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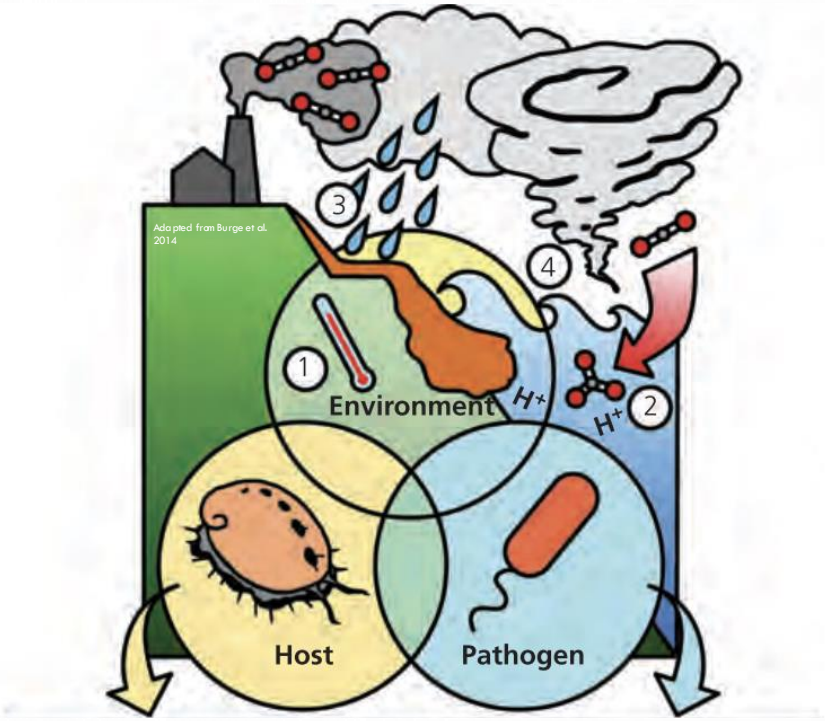
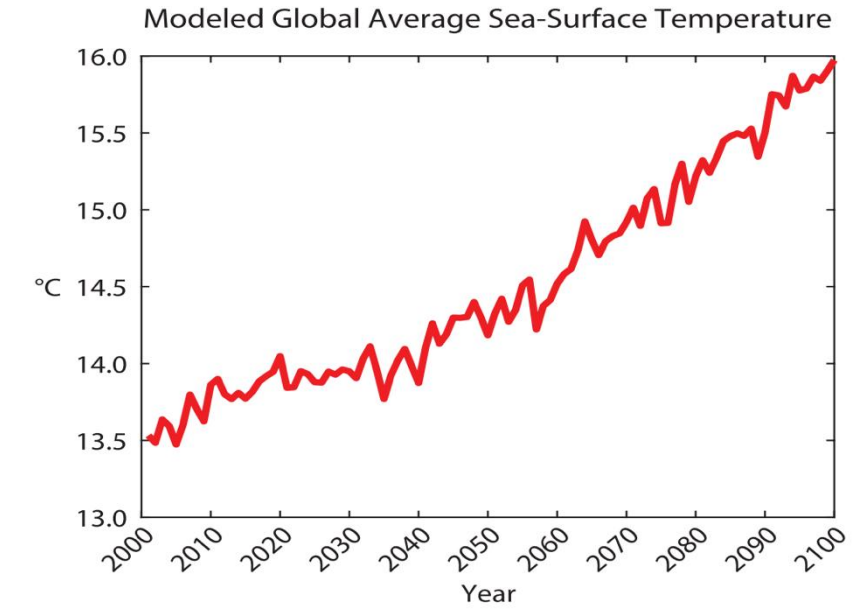
A TEMPERATURE-DRIVEN ECOLOGICAL TRADEOFF BETWEEN PATHOGEN REPLICATION AND INACTIVATION AND ITS IMPACTS ON HOST-PATHOGEN INTERACTIONS

ENVIRONMENTAL FACTORS & HOST-PATHOGEN INTERACTIONS



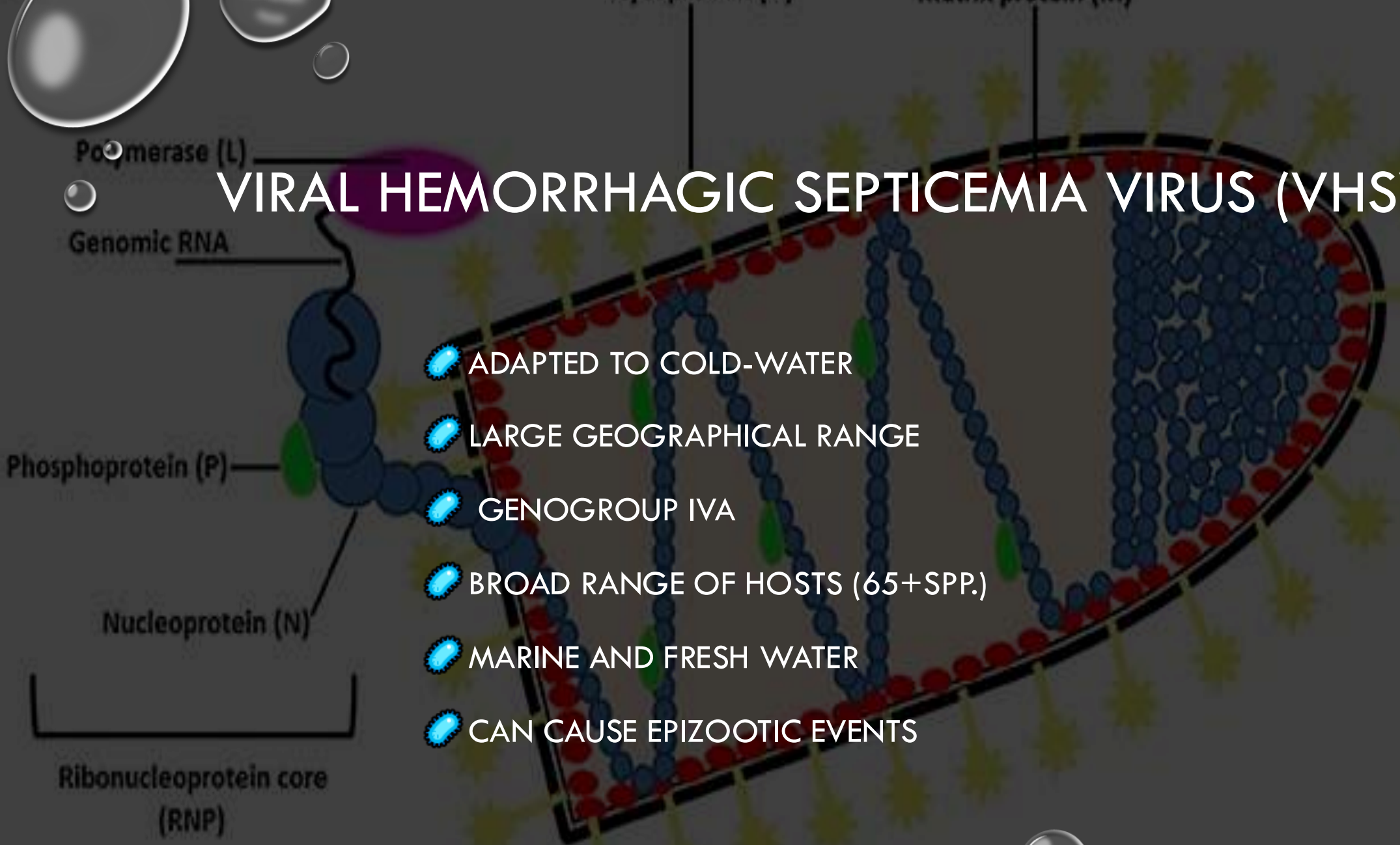


(Meehl et al., 2007)

- Shifts in susceptibility
- Varied immune responses
- Range expansion
- Host fitness shifts

- Amplification
- Transmission
- Range expansion
- Potential varied outbreaks
- Viral fitness shifts

VIRAL HEMORRHAGIC SEPTICEMIA VIRUS (VHSV)



- ADAPTED TO COLD-WATER
- LARGE GEOGRAPHICAL RANGE
- GENOGROUP IVA
- BROAD RANGE OF HOSTS (65+SPP.)
- MARINE AND FRESH WATER
- CAN CAUSE EPIZOOTIC EVENTS

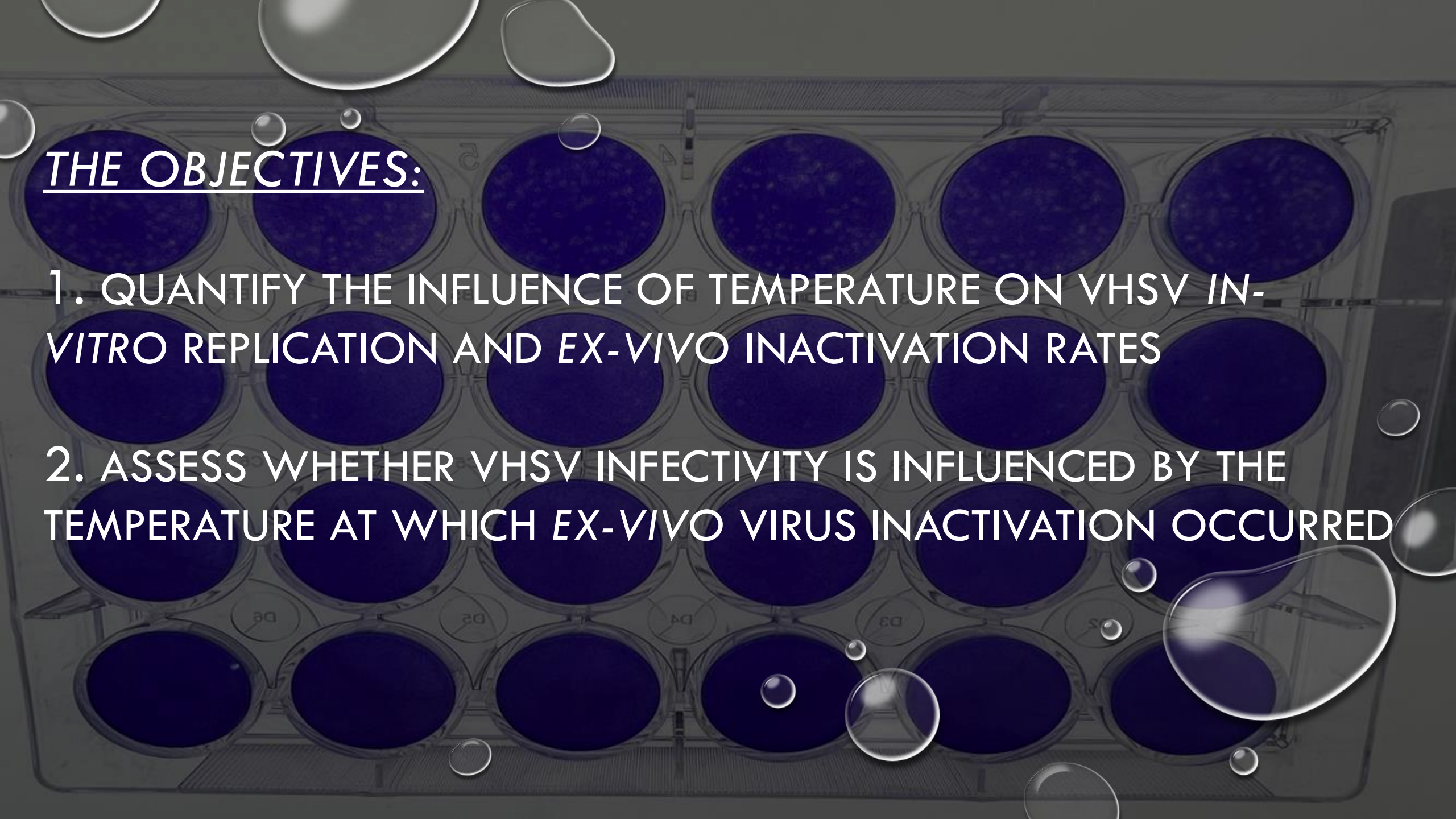
Pereiro et al. 2016

PACIFIC HERRING (*CLUPEA PALLASII*)

- A KEY FORAGE FISH
- ECOLOGICAL AND ECONOMIC IMPORTANCE
- HIGHLY SUSCEPTIBLE TO VHSV
- KNOWN TO HAVE EPIZOOTIC OUTBREAKS
- SENSITIVE TO ENVIRONMENTAL CHANGES
- TEMPERATURE RANGE 5 TO 15 °C



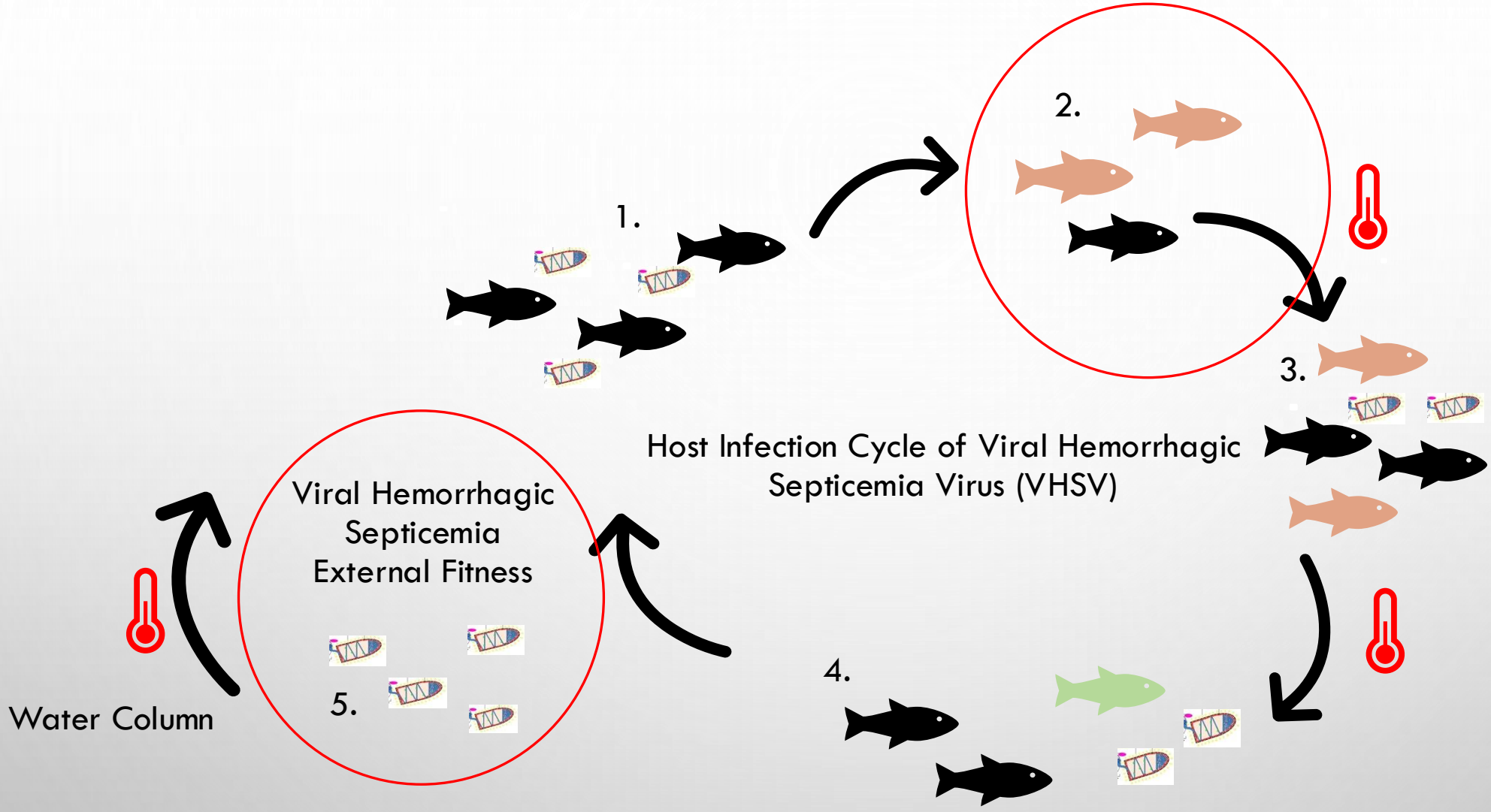




THE OBJECTIVES:

1. QUANTIFY THE INFLUENCE OF TEMPERATURE ON VHSV *IN-VITRO* REPLICATION AND *EX-VIVO* INACTIVATION RATES

2. ASSESS WHETHER VHSV INFECTIVITY IS INFLUENCED BY THE TEMPERATURE AT WHICH *EX-VIVO* VIRUS INACTIVATION OCCURRED


Host Infection Cycle of Viral Hemorrhagic Septicemia Virus (VHSV)
1.
2.
3.
4.
5.
Viral Hemorrhagic Septicemia External Fitness
Water Column

OBJECTIVE 1: REPLICATION & INACTIVATION METHODS

Replication

Temperature treatments 6, 8, 10, 15, or 20°C
5 replicates with virus
3 replicates for control

8 replicate with EPC cells

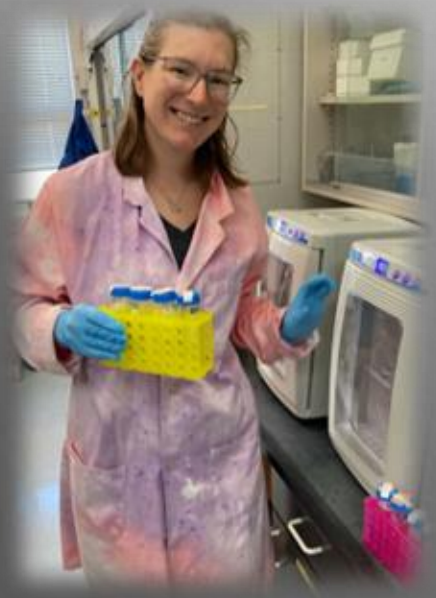
Inactivation

8 replicate with filtered seawater

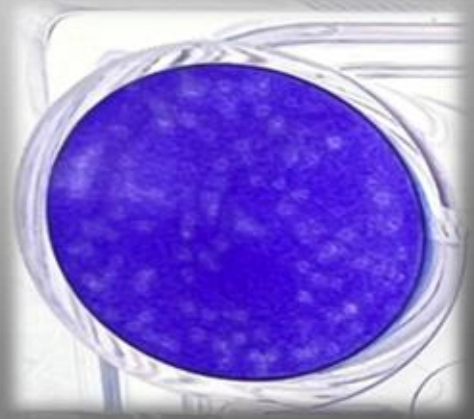
7-day collection period
Samples collected for plaque assay

Dilutions made for plaque assay

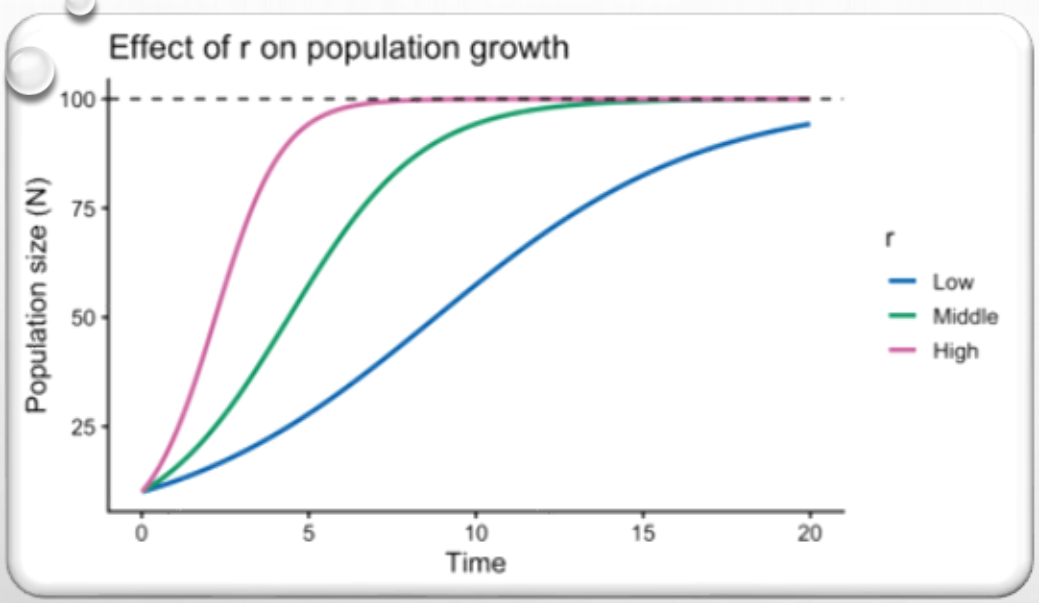
Enumerating plaque forming units (pfu)

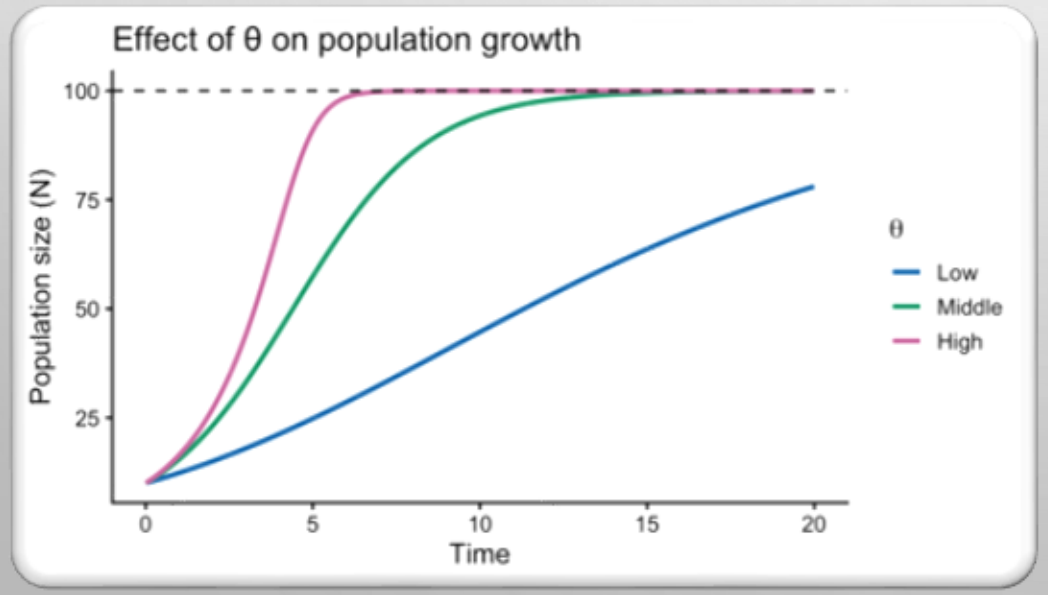






THETA-LOGISTIC GROWTH EQUATION





$$V_t = \frac{K}{\left(1 + \left(\left(\frac{K^\theta - V_0^\theta}{V_0^\theta}\right) e^{-rt}\right)\right)^{1/\theta}}$$

t TIME

V_t IS THE VIRAL DENSITY AT TIME t

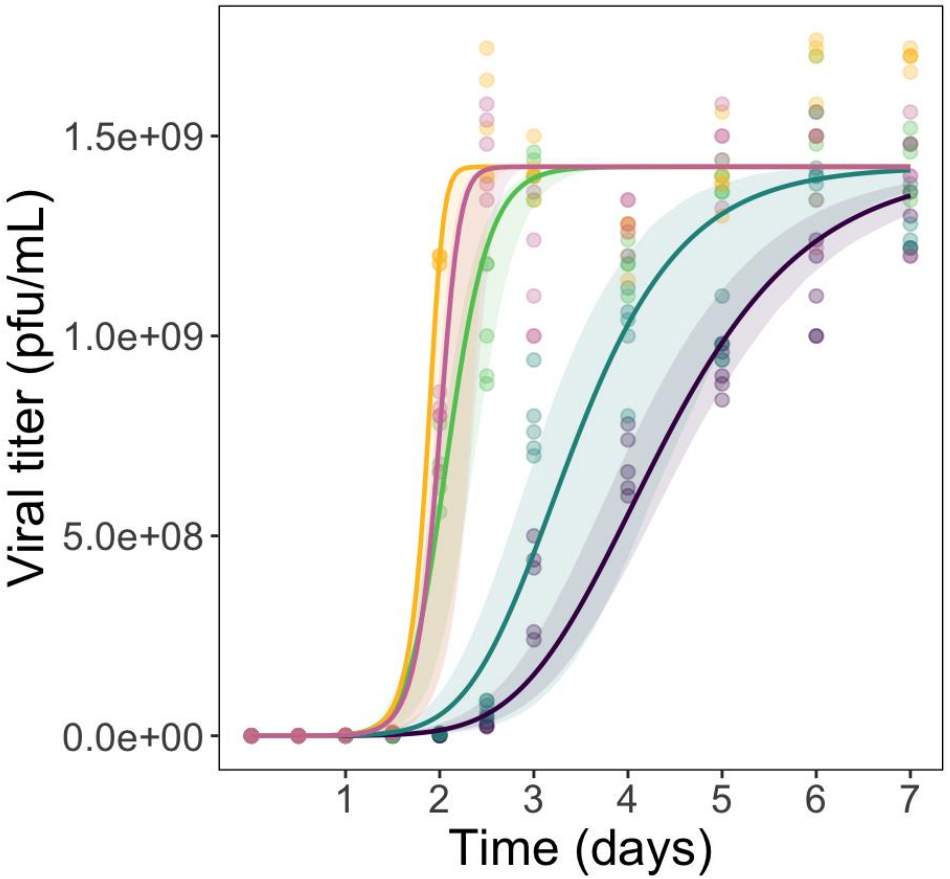
K THE CARRYING CAPACITY

V_0 THE INITIAL VIRAL DENSITY

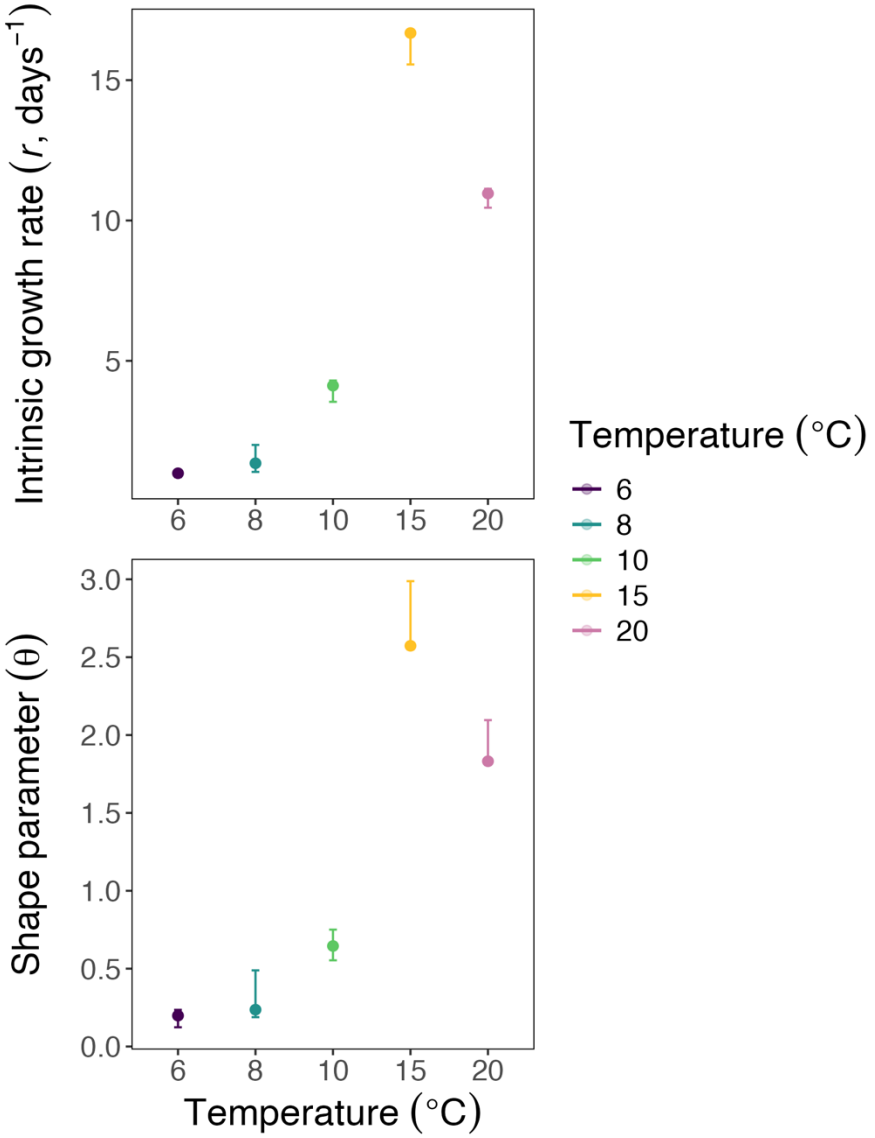
r INSTRINSIC GROWTH RATE

θ DEGREE OF LINEARITY OF DENSITY DEPENDENCE

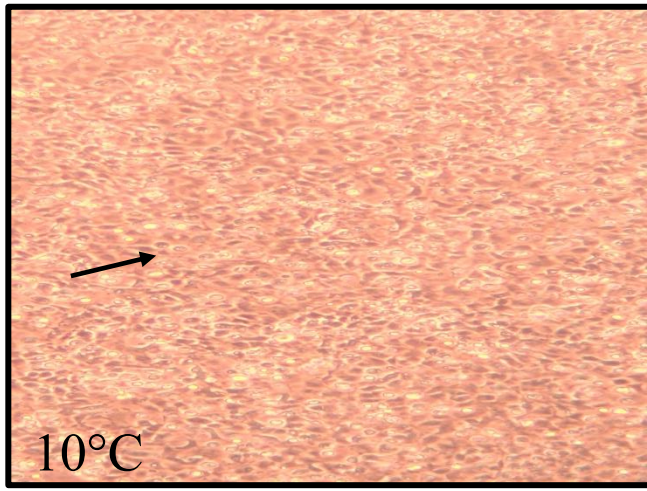
Viral Concentrations

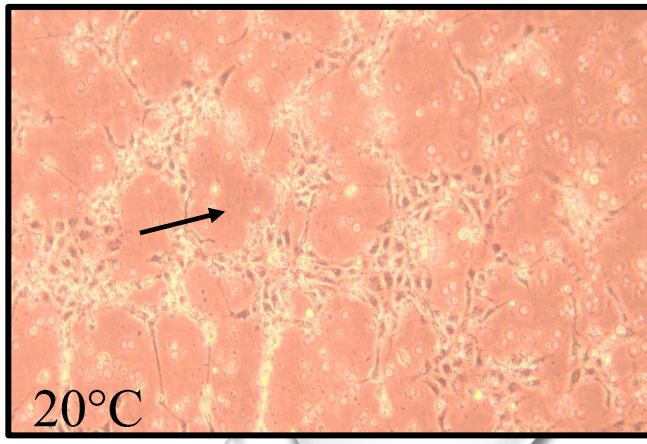


Rates and Parameters

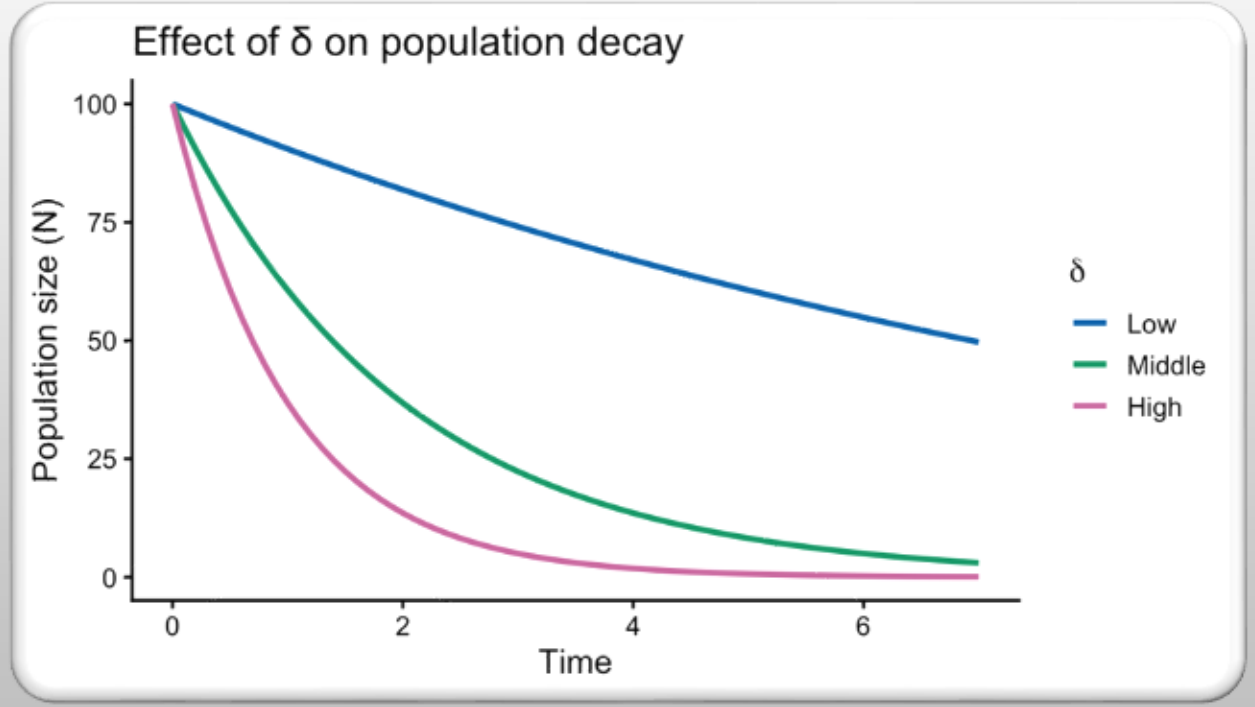








EXPONENTIAL DECAY EQUATION



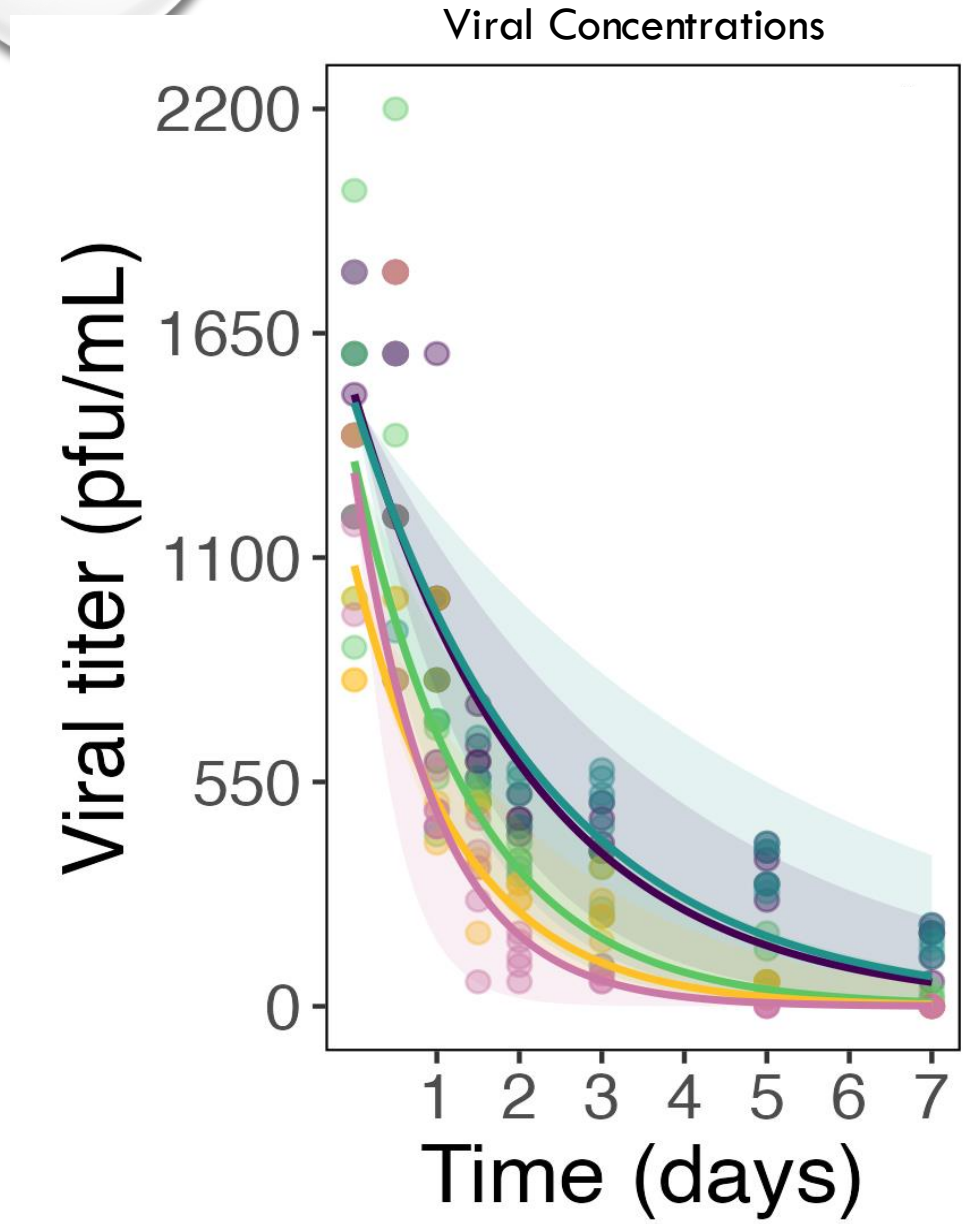
$$V_t = V_0 e^{-\delta t}$$

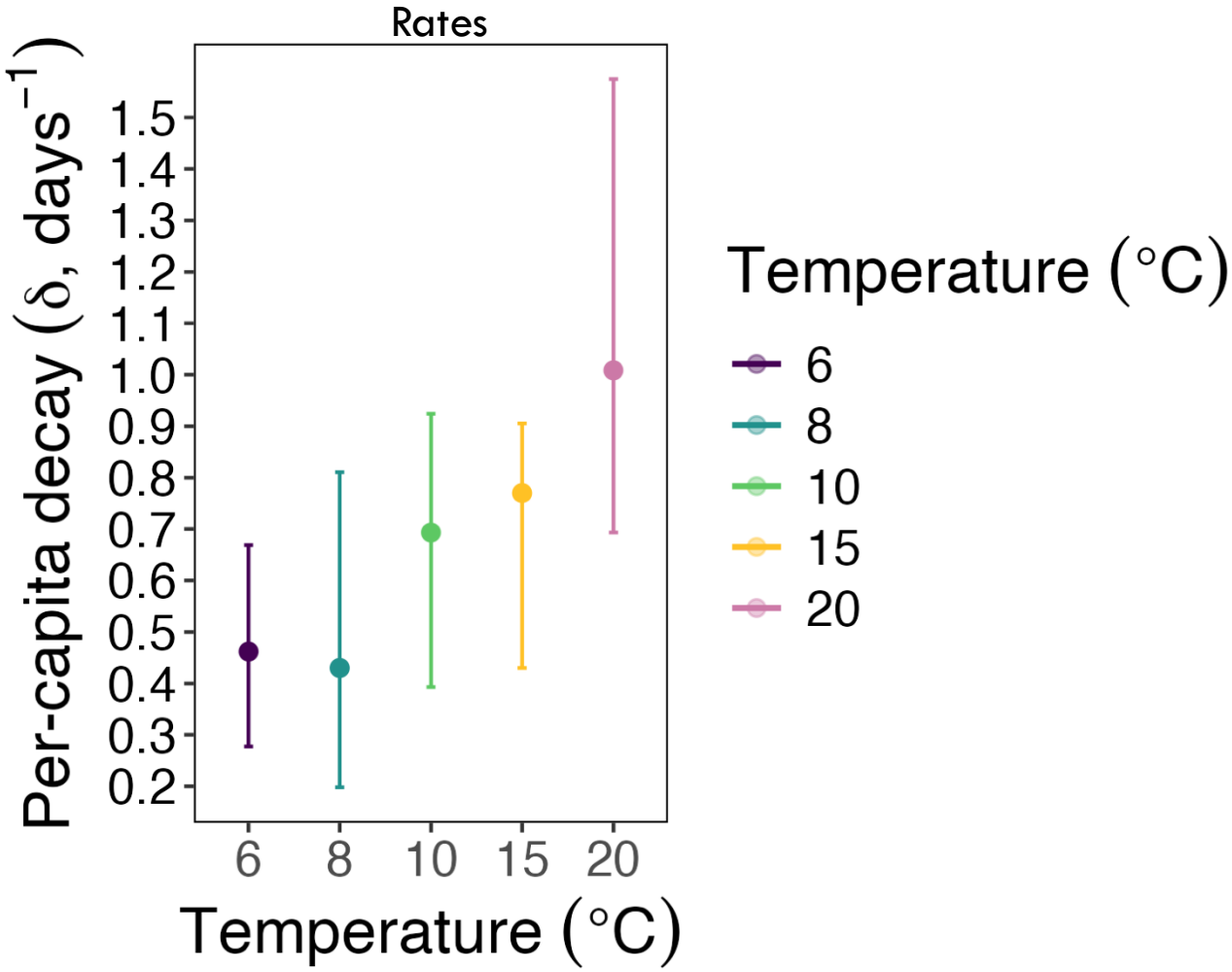
δ PER-CAPITA DECAY RATE

t TIME

V_t IS THE VIRAL DENSITY AT TIME t

V_0 THE INITIAL VIRAL DENSITY


Viral Concentrations
Viral titer (pfu/mL)
2200
1650
1100
550
0
1
2
3
4
5
6
7
Time (days)


Rates
Per-capita decay (δ, days^{-1})
1.5
1.4
1.3
1.2
1.1
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
6
8
10
15
20
Temperature (°C)
Temperature (°C)
6
8
10
15
20

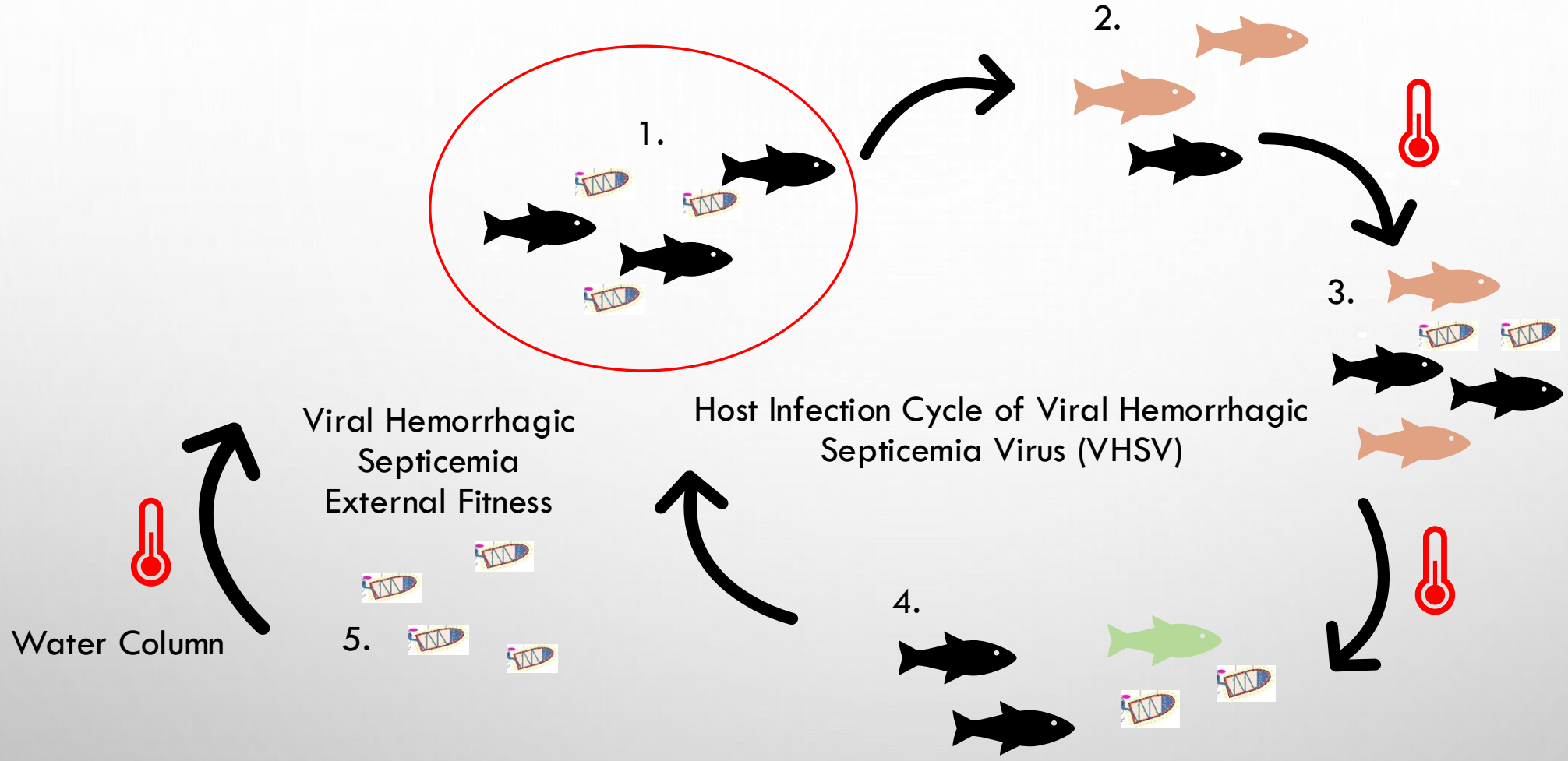
OUTCOMES FOR OBJECTIVE 1

TEMPERATURE INFLUENCES FITNESS TRAITS

TEMPERATURE GRADIENTS MEDIATE TRADE-OFFS

IMPROVED UNDERSTANDING OF ENVIRONMENTAL STABILITY

Background: EPC cells at 20°C after 9 days


1.
2.
3.
4.
5.
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Viral Hemorrhagic Septicemia External Fitness
Water Column

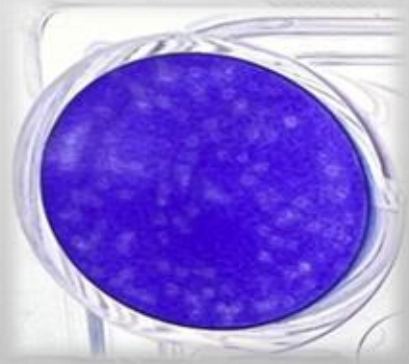
OBJECTIVE 2: INFECTIVITY METHODS





Incubation: 7 days





VHSV present or absent

Buckets=136
Each Bucket=1 Fish
Water Temperature= Same



Trial 1:
Samples from 6,10, and 20°C from Day 3
concentration 20 pfu (plaque forming units)
Titer control
Positive control
Controls pooled from inactivation

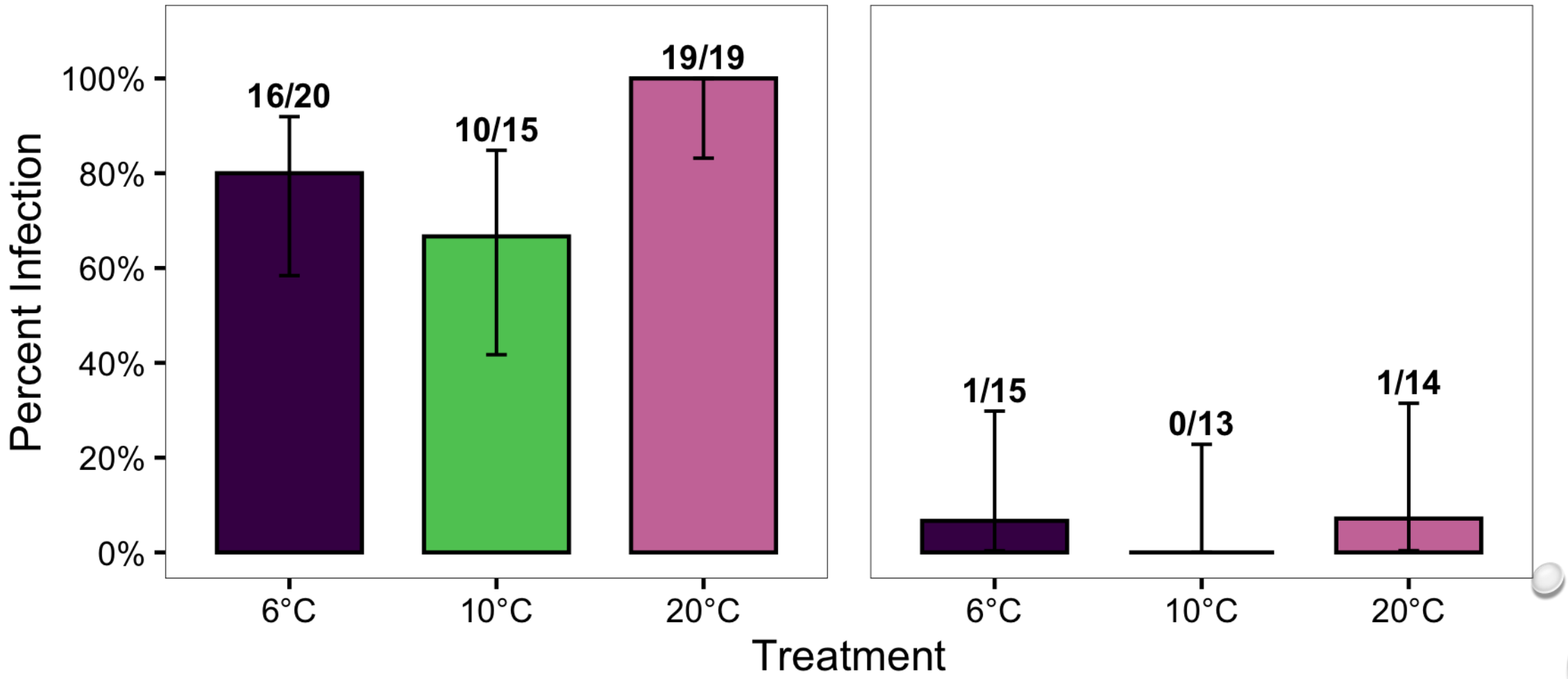
Trial 2:
Samples from Day 5 concentration 2 pfu

TRIAL 1 — 20 pfu

6°C ↑ | **10°C ↓** | 20°C ↑

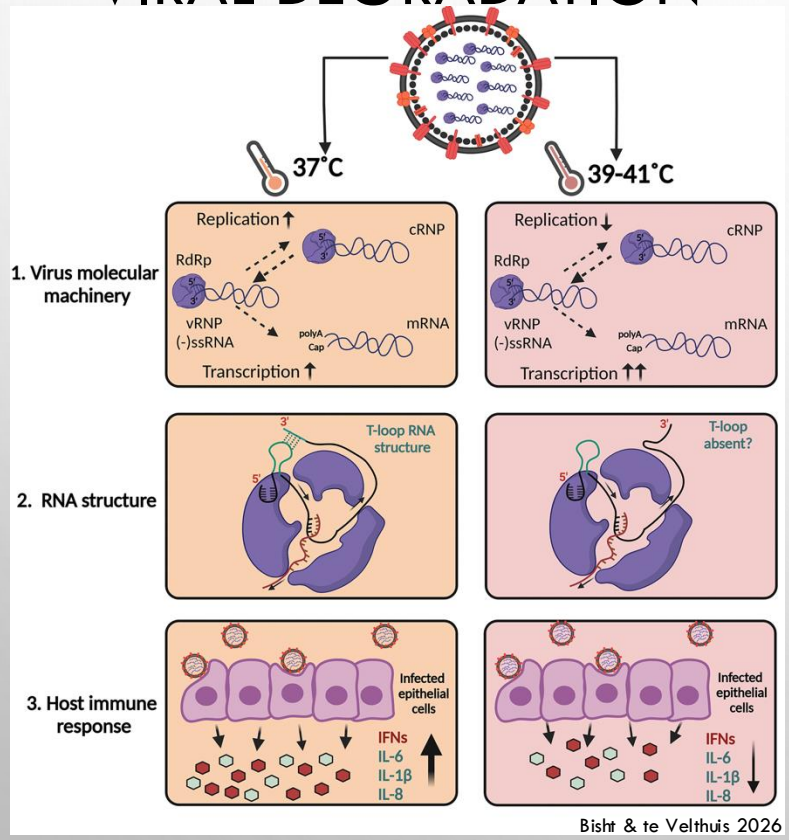
TRIAL 2 — 2 pfu

6°C ↑ | **10°C ↓** | 20°C ↑



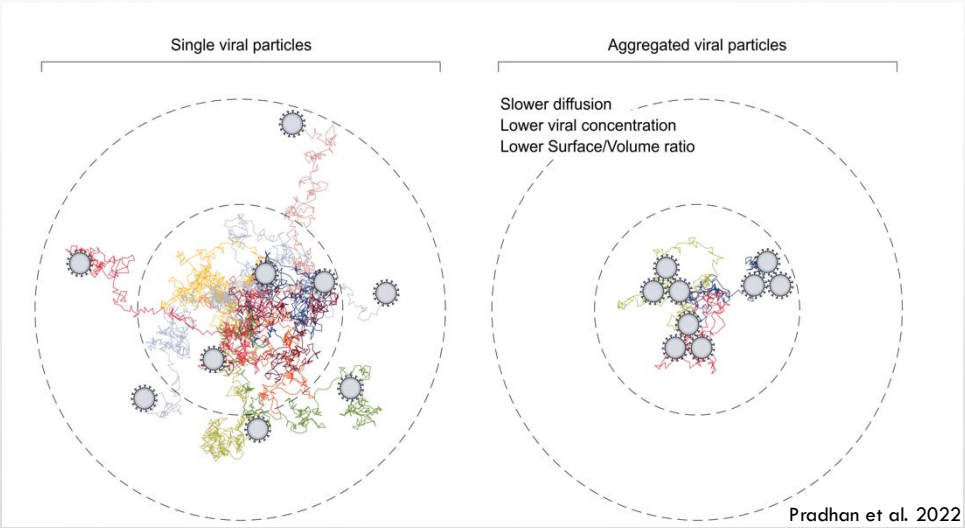
OUTCOMES FOR OBJECTIVE 2

VIRAL DEGRADATION



Bisht & te Velthuis 2026

VIRAL AGGREGATION



Pradhan et al. 2022

STOCHASTIC VARIATION



CONCLUSION

- REPLICATION–INACTIVATION TRADE-OFFS
- LABORATORY DYNAMICS DO NOT FULLY PREDICT INFECTION
- INFECTIVITY DEPENDS ON MORE THAN VIRAL QUANTITY
- INFECTION OUTCOMES REMAIN UNCERTAIN
- CONSEQUENCES FOR PACIFIC HERRING-VHSV INTERACTIONS

A SPECIAL THANK YOU TO:

Shout out to my family and friends for all their support!!!

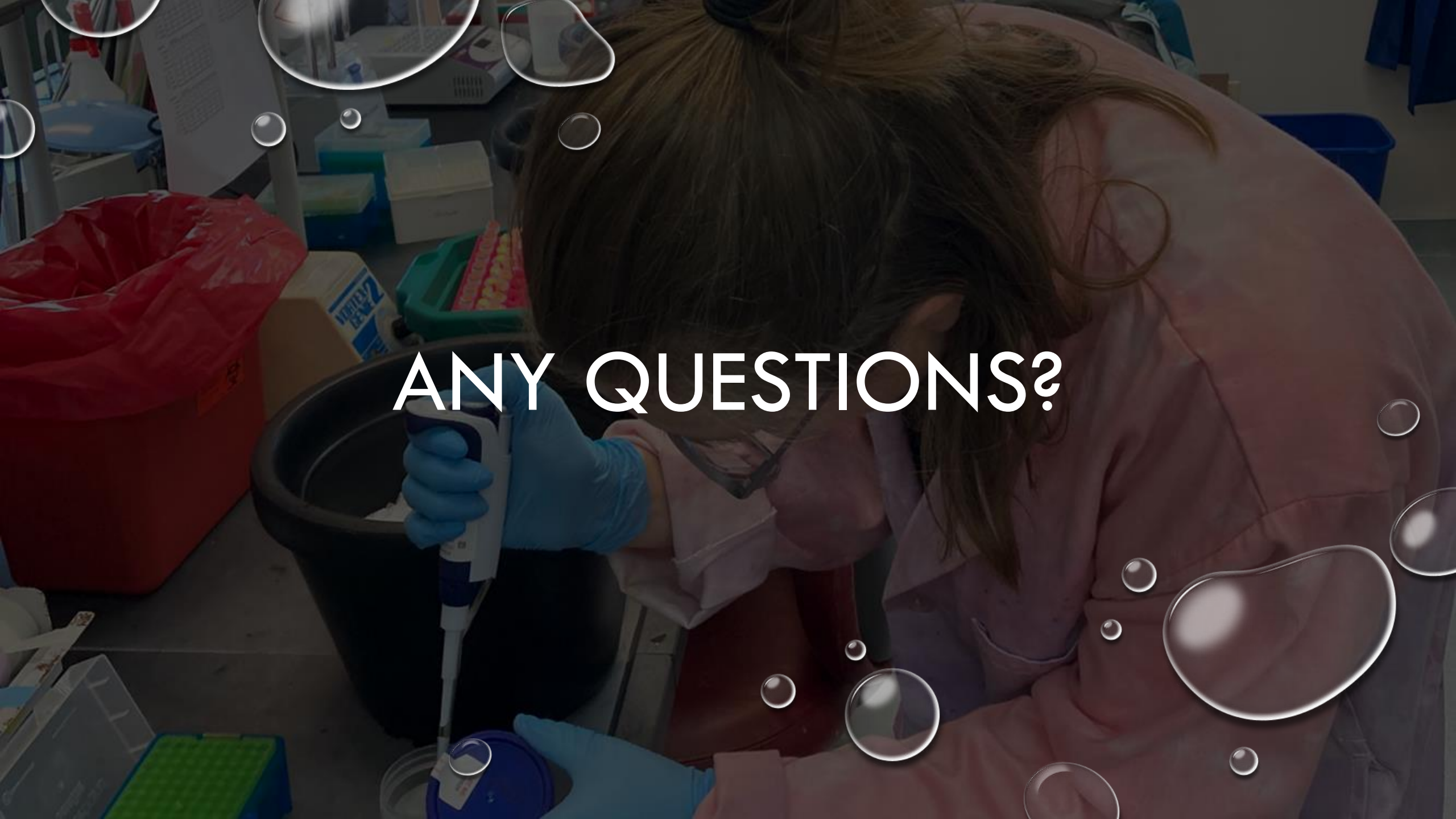
PAUL HERSHBERGER, DAVID PÁEZ, COURTNEY GRABER, AND JACOB GREGG

NATHAN WOLF, MALINA LOEHER, AND THE OTHER STAFF AND STUDENTS

TURNER DEBLIEUX AND JOSEPH MIHALJEVIC

NATIONAL SCIENCE FOUNDATION GRANT

Thank you to Courtney Graber, Shayla Ferreiro-Luce, and Malina Loeher for helping me take photos for the presentation!


ANY QUESTIONS?