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### Agent-Based Modeling to Assess Optimal Conditions for Reducing Pathogenic Air Transmission

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# AGENT-BASED MODELING TO ASSESS OPTIMAL CONDITIONS TO MINIMIZE AIRBORNE TRANSMISSION

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# COVID-19 PANDEMIC

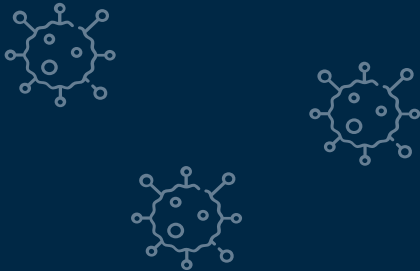
2020



# SARS-COV-2

- ★ ENVELOPED, POSITIVE-SENSE, SINGLE STRANDED RNA VIRUS (Zhu et al., 2020)
- ★ AIR TRANSMISSION VS. AEROSOL TRANSMISSION (Lee, 2020)
- ★ SOCIAL DISTANCING GUIDELINES- 6 FEET

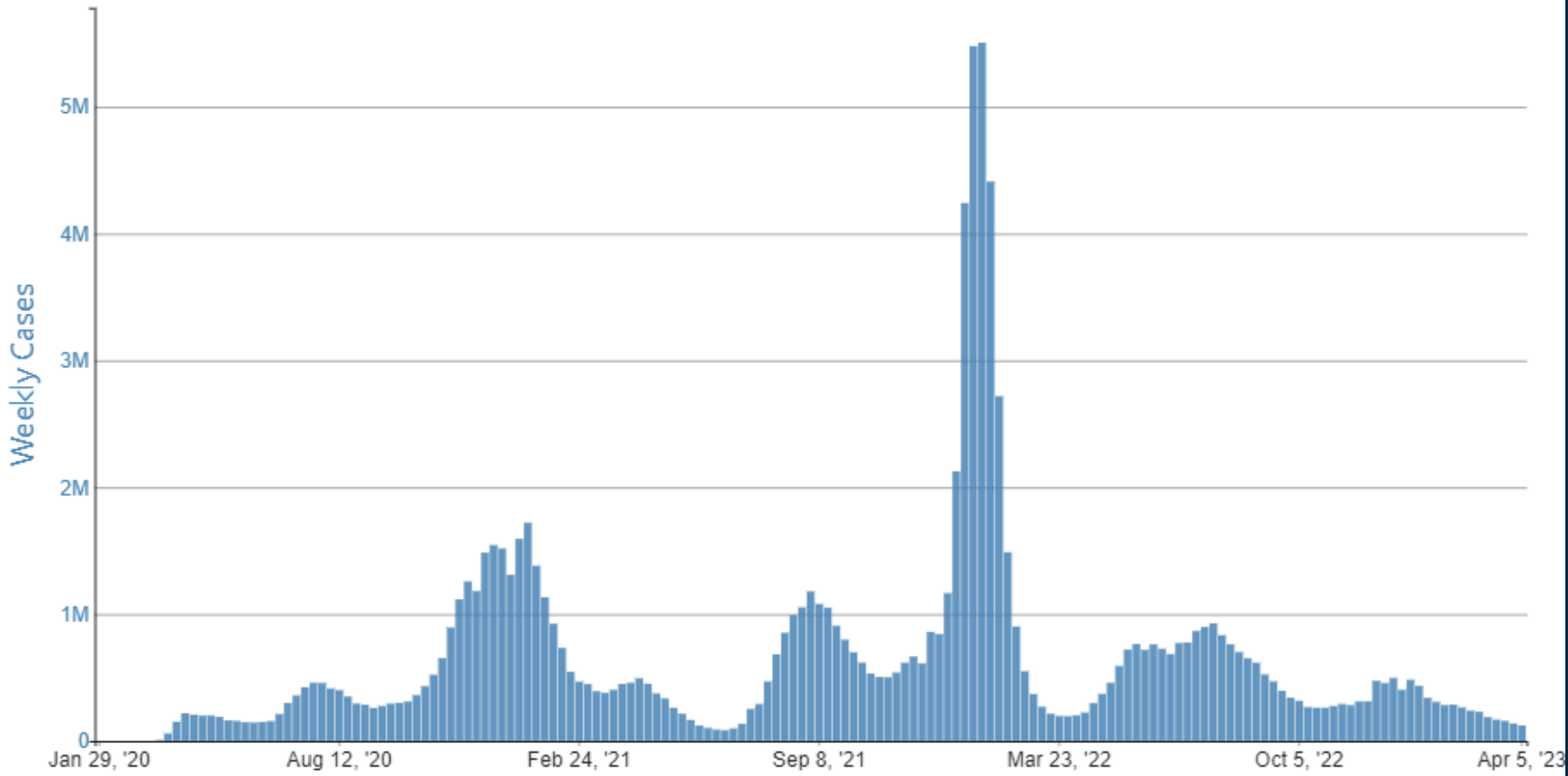
## DROPLETS



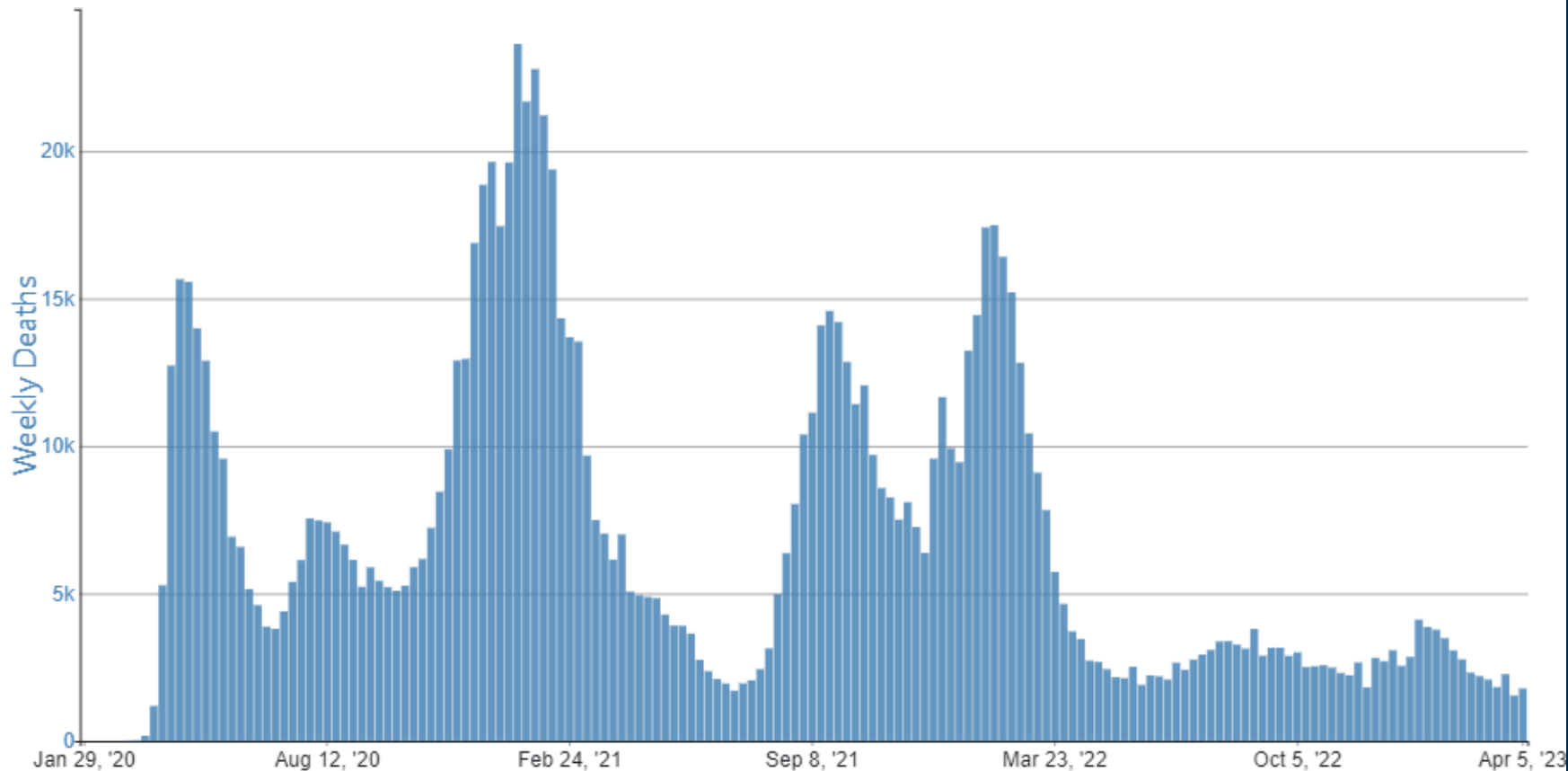
## AEROSOLS



# Weekly Trends in Number of COVID-19 Cases in The United States Reported to CDC



Weekly Trends in Number of COVID-19 Deaths in The United States Reported to CDC



The background is a dark blue field with a sparse, abstract pattern of geometric elements. It includes several thin white vertical lines of varying lengths. Scattered throughout are squares in various colors: light blue, pink, orange, and cyan. Some squares are solid, while others are hollow outlines. The overall composition is minimalist and modern.

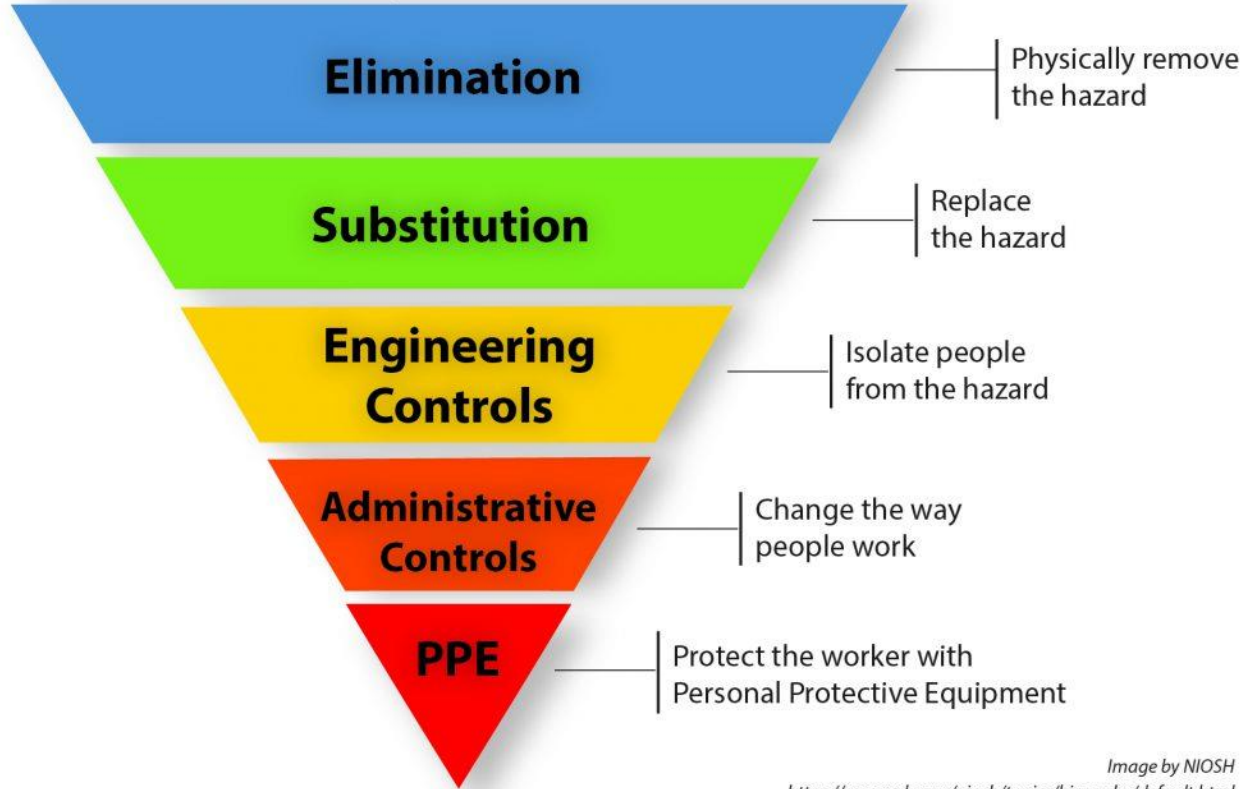
IT IS NOT OVER!

# Hierarchy of Controls

Most effective



Least effective



**Elimination**

Physically remove the hazard

**Substitution**

Replace the hazard

**Engineering Controls**

Isolate people from the hazard

**Administrative Controls**

Change the way people work

**PPE**

Protect the worker with Personal Protective Equipment

Image by NIOSH

<https://www.cdc.gov/niosh/topics/hierarchy/default.html>



A collection of small squares in white, orange, and teal colors scattered in the top right corner of the slide.

GOAL:

TO CREATE A TOOL TO ENHANCE OUR  
UNDERSTANDING OF HOW TO MANIPULATE THE BUILT  
ENVIRONMENT TO REDUCE THE HAZARD OF  
AIRBORNE TRANSMISSION



# VIRAL SURROGATE

## SARS-COV-2

VERY DANGEROUS VIRUS

CANNOT EMIT INTO THE AIR

HARD TO STUDY IN SCHOOL

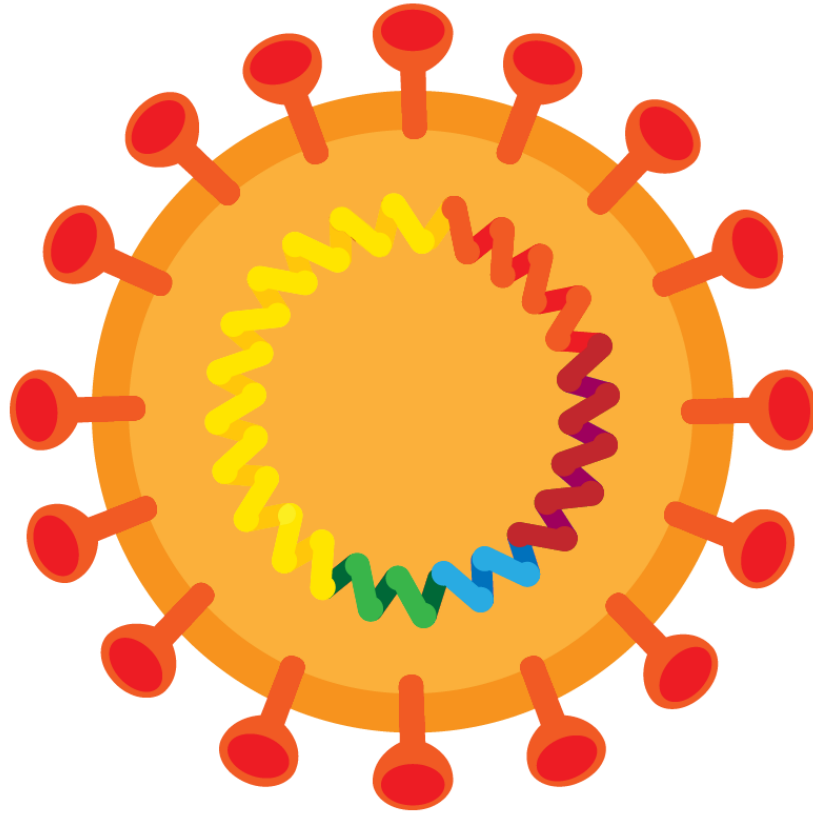
## BACTERIOPHAGE PHI6

PHAGE IS NOT DANGEROUS

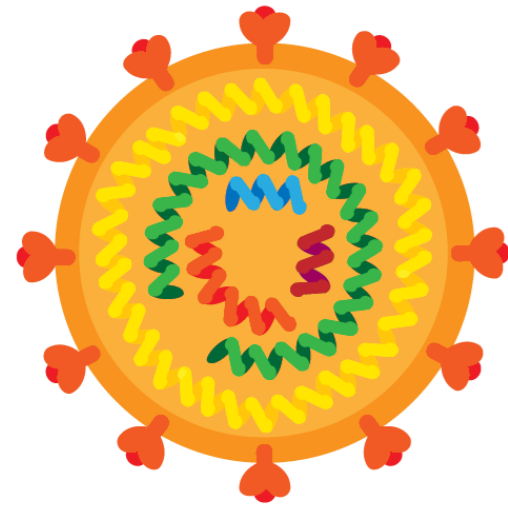
CAN EMIT INTO THE AIR

CONFIRMED SURROGATE





Coronavirus

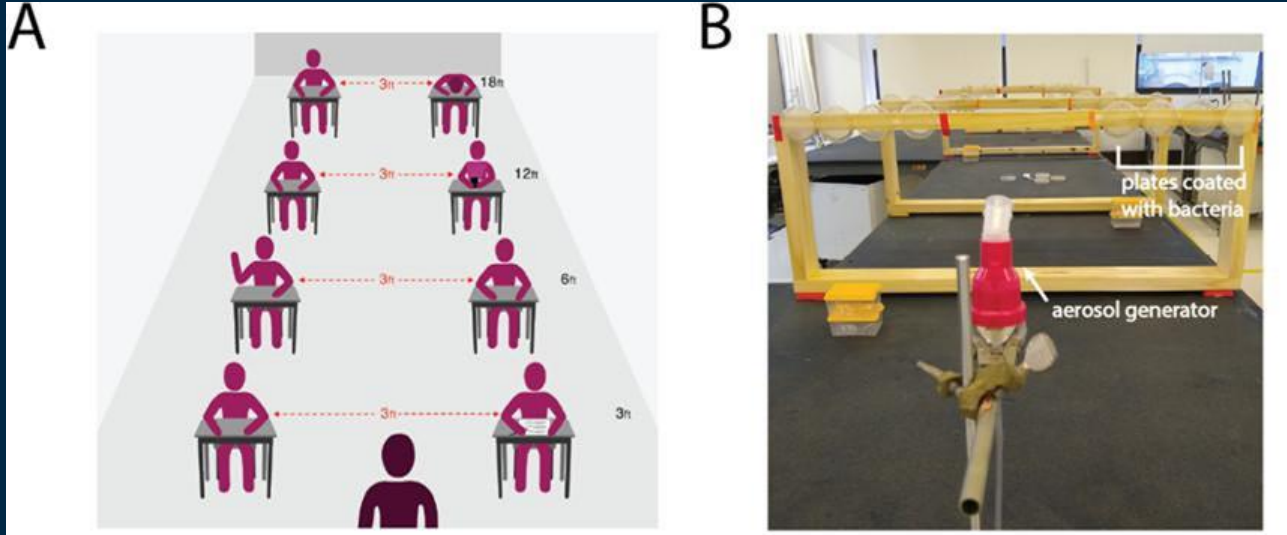


Bacteriophage Phi 6

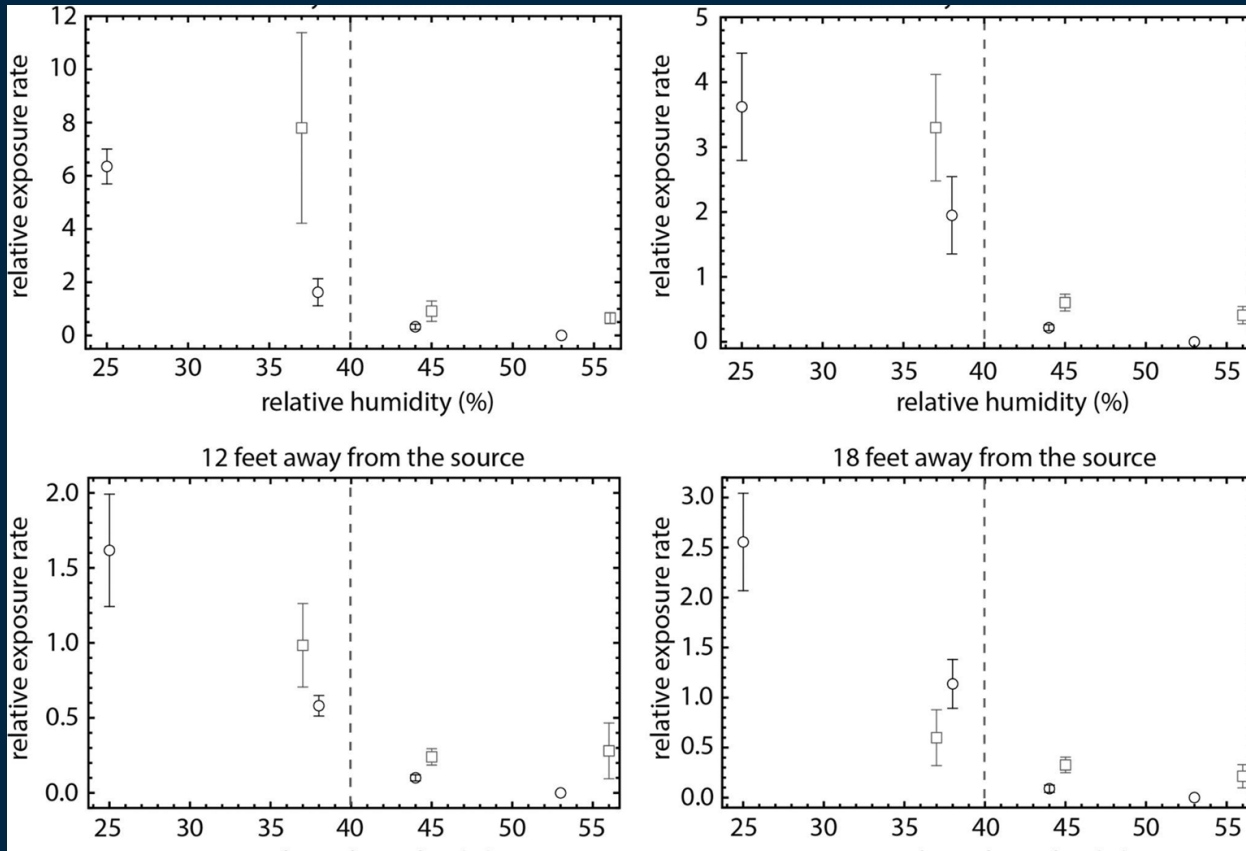


# PHAGE EXPERIMENTS

# EXPERIMENTAL DESIGN



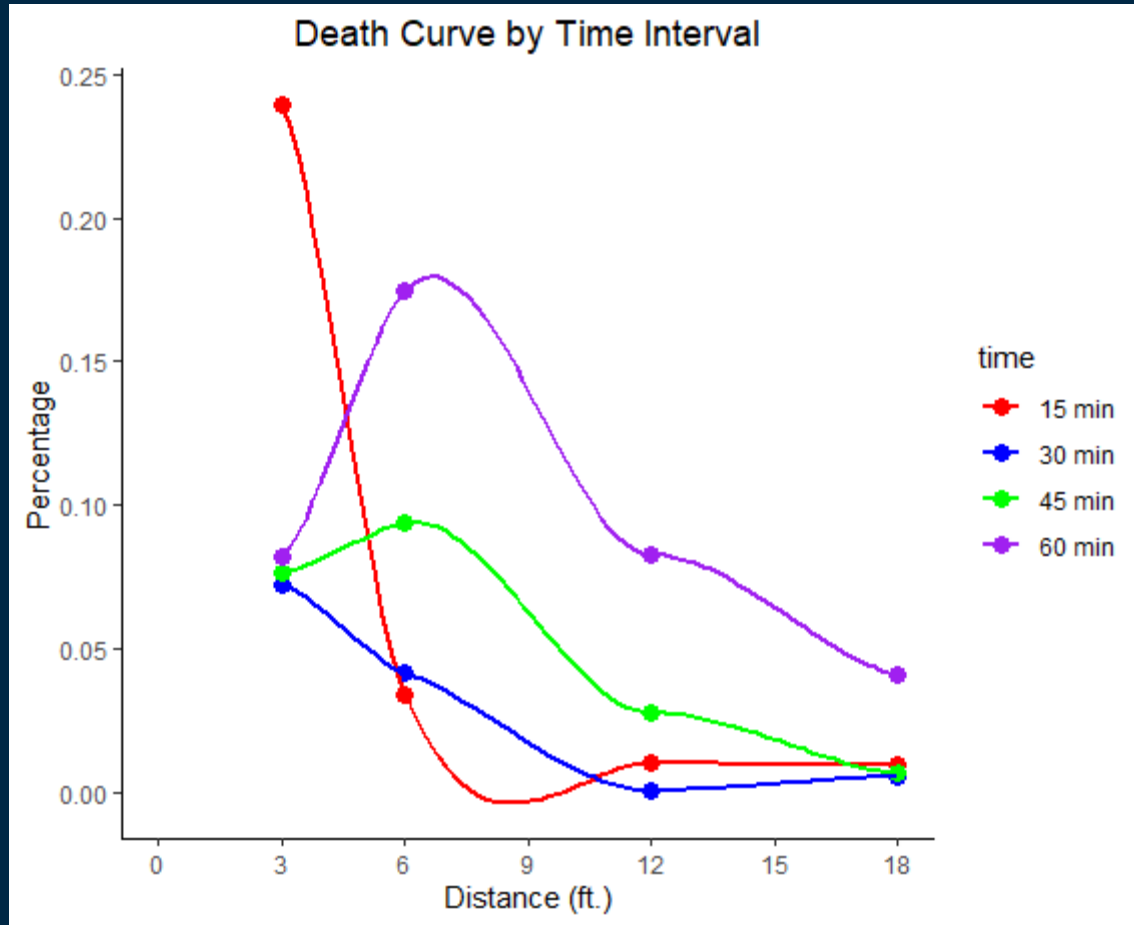
# PUBLISHED FINDINGS



The background is a dark blue field decorated with a sparse, abstract pattern of geometric shapes. It includes several thin white vertical lines of varying lengths, scattered squares in light blue, pink, orange, and cyan, and some squares with thin white outlines. The overall aesthetic is clean and modern.

6 FEET IS NOT ENOUGH!

DEATH = NOT  
DETECTABLE/  
NO LONGER IN  
AIR





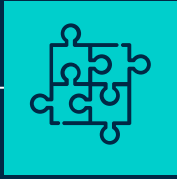
The background is a dark teal color with various geometric elements scattered across it. These include thin white vertical lines, small squares in light blue, orange, and pink, and larger squares in light blue and orange. The overall aesthetic is modern and minimalist.

IS THIS PLATE COUNTING METHOD  
ENCOMPASSING ALL THE PHAGE  
PRESENT IN THE AIR?

NO!



# COMPUTATIONAL RESEARCH



01

COMPLIMENTS REAL  
WORLD EXPERIMENTS



02

IMPOSSIBLE  
OR UNETHICAL  
EXPERIMENTS



03

UNIQUE PATTERNS

# NETLOGO

- ★ PROGRAMMING LANGUAGE
- ★ AGENT-BASED MODELING ENVIRONMENT
- ★ FREE!
- ★ WEB VERSION AVAILABLE



<https://ccl.northwestern.edu/netlogo/>

Interface controls including Edit, Delete, Add, a dropdown menu with 'abc Button', a speed slider set to 'normal speed', a 'view updates' checkbox which is checked, a 'continuous' dropdown menu, and a 'Settings...' button.

Buttons for 'setup' and 'go' with a refresh icon.

Toggle switch for 'record-age' currently set to 'On'.

Toggle switch for 'record-distance' currently set to 'On'.

Toggle switch for 'record-age-at-death' currently set to 'On'.

A 'Humidity' monitor showing a value of 37.2.



# THE CODE: PIECEWISE FUNCTIONS

```
setup environment  
  
go  
  create 10 phages  
  move phages 1 ft  
  how long has each phage been in the air?  
  how far has each phage traveled?  
  how humid is it?  
    does the phage die?- check formula  
  increment age of phage by 1  
  increment time passed by 1  
end
```

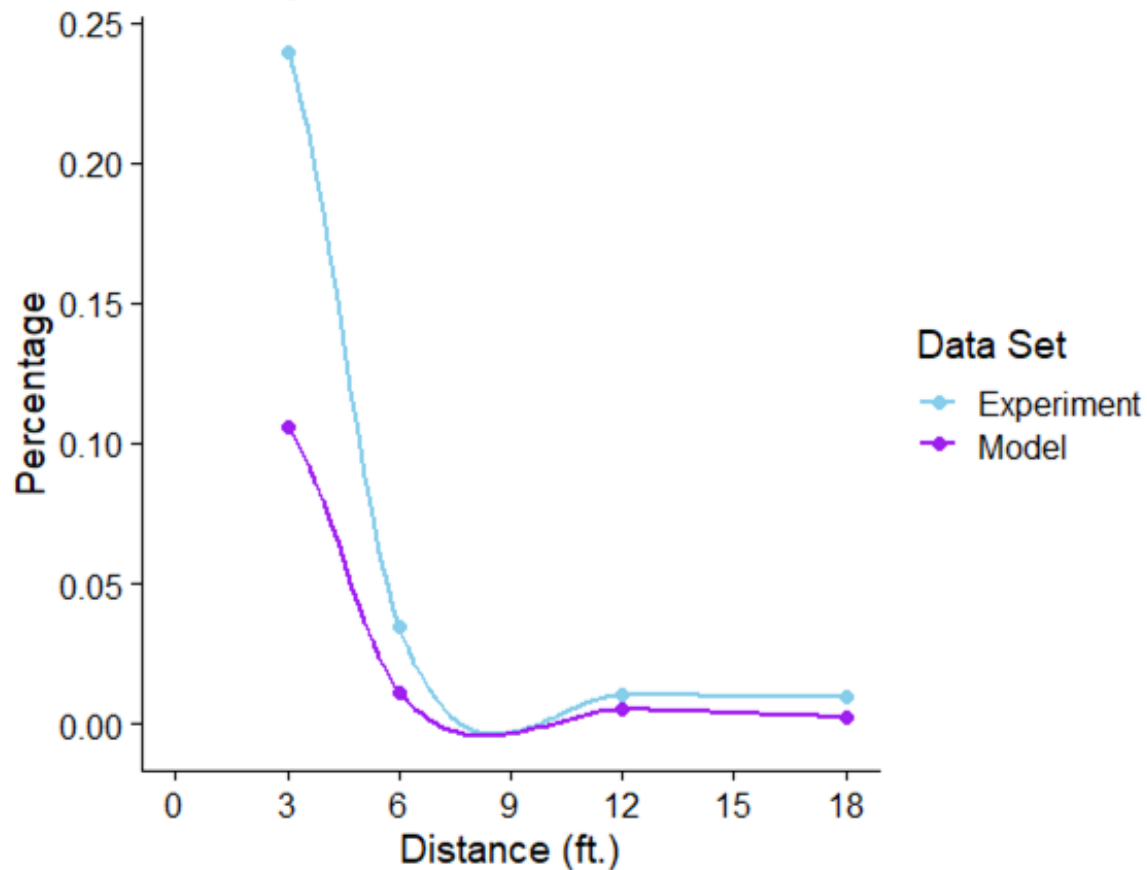
CODE LINGO:

1 PHAGE = 1 PFU

DIE = REMOVED FROM THE  
ENVIRONMENT

AGE = HOW LONG PHAGE HAS  
EXISTED IN THE MODEL

### Experiment vs. Model Data



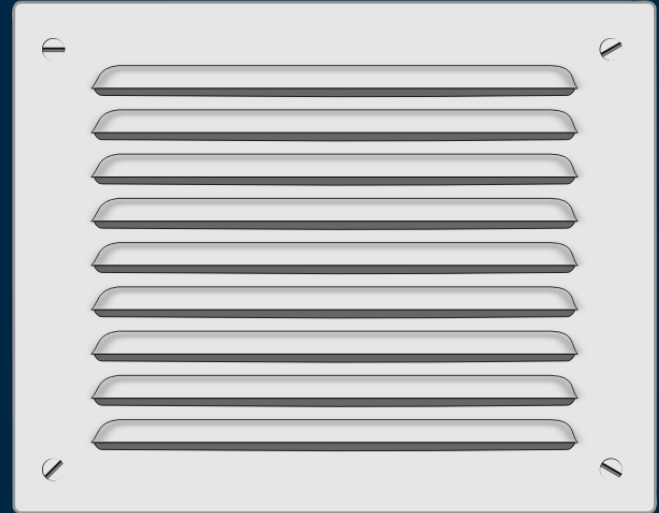
# FUTURE DIRECTIONS

## QUANTIFICATION



<https://www.chaibio.com/innovaprep-airprep-cub-air-sam>

## HVAC





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Do you have any questions?

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TEUFEL LAB | SMYTH LAB

# THANKS



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