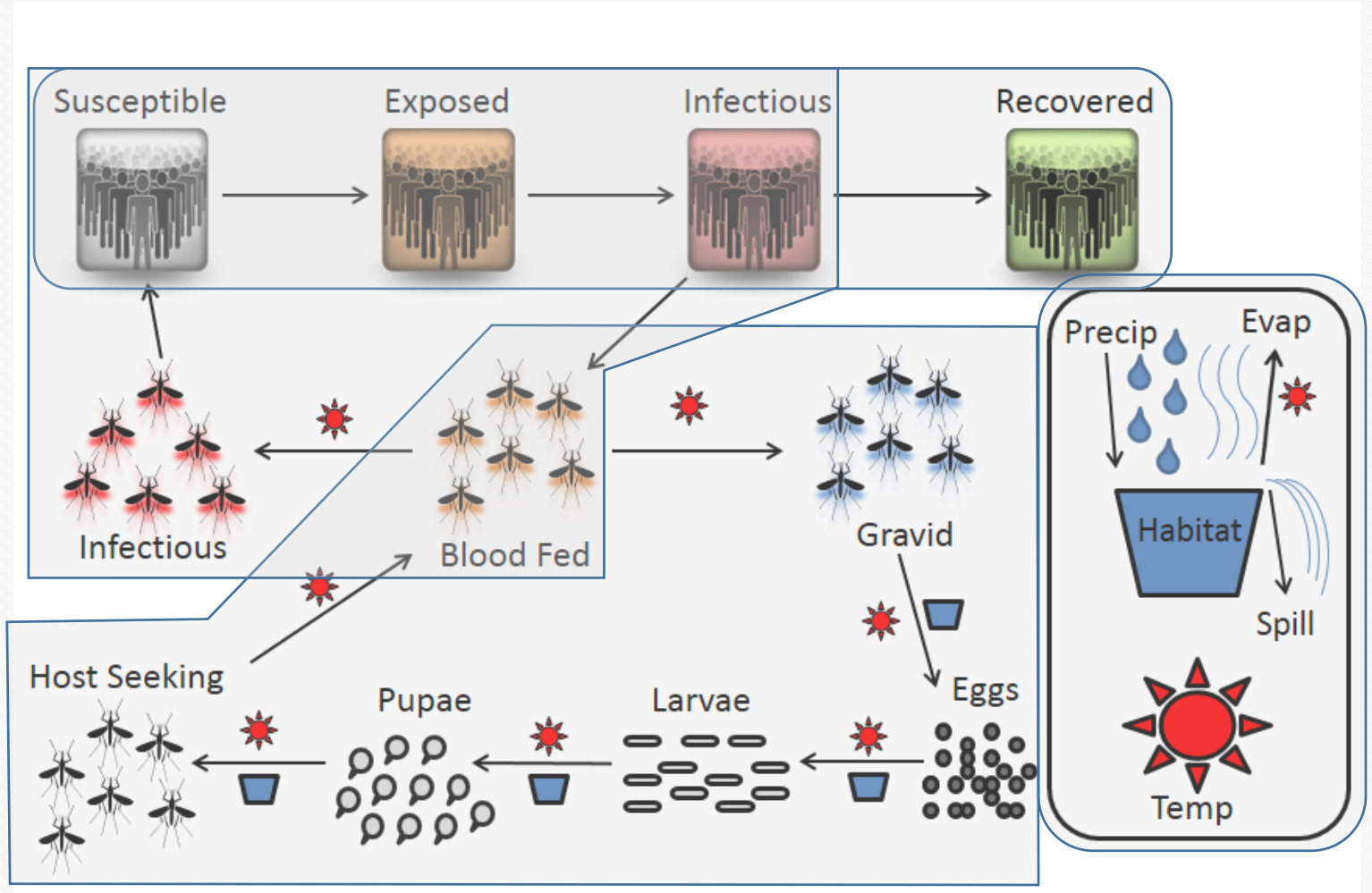
- Sonora, Mexico
  - Arid climate, monsoon precipitation
  - Seasonal/annual cycles of dengue transmission
  - Large variations in case loads between the northern and southern regions
  - Inhabited by *Aedes aegypti* mosquitoes
    - Anthropophilic, dengue vector
- Why is dengue transmission common in Hermosillo while there is little/no transmission in nearby Nogales?
- Hypothesis: Cooler temperatures in Nogales
  - Suppression of mosquito population
  - Extension of extrinsic incubation period (EIP)

Data and Methods

- Meteorological/Dengue case data
  - Daily maximum and minimum temperatures (NLDAS)
  - Daily precipitation (TRMM, NLDAS)
  - Weekly suspected dengue cases for Hermosillo, MX 2006-2011
- Dynamic Mosquito Simulation Model (DyMSiM)
  - Simulates *Aedes aegypti* population and dengue virus transmission dynamics
  - Run from 2006-2011 (500 simulations)
  - Parameterization performed using suspected dengue case data
- Experiments
  - Control: Performed simulations for Hermosillo and evaluated with reported case data
  - 1: Rerun simulations using Nogales meteorological data
  - 2: Rerun experiment 1 with 1°C warming


http://www.interet-general.info/IMG/Aedes-Aegypti-2.jpg

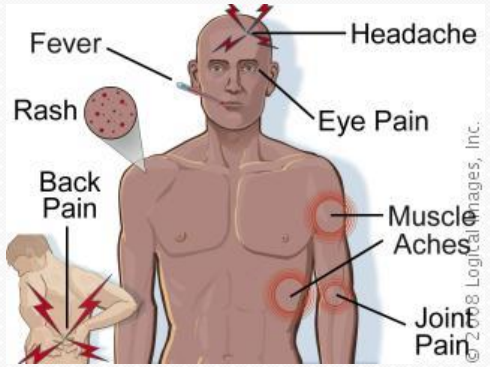
Modeling *Aedes aegypti* and Dengue Virus Ecology



Model Parameter Estimation

- Containers
  - Based on household surveys
  - Human managed and open containers
  - Used mean values and +/- 25% and 50%

Mosquitoeater.com beingalison.com

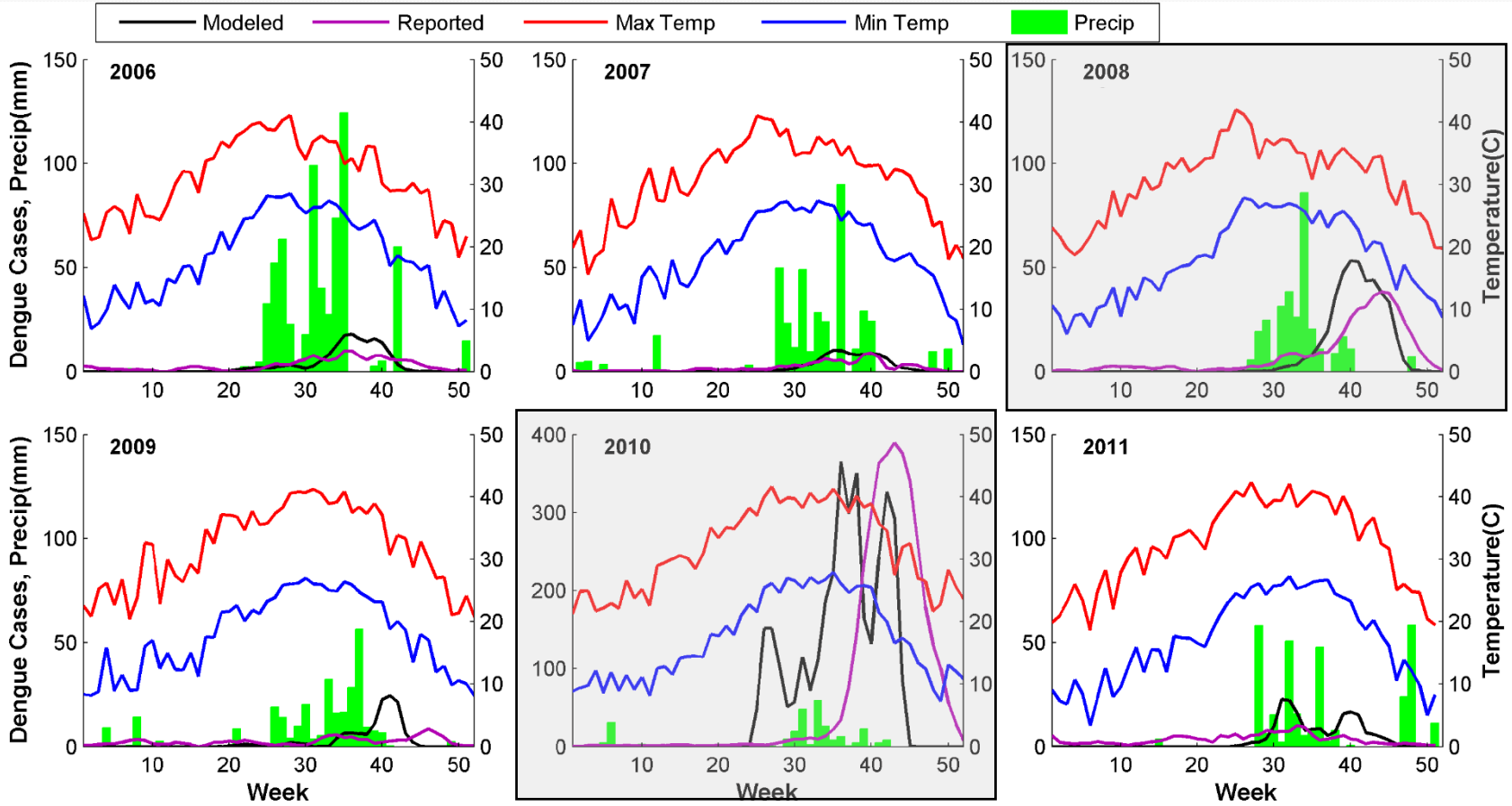


- Minimum infectious rate
  - Minimum amount of infectious humans
  - Maintains virus within the population
  - Based on case data and previous study in San Juan, PR

- Maximum larval density
  - Used to calculate density-dependent mortality
  - Based on observations, literature, and previous study in San Juan, PR

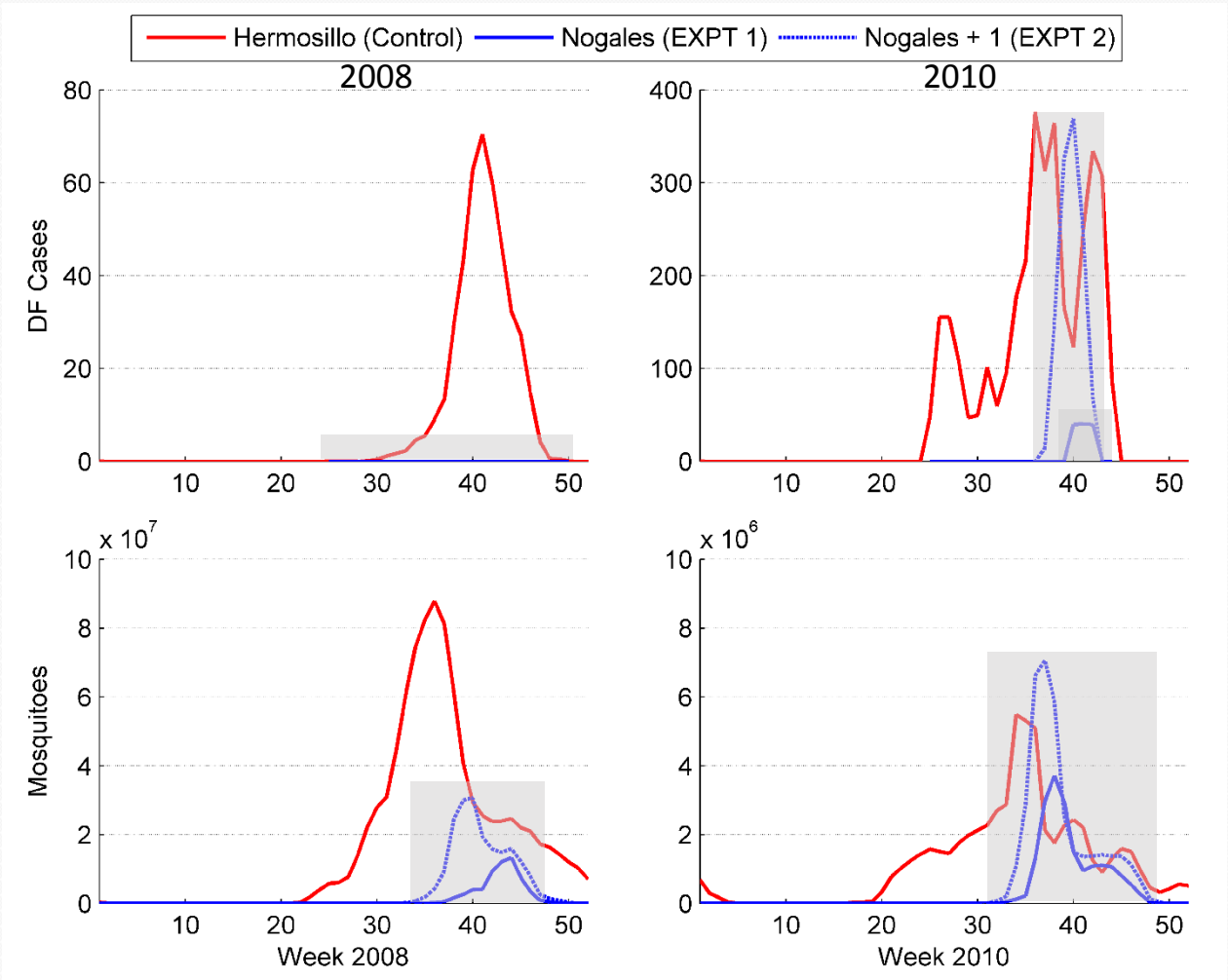
answers.yahoo.com

Control: Simulating Dengue Cases in Hermosillo



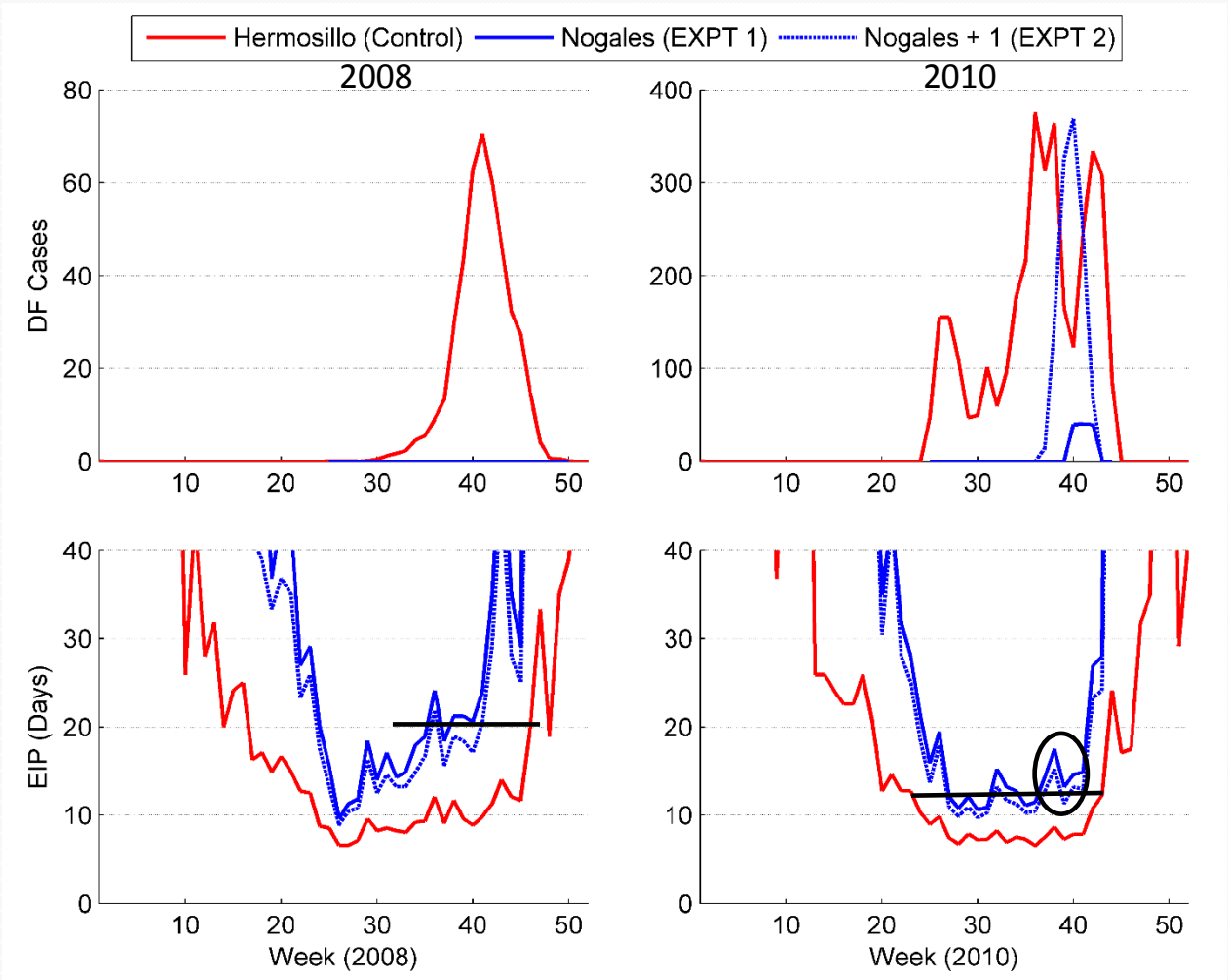
- 2008 and 2010 are largest dengue years
  - Use for Nogales comparison simulations
- Generally epidemics follow monsoon rains
- Precipitation magnitude has little influence on dengue magnitude
- Introduction from nearby areas is likely important

Experiments: Dengue Cases and Mosquitoes



- Little/no dengue is simulated under Nogales meteorological conditions
- With warming, there is a modest mosquito population increase in 2008
  - No dengue
- Warming increases the mosquito considerably population in 2010
  - Results in increased virus transmission

Experiments: Dengue Cases and EIP



- EIP is considerably longer under Nogales conditions
- Under Nogales conditions, the EIP is longer during the transmission season in 2008 compared to 2010
  - Prevents completion of EIP during mosquito lifetime
- EIP shortened under 1°C warming conditions
  - Small change produces dramatic shift in dengue fever cases

Conclusions

- Climate is an important regulator of dengue transmission in Sonora, MX
  - Precipitation influences the timing but not magnitude of dengue epidemics
  - Temperature influences mosquito population dynamics and the virus EIP
    - Small changes in temperature can have significant impacts on transmission
  - Year to year climate variability is important especially along fringe regions
    - Difference in dengue transmission suitability in Nogales between 2008 and 2010

- Dengue transmission dynamics in northern Mexico may affect dengue risk in the United States
  - Travel, climate change
  - Recent dengue epidemic in Nogales

Thank You for Your Attention!

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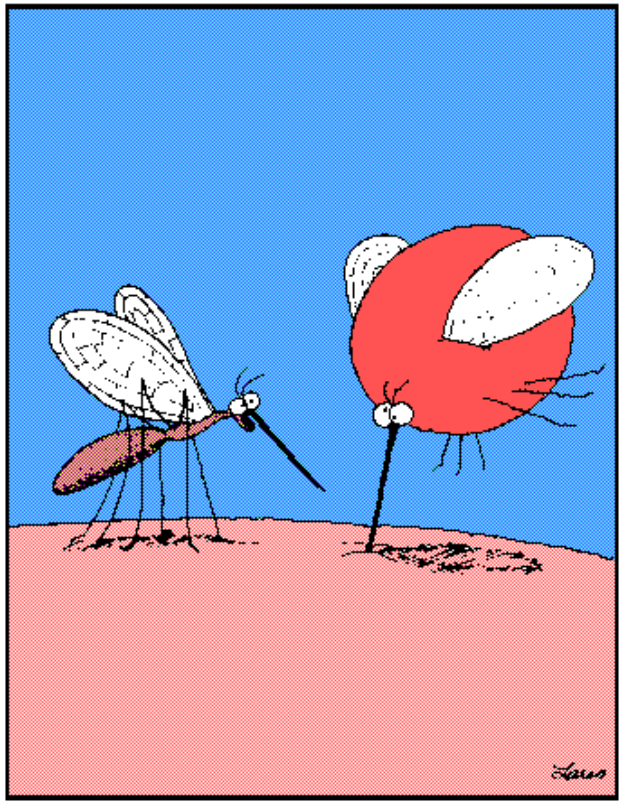

"Pull out, Betty! Pull out! ... You've hit an artery!"