Preventing Tick-Borne Disease

Joanna Buchthal & John Min

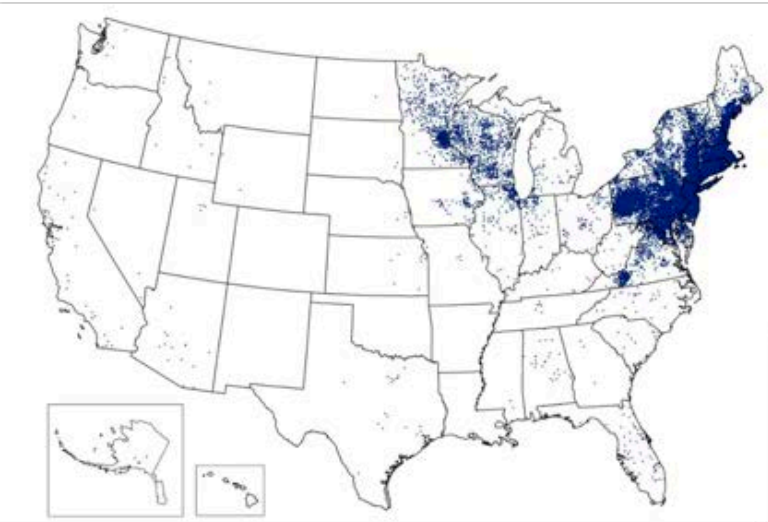
Whitehead Institute's 2017-2018 Seminar Series for High School Teachers

mit media lab

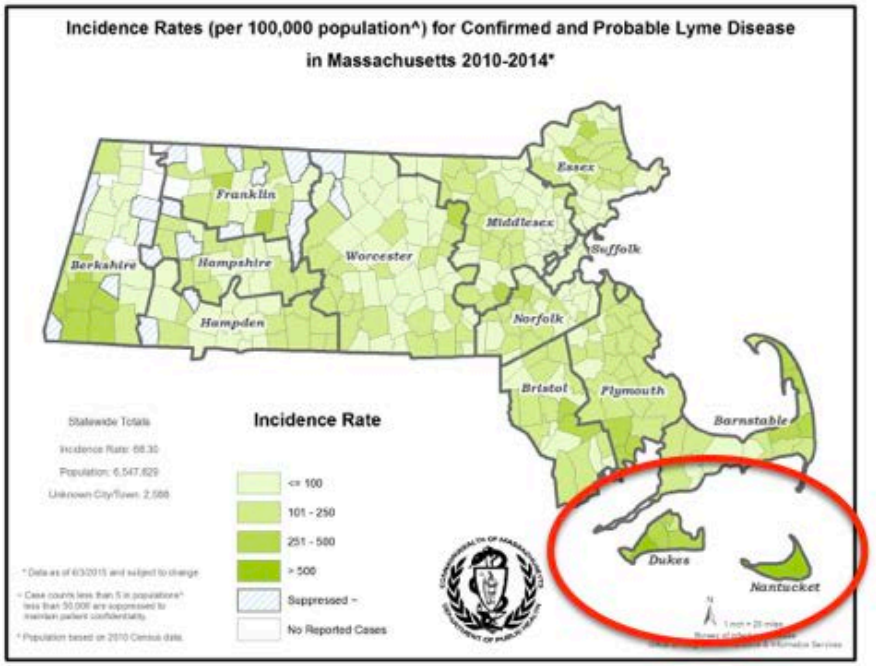
sculpting evolution

Growing risk of tick-borne disease

Reported Cases of Lyme Disease in 2014

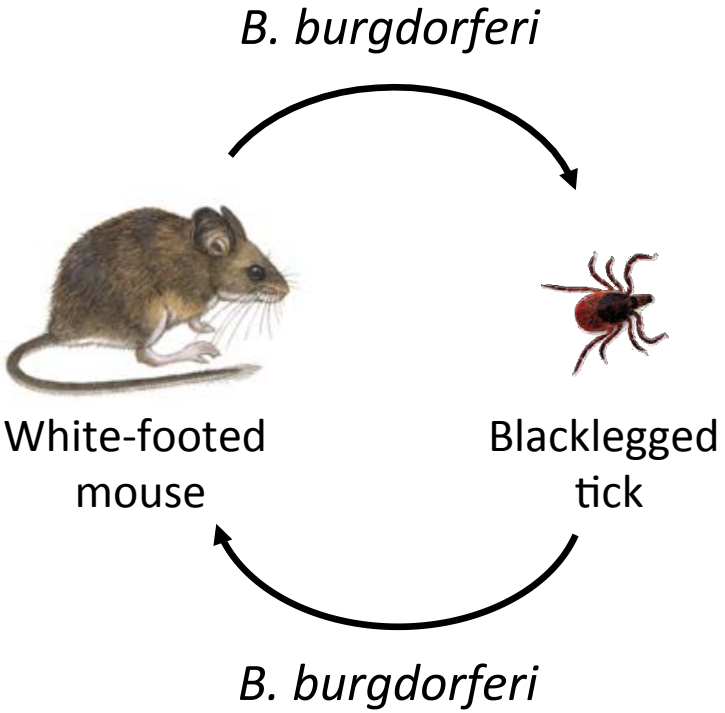


Centers for Disease Control and Prevention



MA Special Commission Report

Tick-borne Disease is an ecological problem



The pathogens that cause Lyme and other diseases persist by moving between mice and ticks

Breaking the cycle

If ***every mouse*** produced antibodies conferring effective immunity from birth, the main reservoir of tick-borne pathogens would likely collapse.

No infected mice ⟶ Few infected ticks ⟶ Few infected people

Important note:

Some ticks could become infected from residual secondary reservoirs, but the rate should be *far* lower than today.

The proposal

To stably reduce the incidence of tick-borne disease by breaking the transmission cycle between white-footed mice (the primary reservoir) and ticks

Controlled releases of resistant mice would introduce immunity to most or all of the native mouse population

Released mice would be genetically altered, but 100% mouse

A percentage of the Nantucket's white-footed mice naturally express antibodies against the Lyme-causing spirochete Borrelia burgdorferi

Two types of antibodies

Anti-Lyme Antibody

Protects mice from the Lyme spirochete only

Antibody target: *OspA*
an outer surface protein on
Borrelia burgdorferi

Anti-tick Antibody

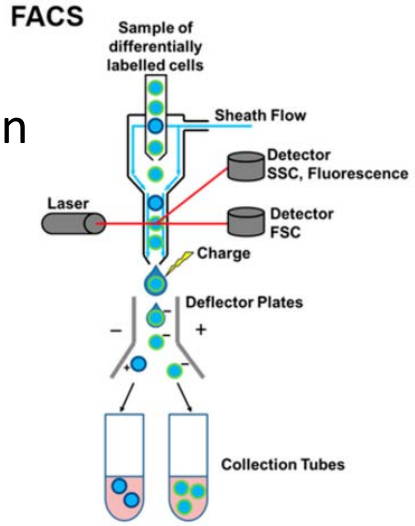
Protects mice from ***all*** pathogens carried by black-legged ticks

Antibody target: *subolesin*,
a tick salivary protein

How to make mice heritably Lyme resistant

Step 1: Inject white-footed mice with surface markers from *B. burgdorferi*

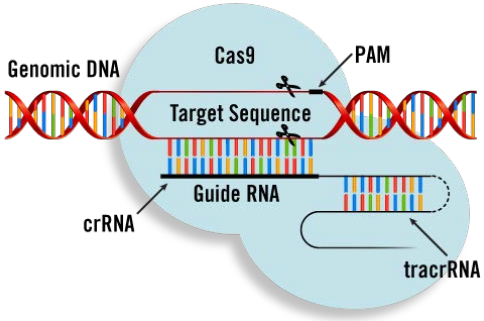
Step 2: Isolate B cells with antibodies that target the pathogen



Step 3: Sequence DNA from B cells

Step 4: Identify anti-Lyme antibody gene sequences

Step 5: Integrate antibodies into the mouse genome using CRISPR



No gene drive!

Timeline

Build heritably immune mice

~2 years to engineer immune mice

~2 years to generate enough mice for a small island

Release on an uninhabited island

2+ years to evaluate effects and raise enough mice for a large island

Release on an inhabited island

Implementation

Release immune mice in early spring

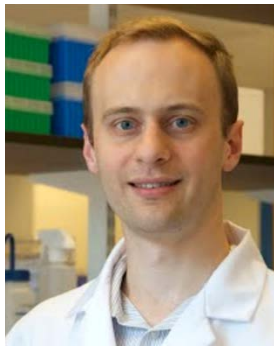
- Introduced mice would at most ***double the local mouse population*** for that time of year

- For context, mouse populations often fluctuate by >400% over the course of a year

- Bait stations could be used to reduce populations near commercial and residential areas

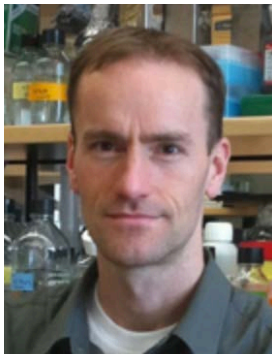
  Local reductions will not impact the spread of resistance

Technical team



Dr. Kevin Esvelt
MIT

Dr. Sam Telford
Tufts



Dr. Duane Wesemann
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Dr. Linden Hu
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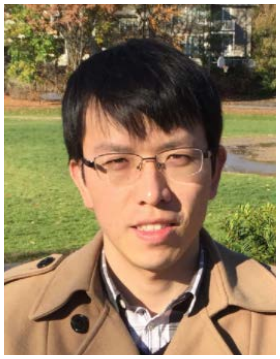

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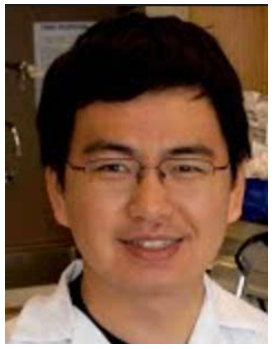

John Min MIT/
Harvard

Plus: Dr. Tom Watson (Arc Bio) and Dr. Tanja Petnicki-Ocwieja (Tufts)

Community-guided science

Local Presentations

- Jun 2016: Nantucket Board of Health meeting
- Jul 2016: Martha's Vineyard health agents meeting
- Jul 2016: Edgartown Library presentation with Professor Sam Telford and Dr. Michael Jacobs
- Oct 2016: Martha's Vineyard All-island Board of Health meeting
- Jan 2017: Nantucket Board of Health meeting
- Mar 2017: Edgartown Board of Health meeting
- May 2017: Aquinnah Board of Health meeting
- May 2017: Presentation at Martha's Vineyard Regional High School
- August 2017: Nantucket Board of Health meeting
- Dec 2017: Steering Committee meeting on Martha's Vineyard

Project Management Structure

Local Steering Committees
Separate committees on Nantucket & MV, each with 6 BOH appointed representatives

Data Safety Monitoring Board
Independent committee of national and local experts

Project Manager
Reports to both Steering Committees

Responsive Science website