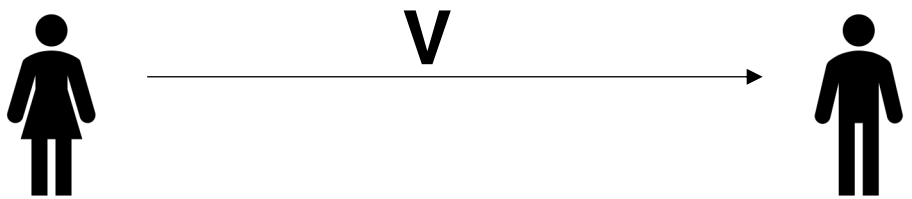
Introduction to Traits

- Define a “trait”
- Understand the role of traits (and their variation) in VBDs
- Discuss how traits can be incorporated into VBD predictions

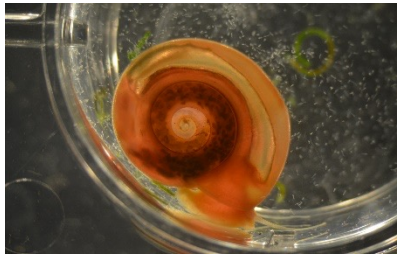
What is a vector?

- any agent which carries and transmits an infectious agent between hosts



What kinds of animals are vectors?

- Many!



Snails!

Tabanid Fly

Ticks

Mosquitoes

Midges

Assassin Bugs

Lice

White Fly

Glassy Winged Sharpshooter

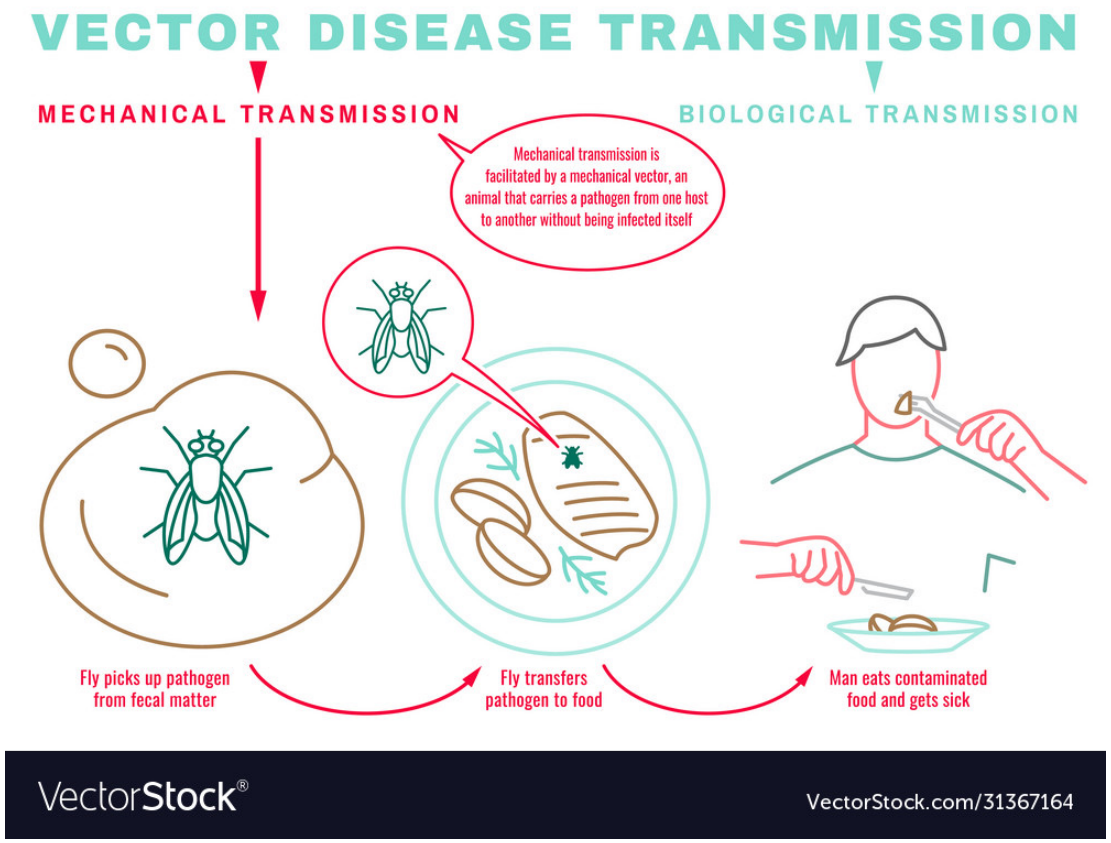
Aphids

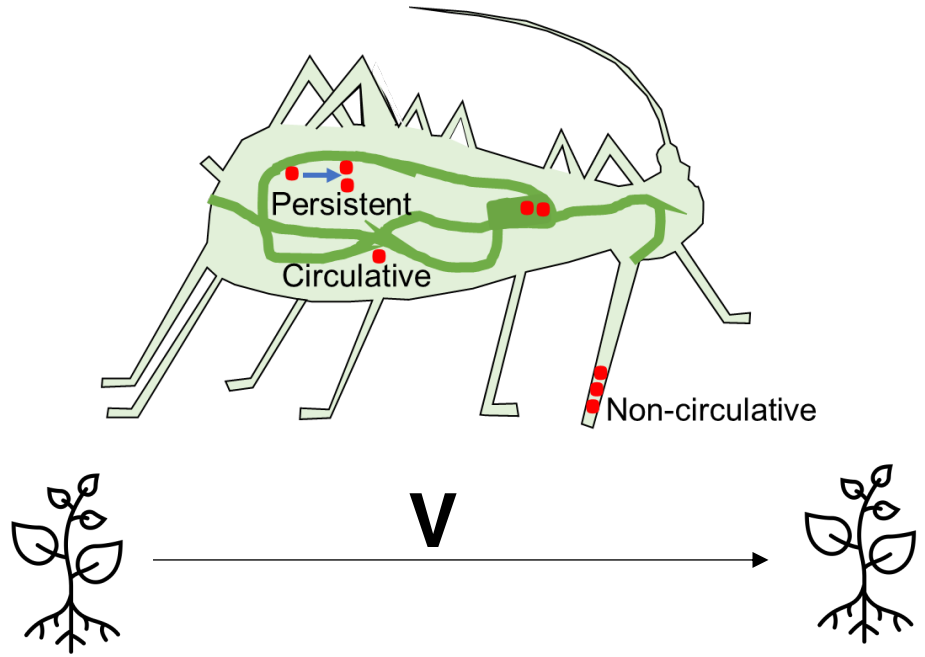
Mealybugs

Sawyer beetles

Overview of VBD Transmission

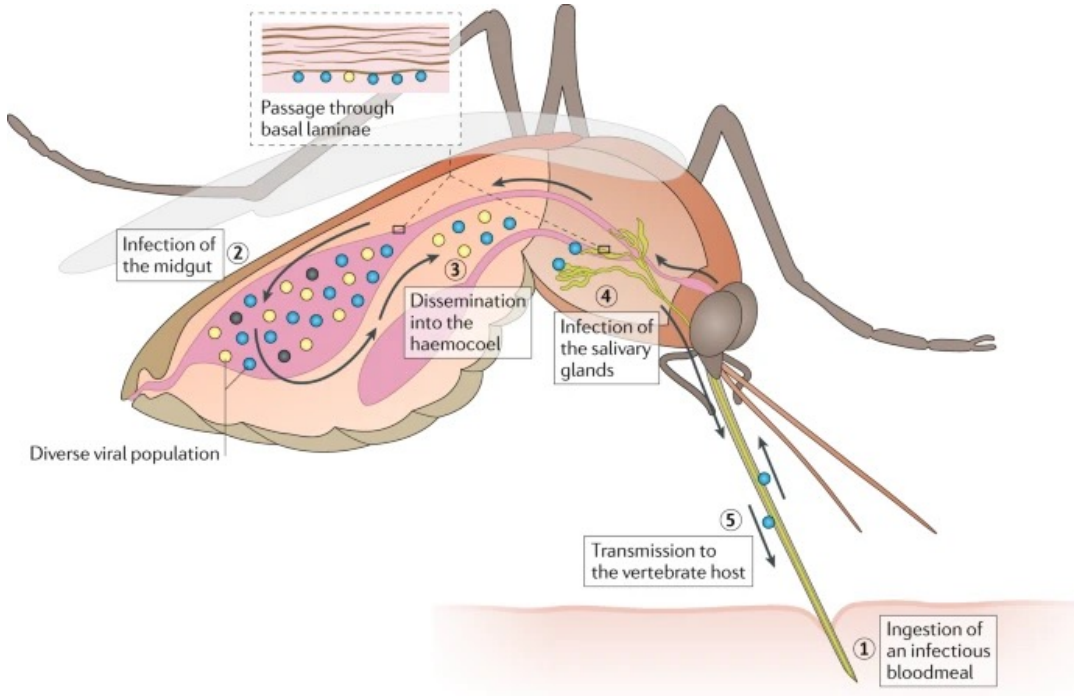
- Mechanical transmission



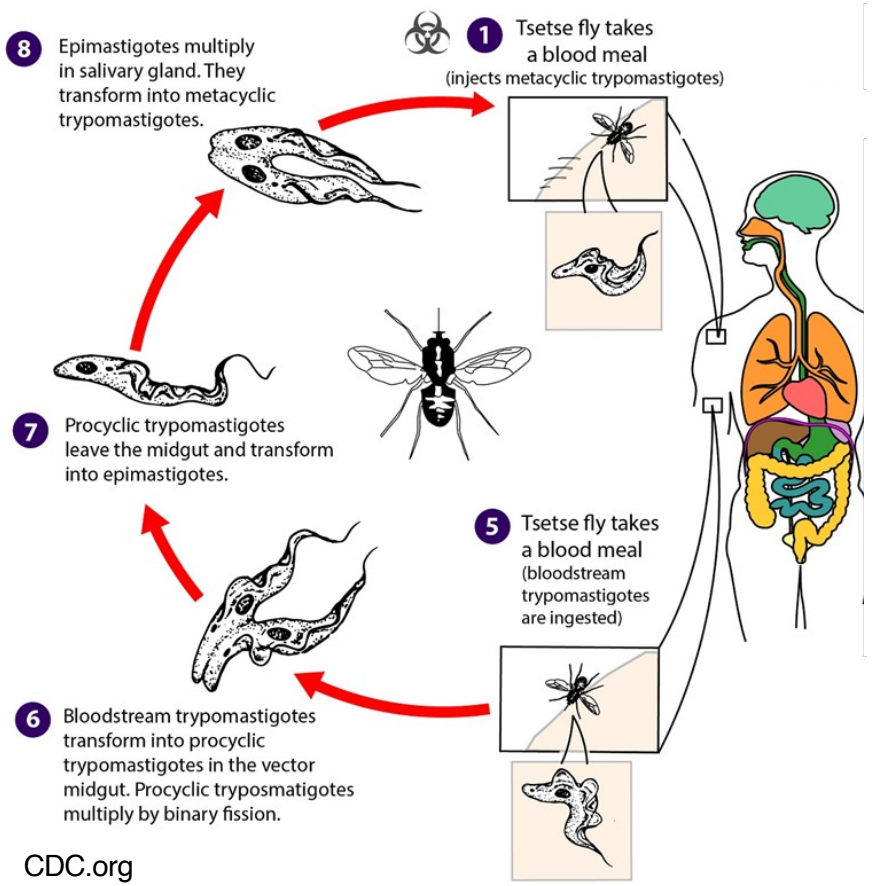


Overview of VBD Transmission

- Biological transmission

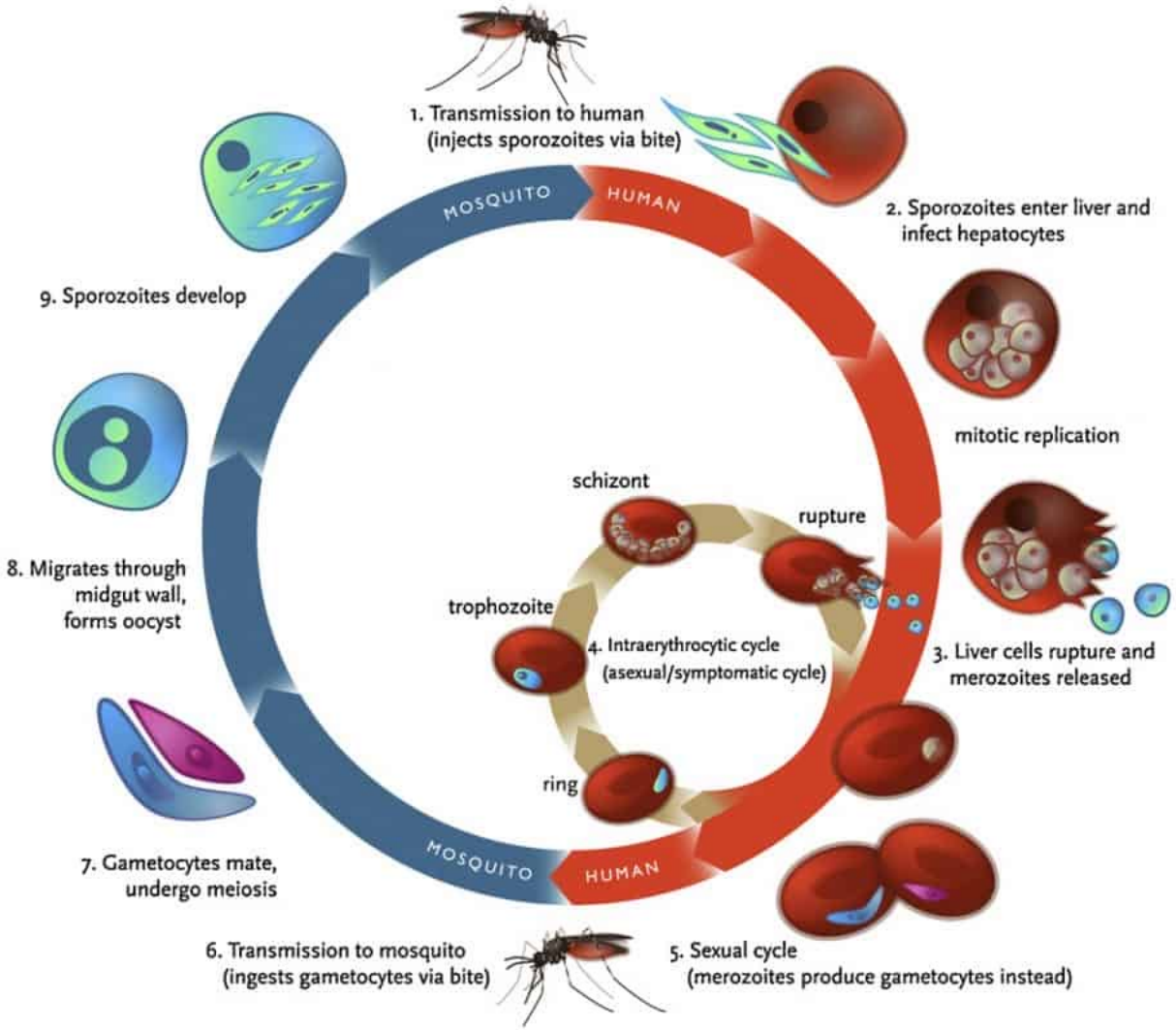


Weaver et al. 2021 *Nature Reviews Microbiology*



CDC.org

Life Cycle of the Malaria Parasite



Source: Klein EY. Antimalarial drug resistance: a review of the biology and strategies to delay emergence and spread. Int J Antimicrob Agents (2013), http://dx.doi.org/10.1016/j.ijantimicag.2012.12.007

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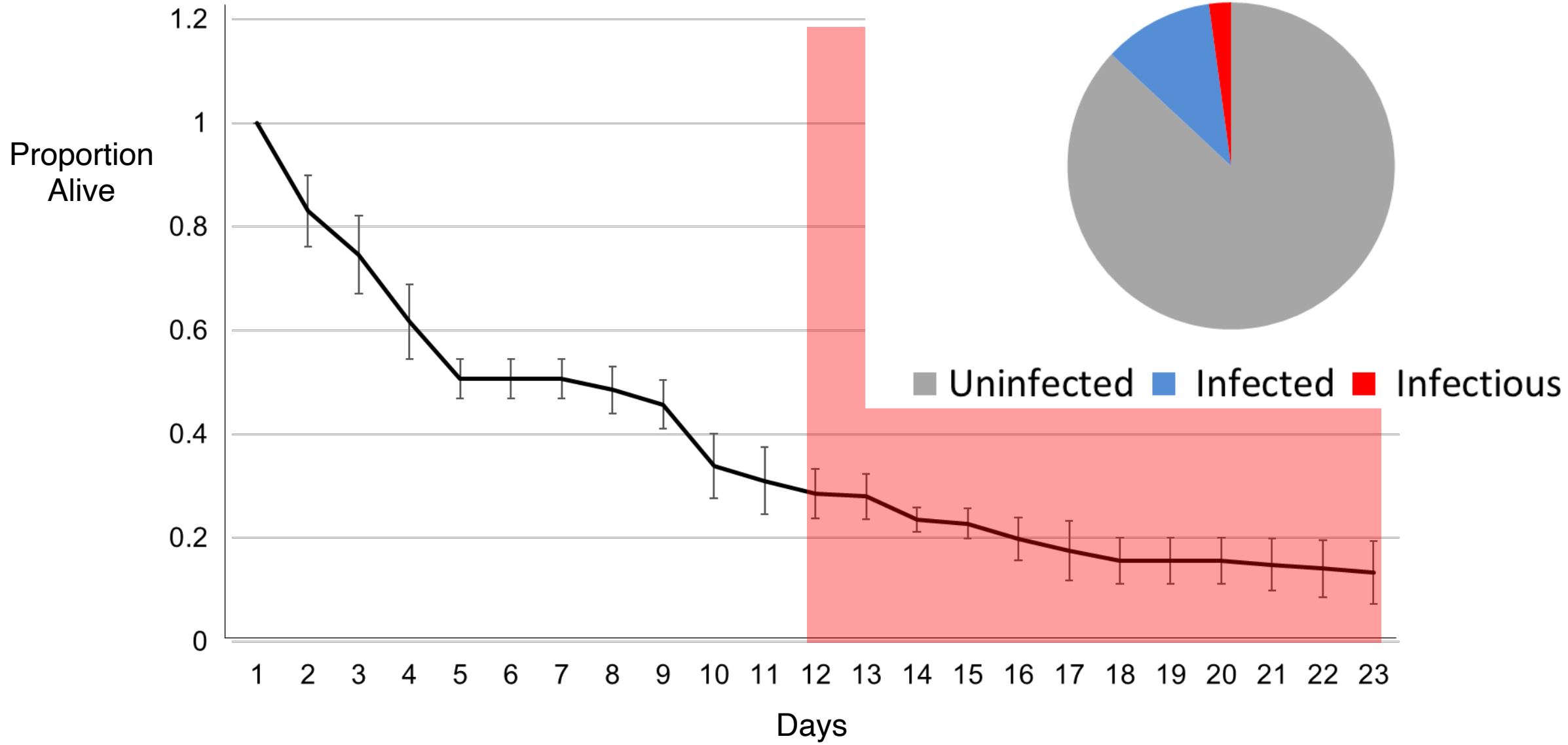
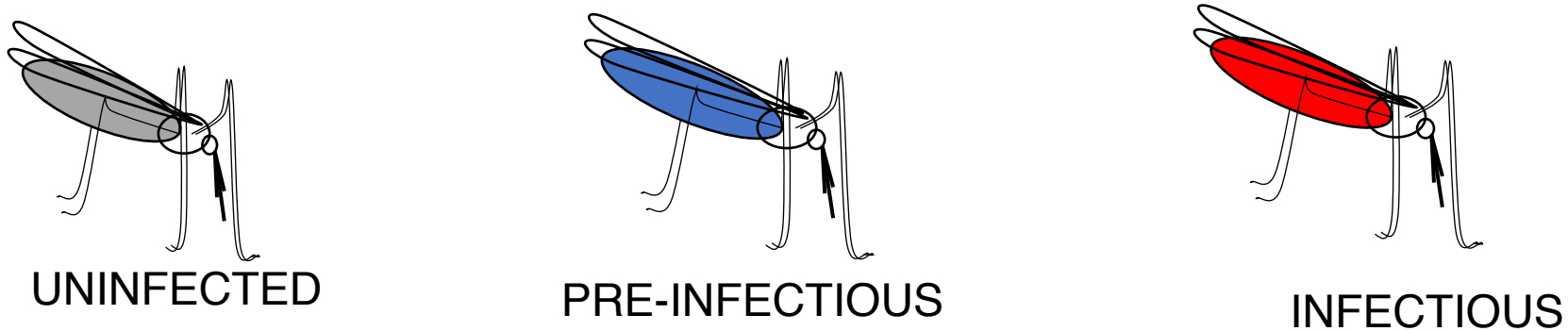
Overview of VBD Transmission- Survival

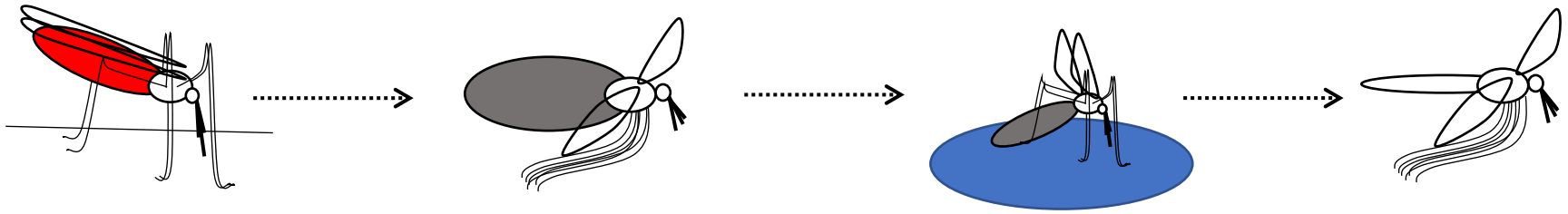


Ohm et al. 2016

Pathogens undergo obligate development in the mosquito

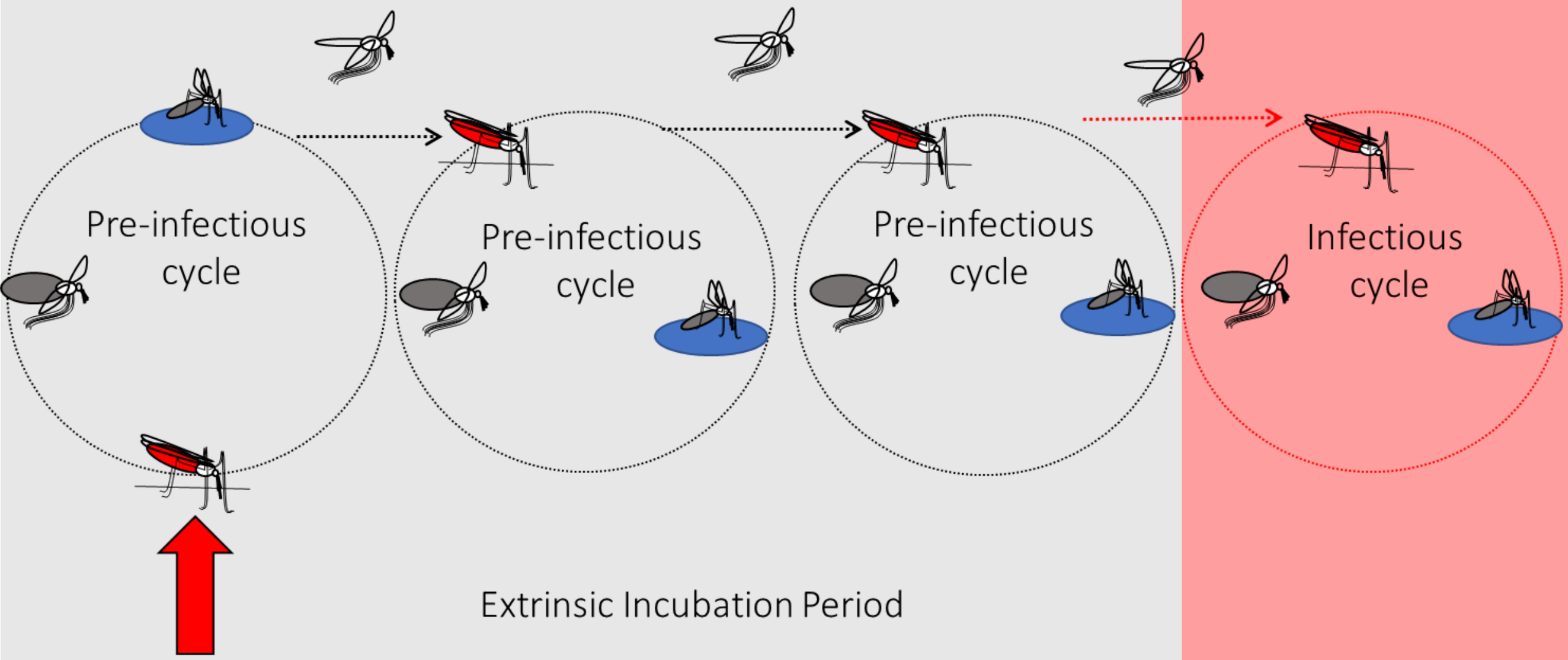


Extrinsic Incubation Period
(EIP)
Malaria: 10-12 Days
Dengue: 3-10 Days

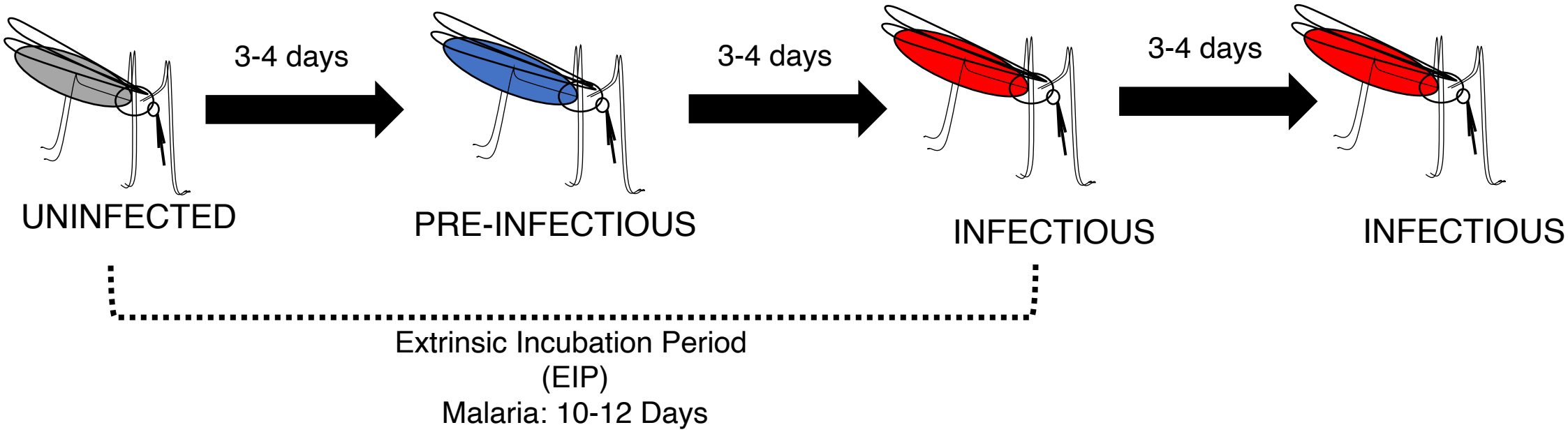


Gonotrophic Cycle
3-4 Days

Transmission is at the intersection of two cycles:

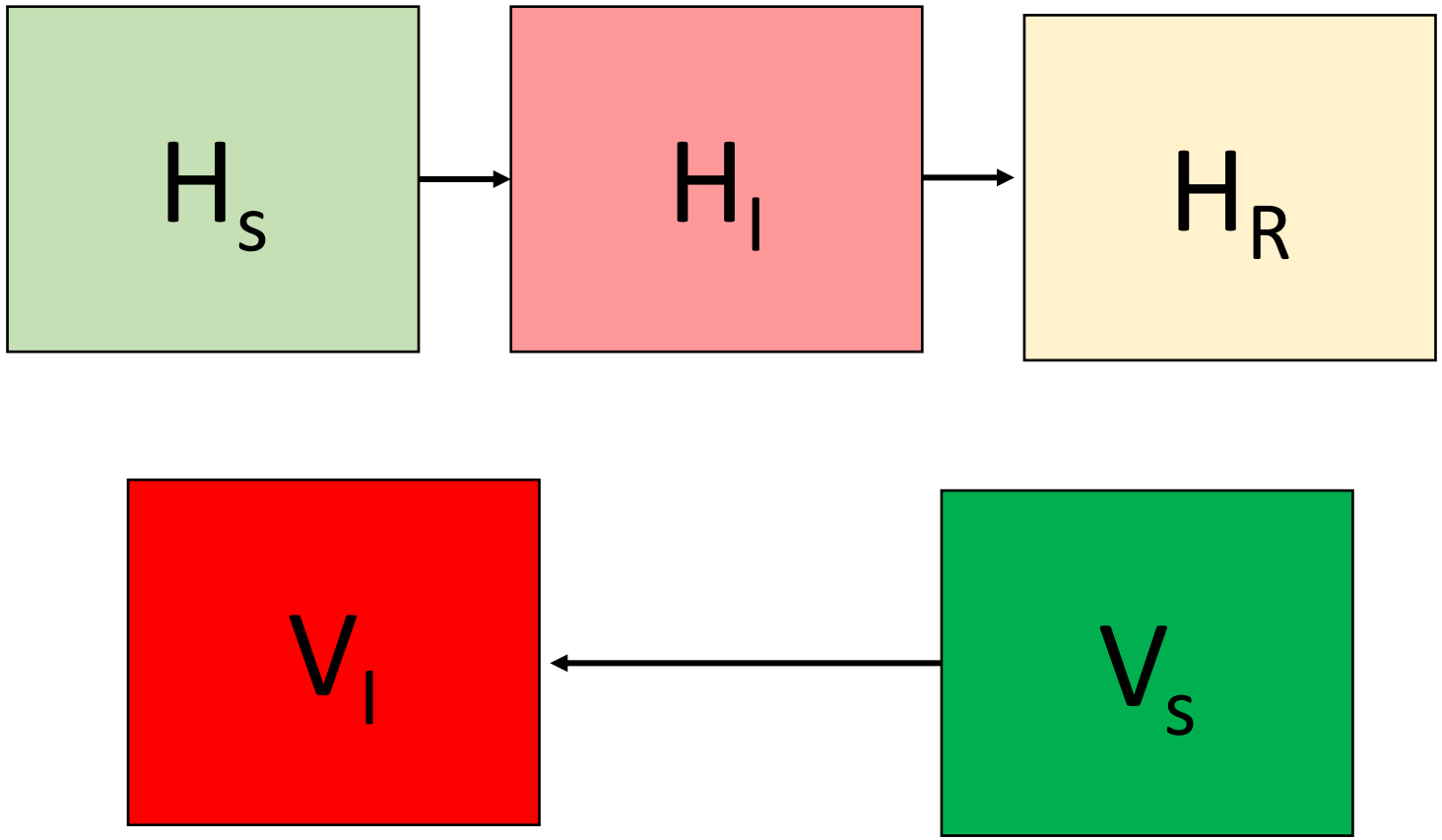


Overview of VBD Transmission



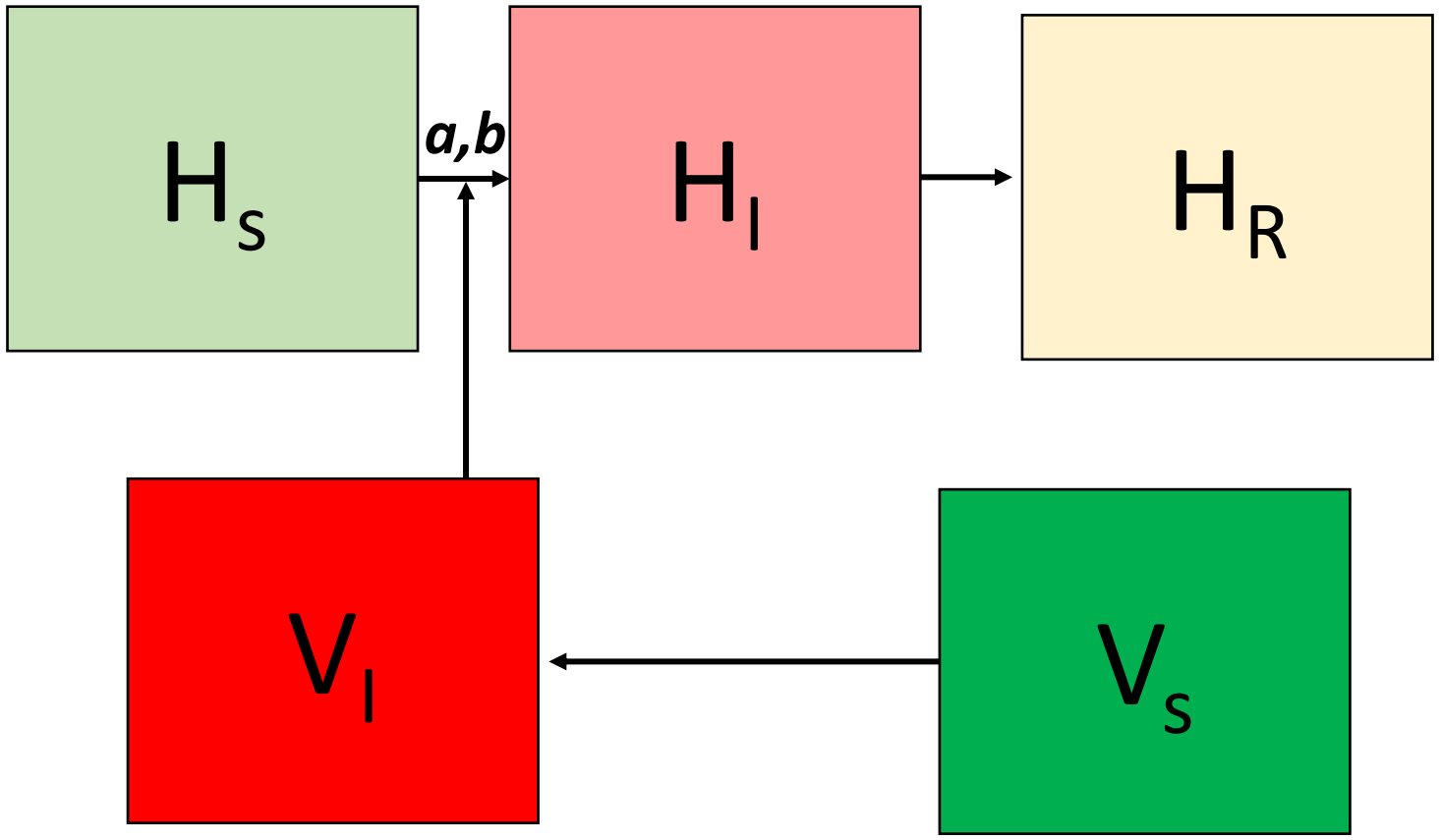
What are the elements we need to include?

Vector-borne Disease Modelling



H= Host, V=Vector $_s$=susceptible, $_I$=infected, $_r$=recovered,

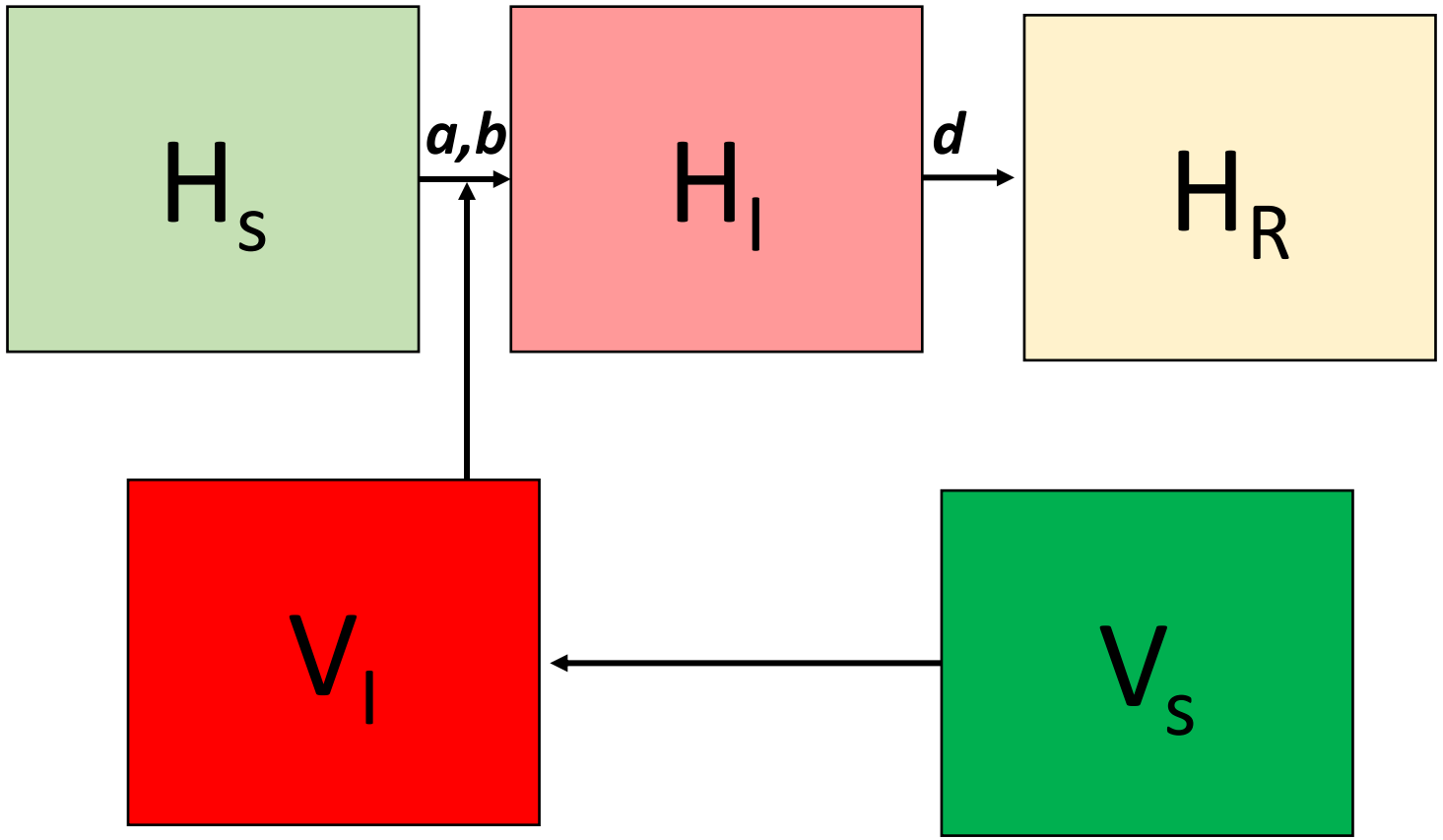
Vector-borne Disease Modelling



H= Host, V=Vector $_s$=susceptible, $_I$=infected, $_r$=recovered, $_e$=exposed

a= per-vector biting rate, *b*=vector->host transmission success (proportion of bites)

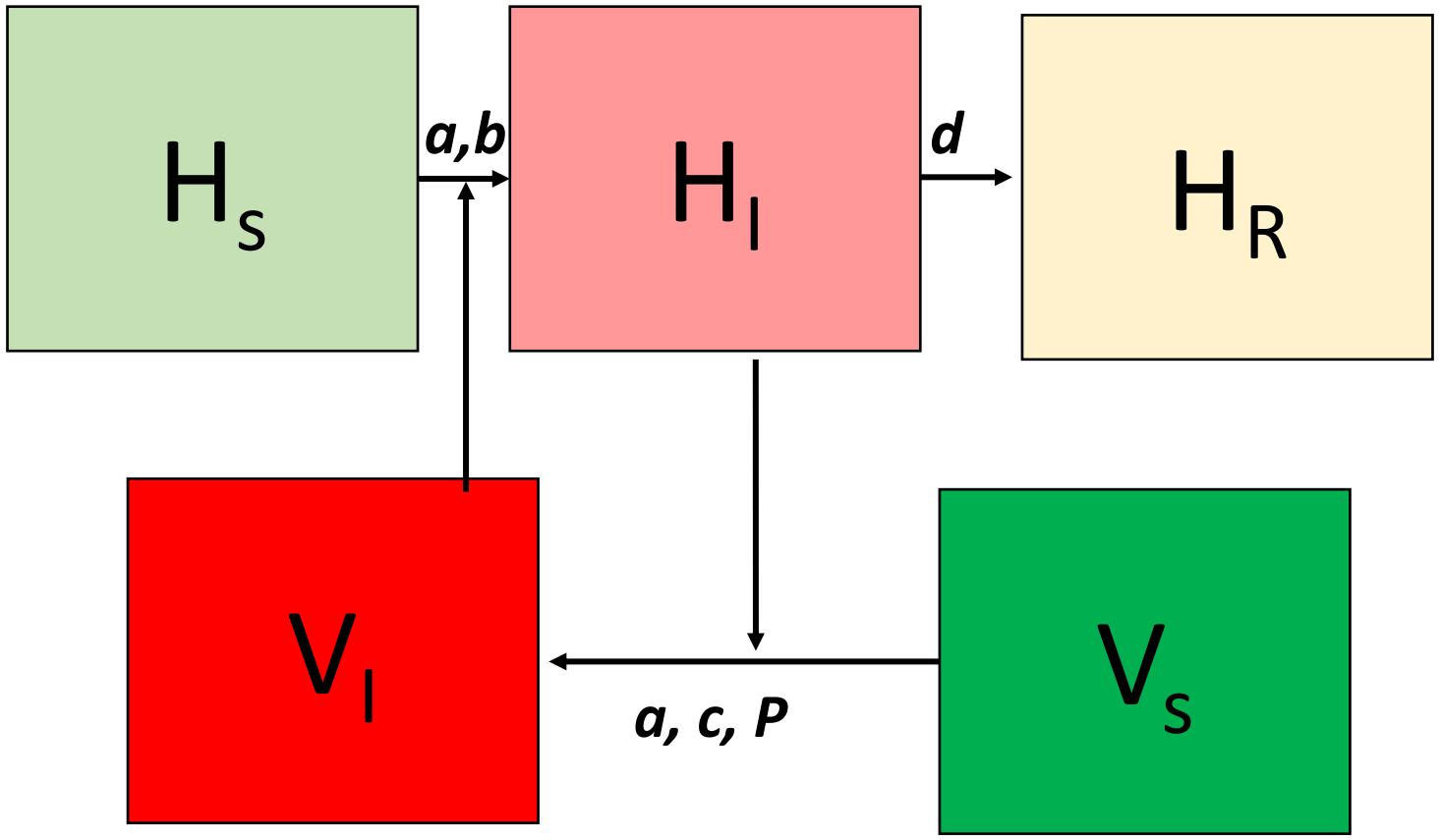
Vector-borne Disease Modelling



H= Host, V=Vector $_s$=susceptible, $_I$=infected, $_r$=recovered, $_e$=exposed

a= per-vector biting rate, *b*=vector->host transmission success (proportion of bites), *d*=recovery

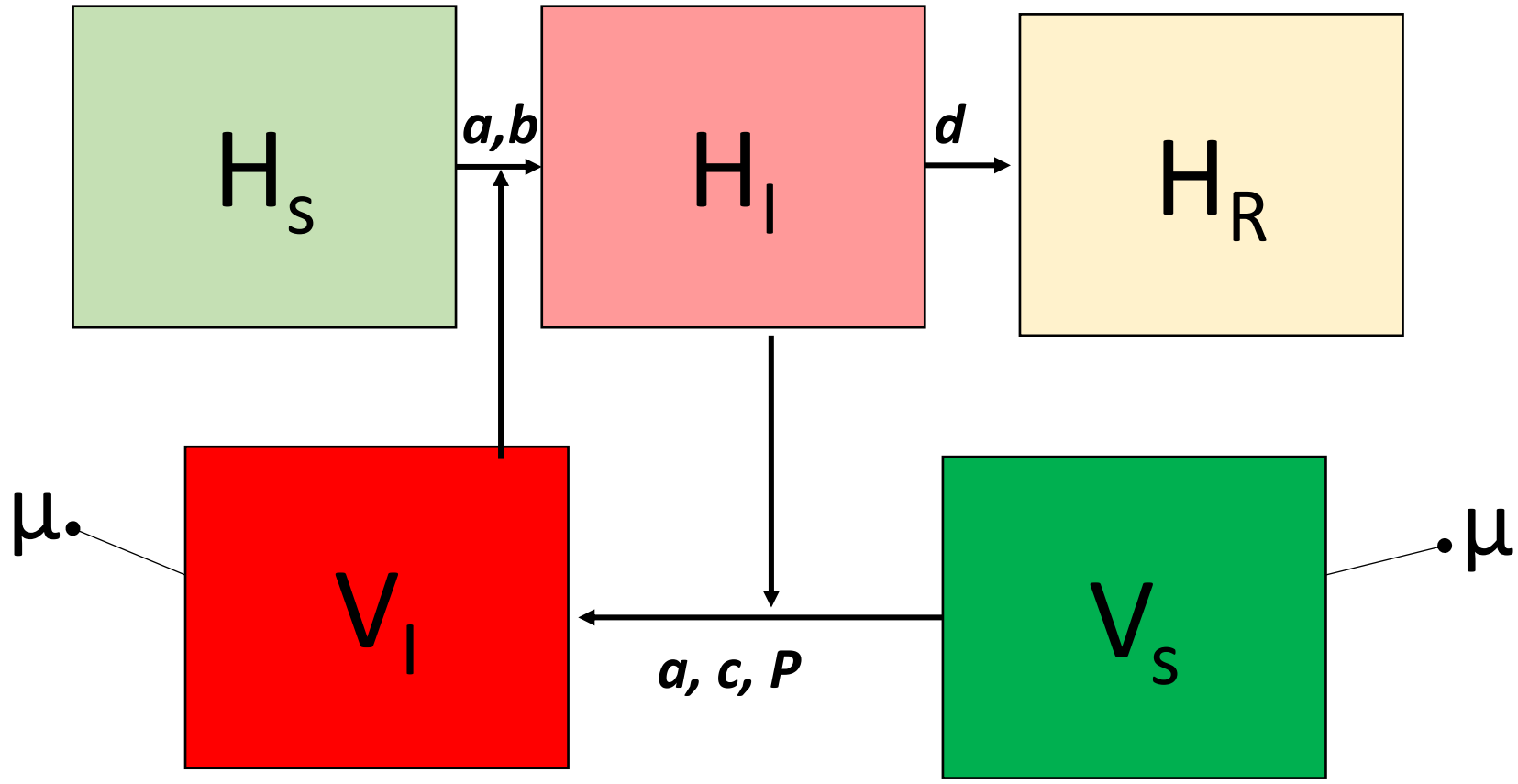
Vector-borne Disease Modelling



H= Host, V=Vector $_s$=susceptible, $_I$=infected, $_r$=recovered, $_e$=exposed

a= per-vector biting rate, *b*=vector->host transmission success (proportion of bites), *c*= host-> vector transmission success (proportion of bites), *d*=recovery, rate, *P*= extrinsic incubation period

Vector-borne Disease Modelling



H= Host, V=Vector $_s$=susceptible, $_I$=infected, $_r$=recovered, $_e$=exposed, *a*= per-vector biting rate, *b*=vector->host transmission success (proportion of bites), *c*= host-> vector transmission success (proportion of bites), *d*=recovery, rate, *P*= extrinsic incubation period, μ= adult vector mortality rate

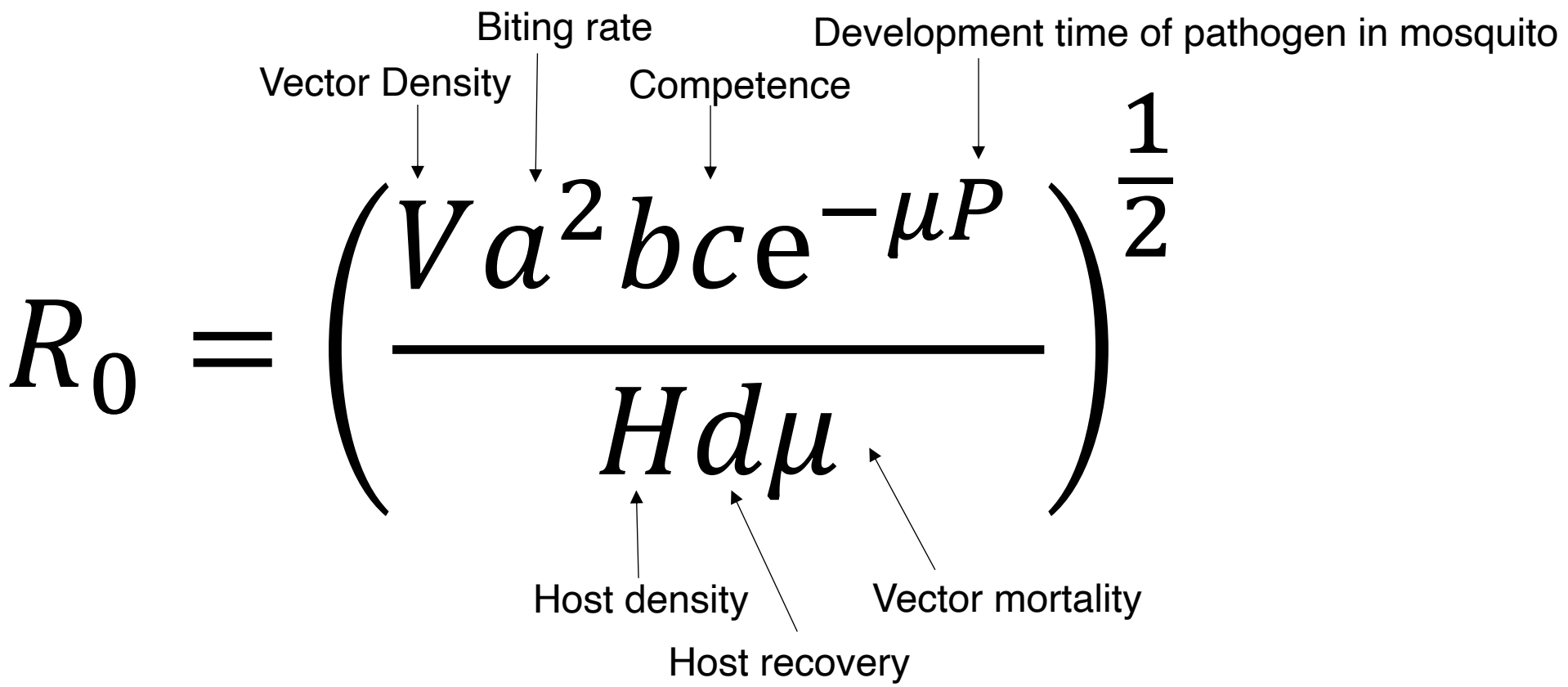
R_0 for a Directly-Transmitted Pathogen

$$R_0 = \beta N D$$

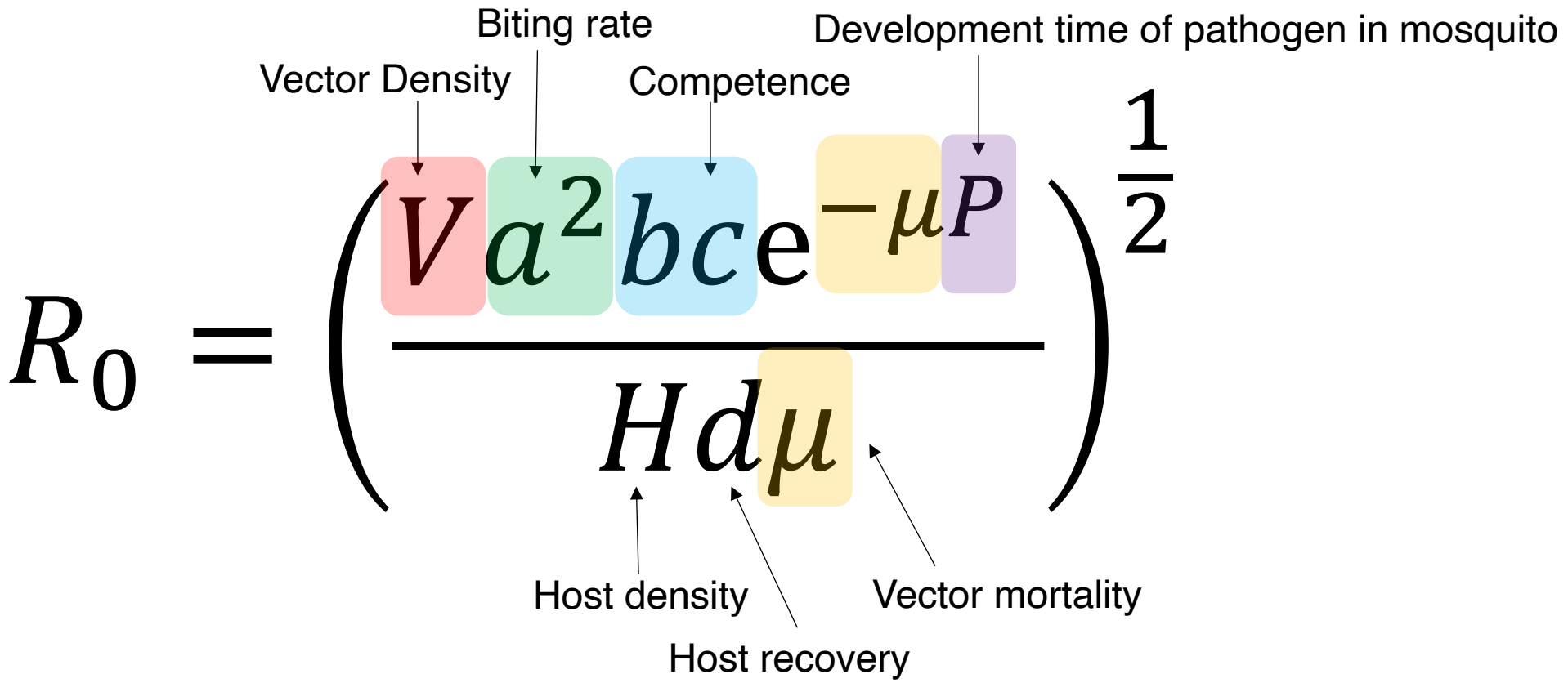
- β: Rate at which individuals come into effective contact per unit time
- N: Population size
- D: Duration of infectiousness

The higher the contact rate, population size, and infectious period the greater the R0.

R_0 for a Vector-Borne Disease



R_0 for a Vector-Borne Disease



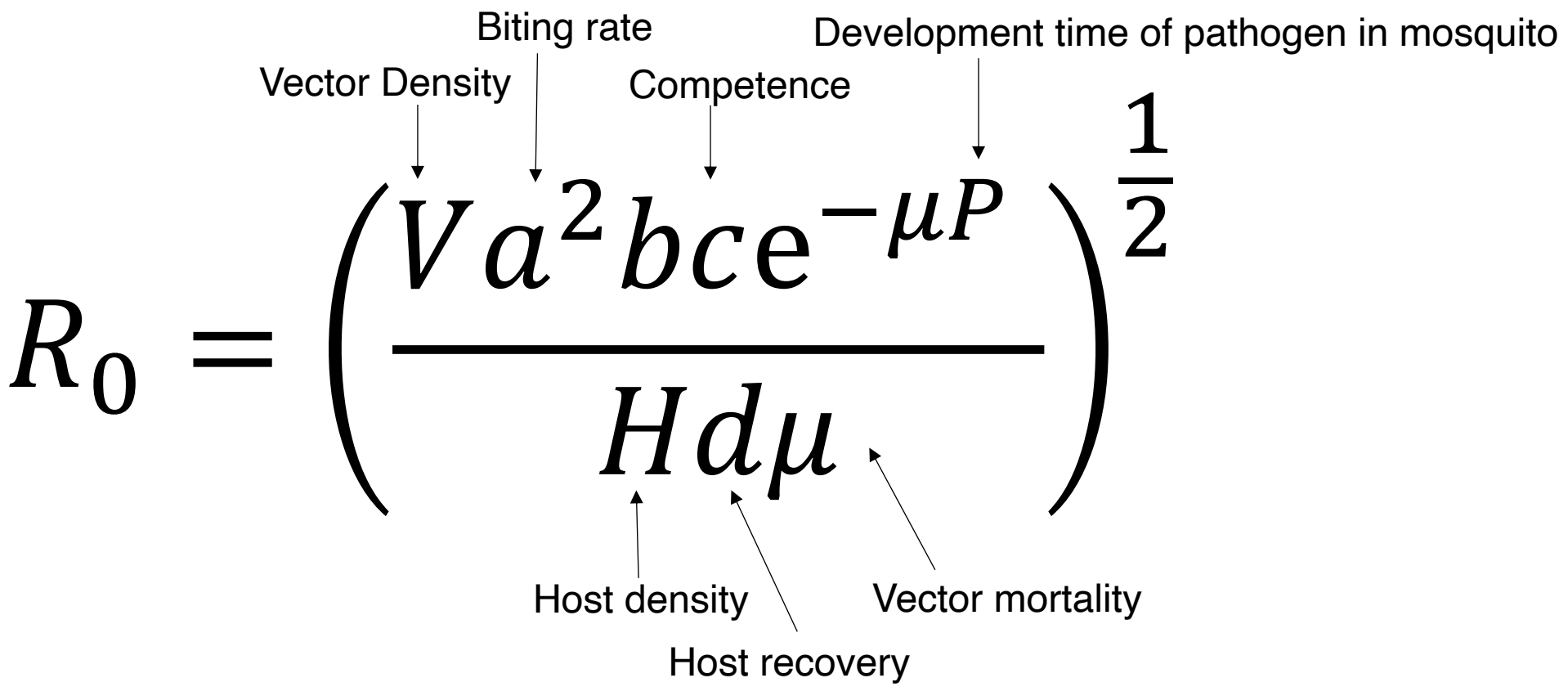
Trait

any measurable feature of an individual organism

Functional trait

feeding rate, size, metabolic rate, eggs per day

R_0 for a Vector-Borne Disease



The Combined Effects of Bacterial Symbionts and Aging on Life History Traits in the Pea Aphid, *Acyrthosiphon pisum*

Alice M. Laughton,[a,b] Maretta H. Fan,[a] Nicole M. Gerardo[a]

Stage-Structured Infection Transmission and a Spatial Epidemic: A Model for Lyme Disease

Thomas Caraco,[1,*] Stephan Glavanakov,[1] Gang Chen,[2] Joseph E. Flaherty,[2] Toshiro K. Ohsumi,[2] and Boleslaw K. Szymanski[2]

Plant viruses alter insect behavior to enhance their spread

Laura L. Ingwell, Sanford D. Eigenbrode & Nilsa A. Bosque-Pérez

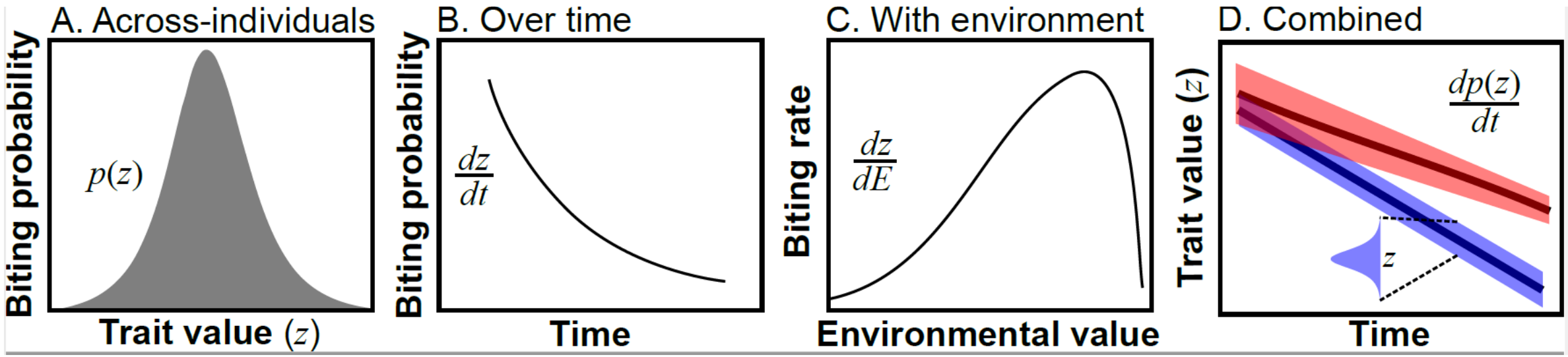
Blood-Feeding Behavior of Vesicular Stomatitis Virus Infected *Culicoides sonorensis* (Diptera: Ceratopogonidae)

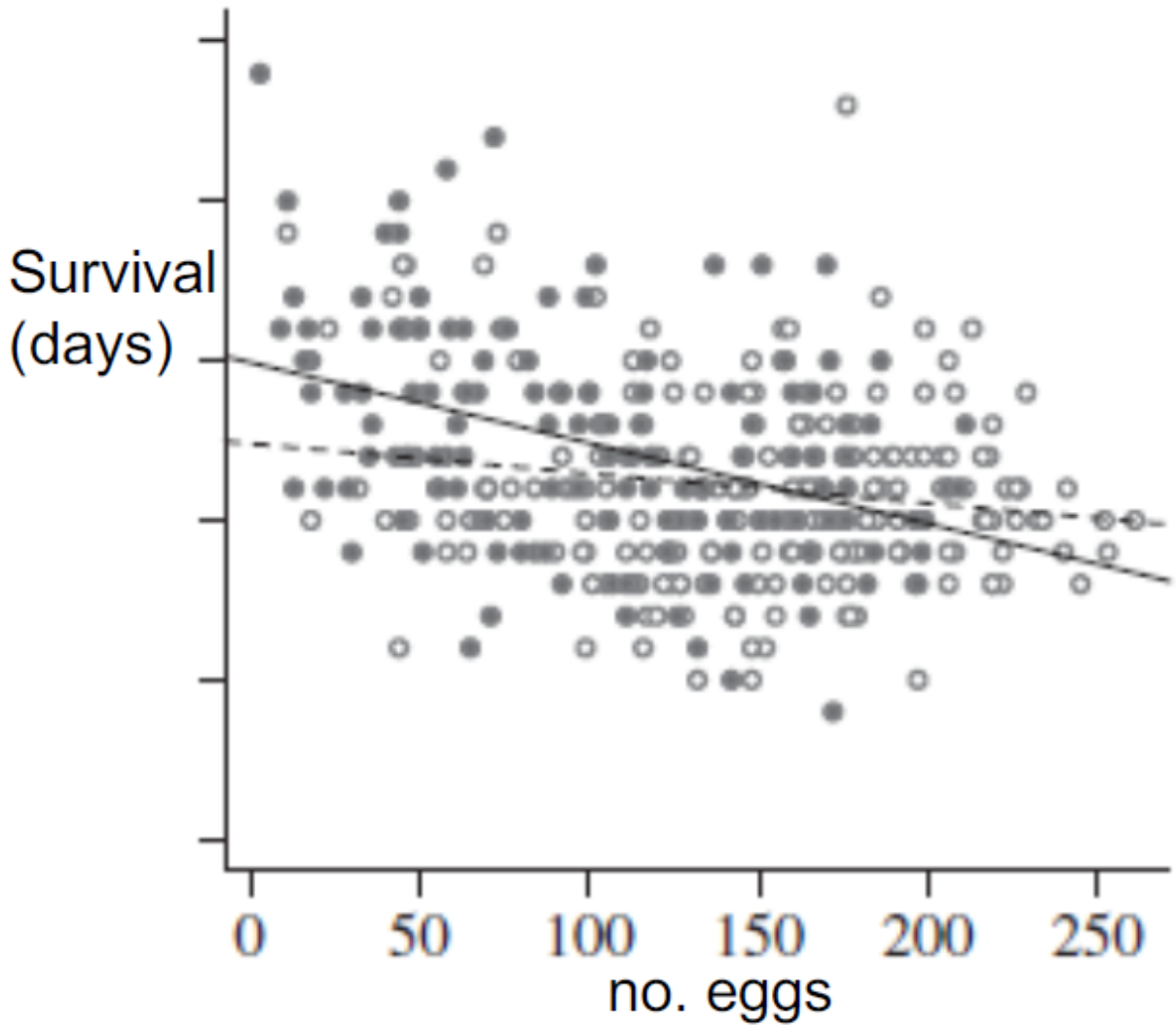
KRISTINE E. BENNETT,[1,2] JESSICA E. HOPPER,[1] MELISSA A. STUART,[1] MARK WEST,[3] AND BARBARA S. DROLET[1]

MARCH, 1986 J. AM. MOSQ. CONTROL ASSOC. 61

THE SIZE OF EMERGING AND HOST-SEEKING *AEDES AEGYPTI* AND THE RELATION OF SIZE TO BLOOD-FEEDING SUCCESS IN THE FIELD[1]

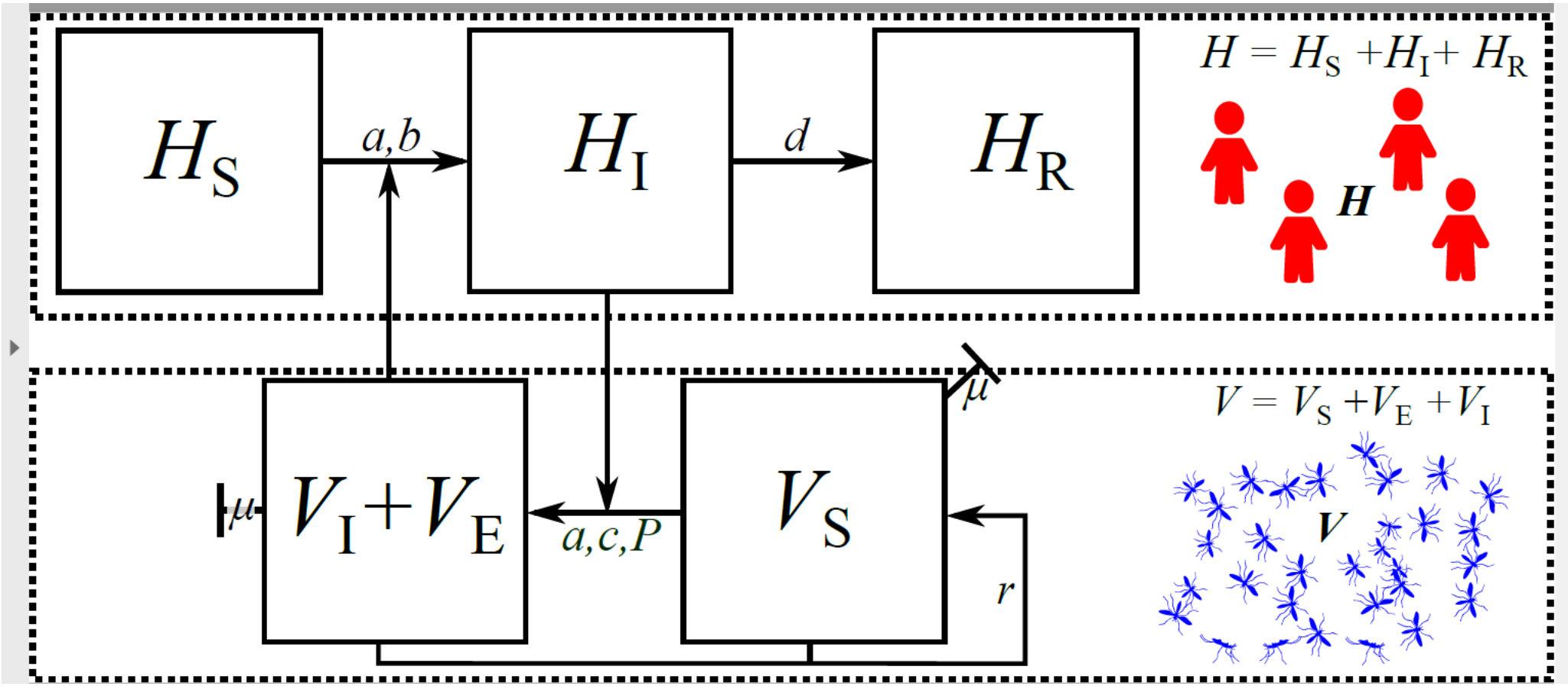
ROGER S. NASCI
Department of Biological and Environmental Sciences, McNeese State University, Lake Charles, LA 70609

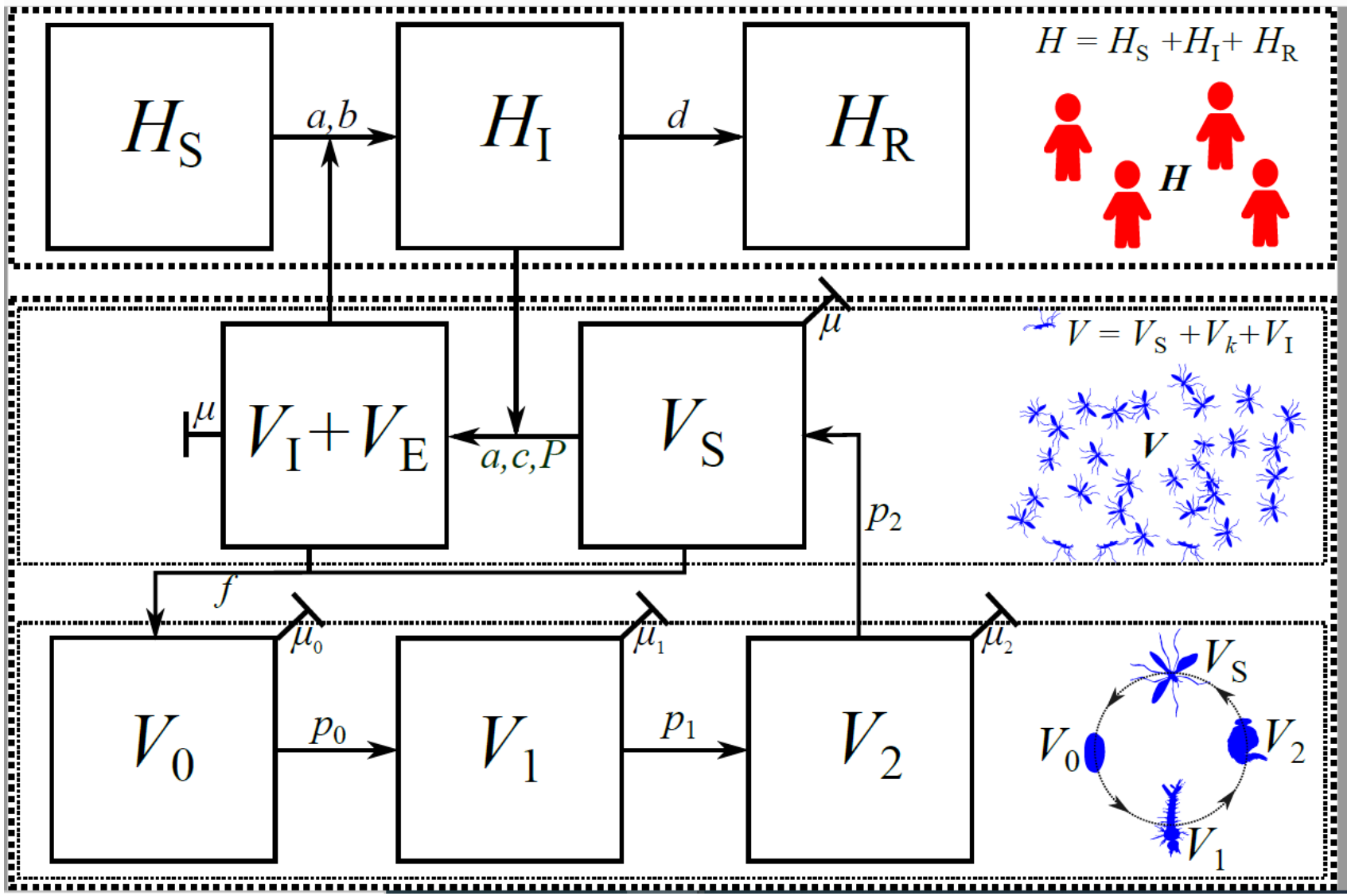

A. Across-individuals
Biting probability
p(z)
Trait value (z)
B. Over time
Biting probability
dz/dt
Time
C. With environment
Biting rate
dz/dE
Environmental value
D. Combined
Trait value (z)
dp(z)/dt
z
Time

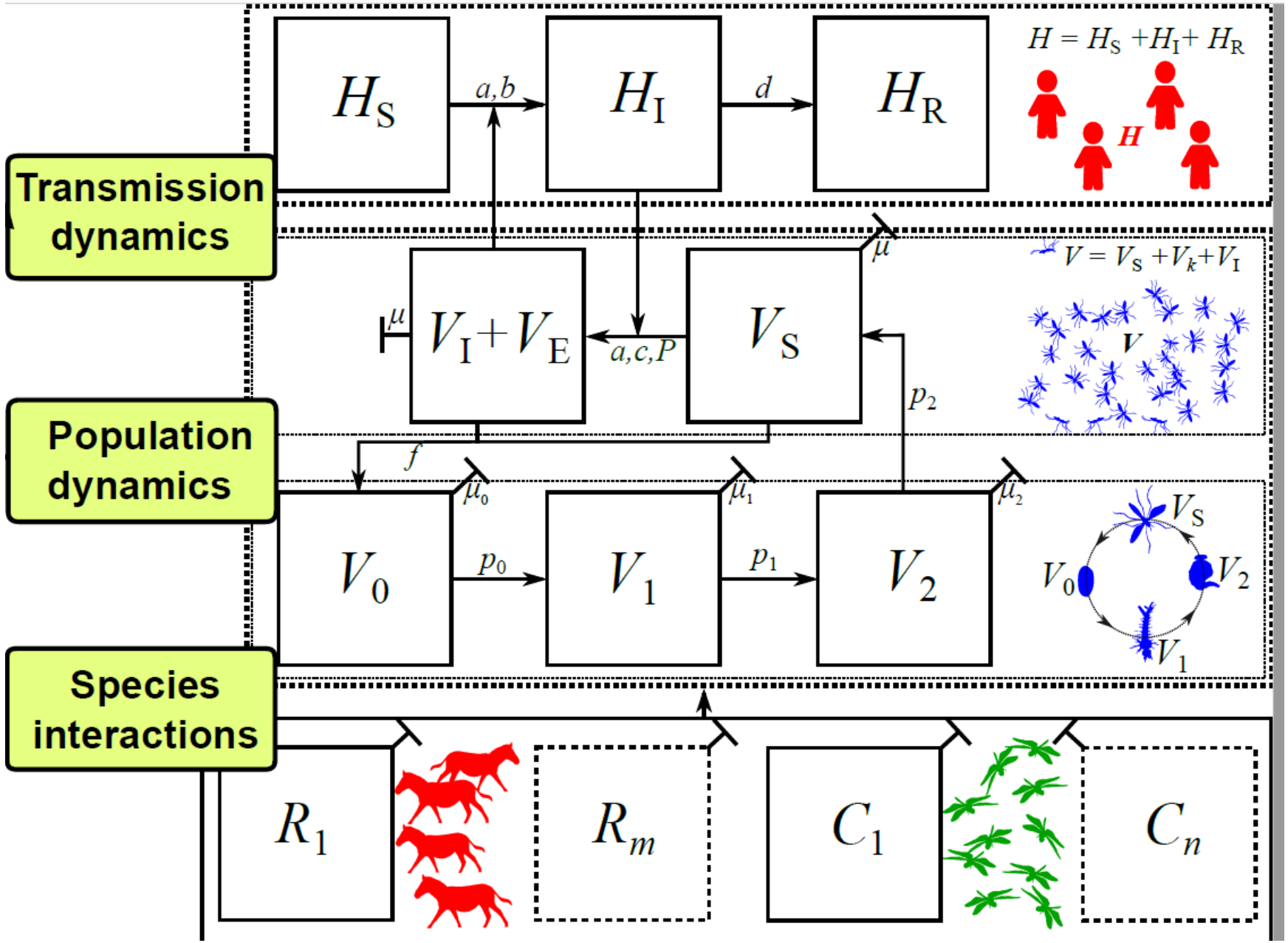


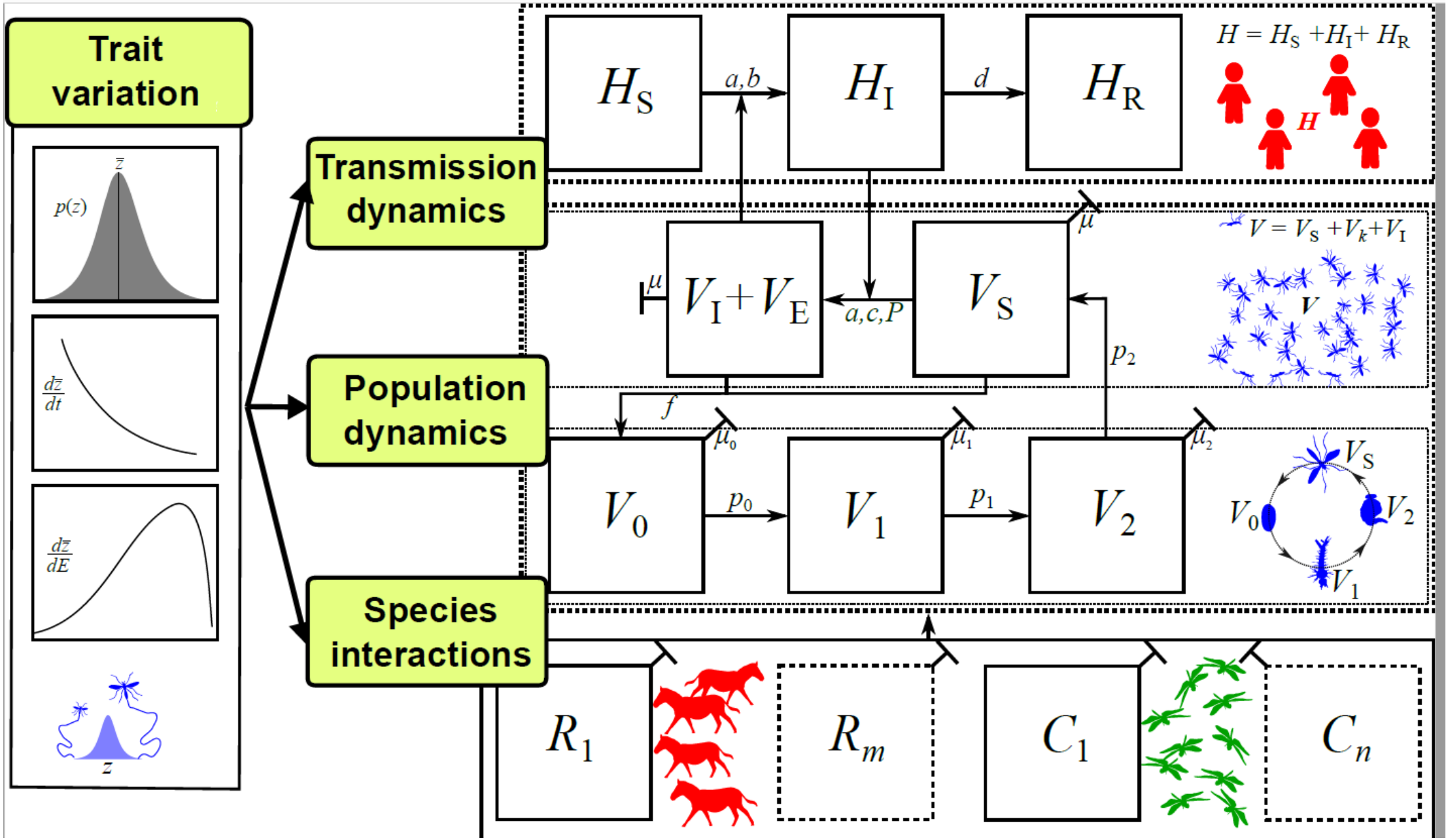
Within the adult stage

Vézilier et al. 2012


H_S
a,b
H_I
d
H_R
$H = H_S + H_I + H_R$
H
μ
$V_I + V_E$
a,c,P
V_S
μ
r
$V = V_S + V_E + V_I$
V


H_S
a,b
H_I
d
H_R
$H = H_S + H_I + H_R$
H
μ
$V_I + V_E$
a,c,P
V_S
$V = V_S + V_k + V_I$
V
p_2
f
μ_0
μ_1
μ_2
V_0
p_0
V_1
p_1
V_2
V_S
V_0
V_2
V_1


Transmission dynamics
Population dynamics
Species interactions
H_S
a,b
H_I
d
H_R
$H = H_S + H_I + H_R$
H
μ
$V_I + V_E$
a,c,P
V_S
$V = V_S + V_k + V_I$
V
p_2
f
μ_0
μ_1
μ_2
V_0
p_0
V_1
p_1
V_2
V_S
V_0
V_2
V_1
R_1
R_m
C_1
C_n


Trait variation
$\bar{z}$
$p(z)$
$\frac{d\bar{z}}{dt}$
$\frac{d\bar{z}}{dE}$
z
Transmission dynamics
Population dynamics
Species interactions
H_S
a,b
H_I
d
H_R
$H = H_S + H_I + H_R$
H
μ
$V_I + V_E$
a,c,P
V_S
$V = V_S + V_k + V_I$
V
p_2
f
μ_0
μ_1
μ_2
V_0
p_0
V_1
p_1
V_2
V_S
V_0
V_2
V_1
R_1
R_m
C_1
C_n