



Medical Entomology

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How do insects affect human health?

Nuisance or Phobia

Flies, ants, cockroaches

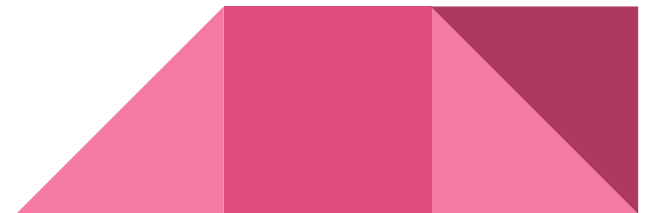
Biting & Sucking

Bed bugs, mosquitoes, fleas

Venoms & Allergies

Wasps, bees, ticks, dust mites

Disease & Infestation



What are vectors?

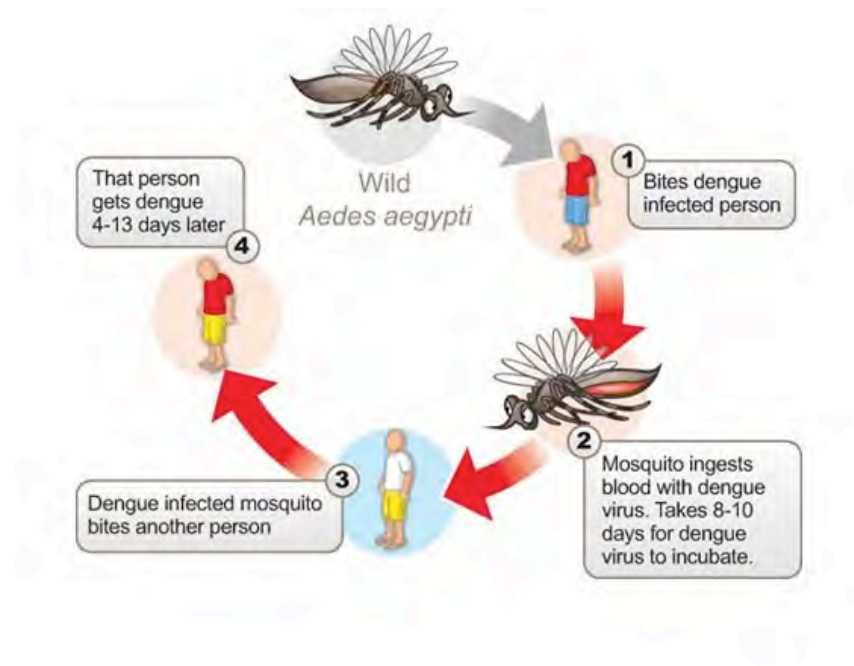
Any agent that carries and transmits an infectious pathogen into another living organism.

Two mechanisms of transmission

Mechanical (flies)

Biological (mosquitoes)

Bloodsucking insects



Ingest disease-producing microorganisms during a

Mosquito-borne Diseases

Ability to carry & spread disease causes millions of human deaths/year

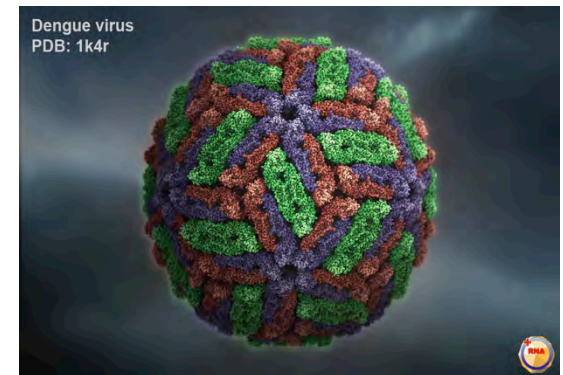
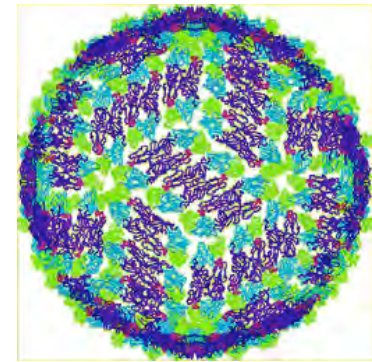
Zika, dengue, chikungunya, and yellow fever- *Aedes aegypti*

Different insects can cause different diseases

Assassin bugs: Chagas disease

Sand flies: Carrion's disease

Mosquitoes (genus *Anopheles*): Malaria



Worldwide incidence of dengue has risen 30-fold in the

Dengue Fever

More than $\frac{1}{3}$ of the world is at risk for infection

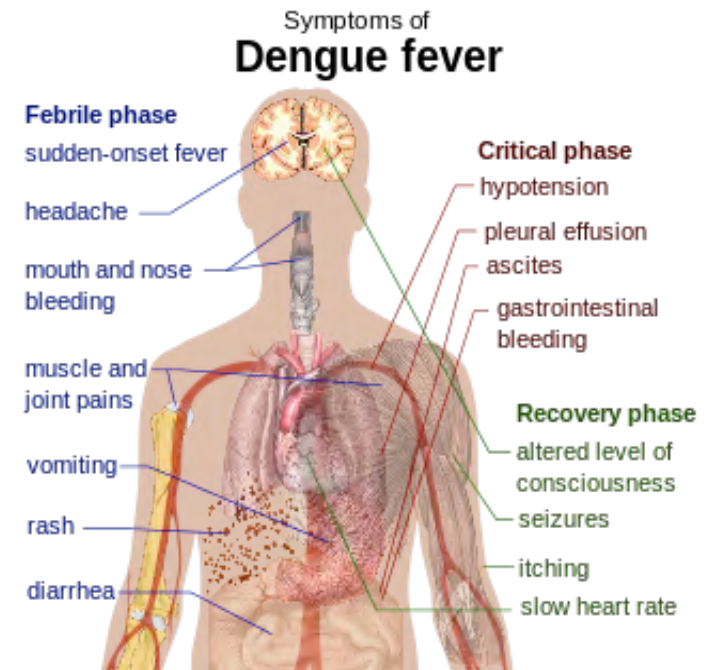
50-100 million people infected yearly

Caused by any one of four dengue arboviruses

Dengue Hemorrhagic Fever

No vaccine or medication currently exists

Vector: *Aedes* mosquitoes



Aedes Mosquitoes and Dengue Transmission



Primary vector: *A. aegypti*

Prefers to live around human habitation

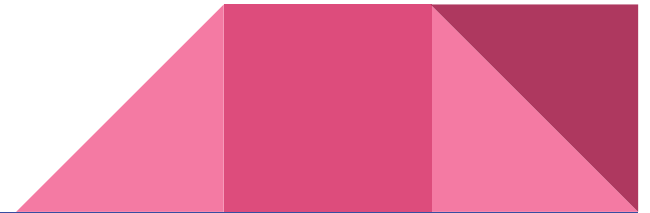
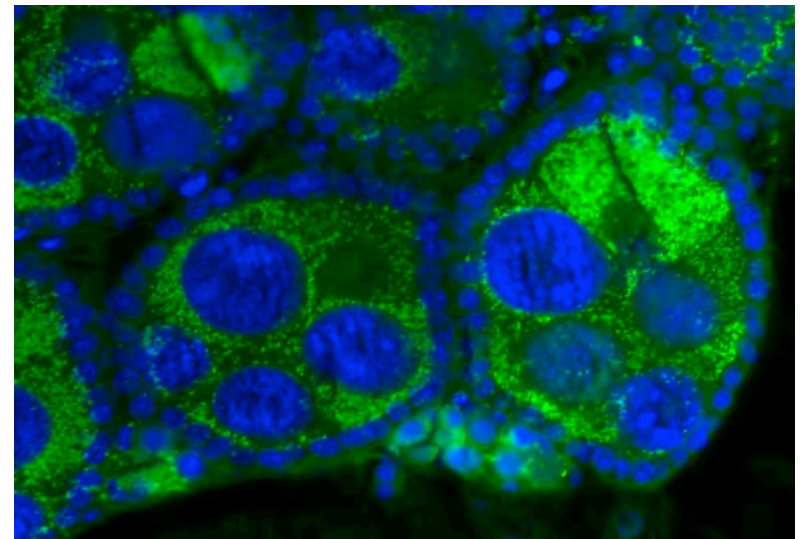
Dengue viruses require a period of incubation before being transmitted.

Sensitive relationship between mosquito survival and vectorial capacity.

Incubation period can be utilized to interrupt transmission.

Wolbachia as a lifespan-shortening agent

Wolbachia pipientis, wMelPop, reduces lifespan of *D. melanogaster* by ~50%



Discussion Question

It is confusing to consider how frequencies of *Wolbachia* infected mosquitoes can increase when their lifespan is cut in half. What is responsible for this? Explain.

Cytoplasmic Incompatibility: uninfected females can only successfully reproduce with uninfected males.

Specific mechanism is unknown, but infected male DNA has been observed to form heterochromatic clumps and prevent mitosis.



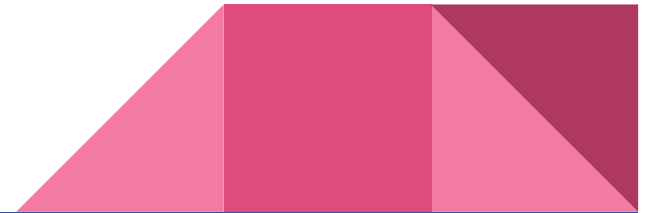
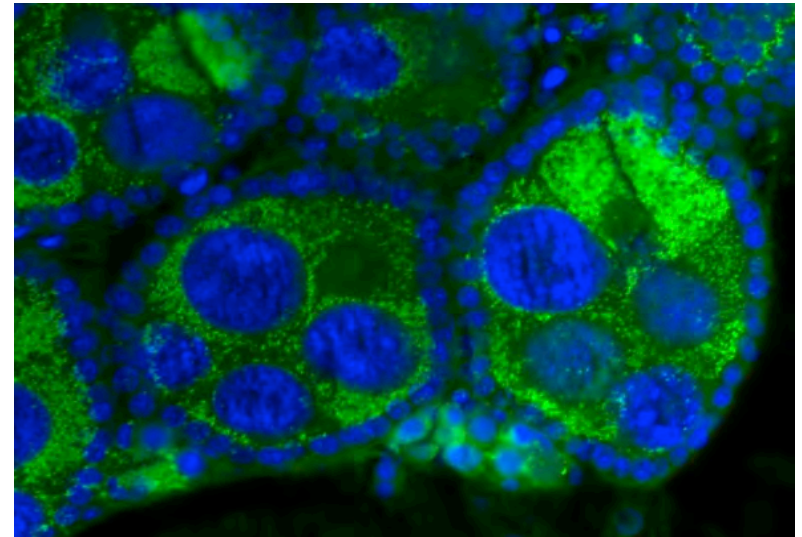
Wolbachia as a lifespan-shortening agent

Wolbachia pipientis, wMelPop, reduces lifespan of *D. melanogaster*

C.I. renders wMelPop a viable candidate

Rapid spread in natural populations (provides infected females a reproductive advantage)

Wolbachia strains do not naturally occur in *A. aegypti*



Is *Wolbachia* an appropriate candidate?

McMeniman *et al.* Methods

Can *Wolbachia* be introduced into *A. aegypti*?

Attempted to facilitate the transfer of *Wolbachia* into *A. aegypti*

Does *Wolbachia* cause similar lifespan reduction?

Compared lifespan reduction in infected and uninfected individuals

Evaluated temperature and genetic drift as a potential external influences.

Does *Wolbachia* have the potential to initiate population invasion?

Determined the strength of C.I. in *A. aegypti*

Results

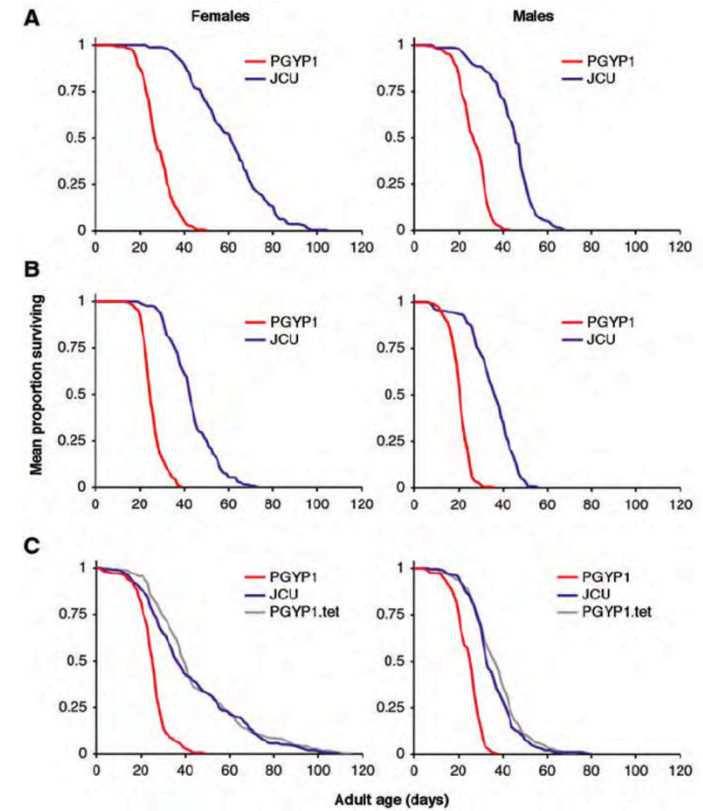
Isolated two strains with stable *Wolbachia* infections

PGYP1 and PGYP2

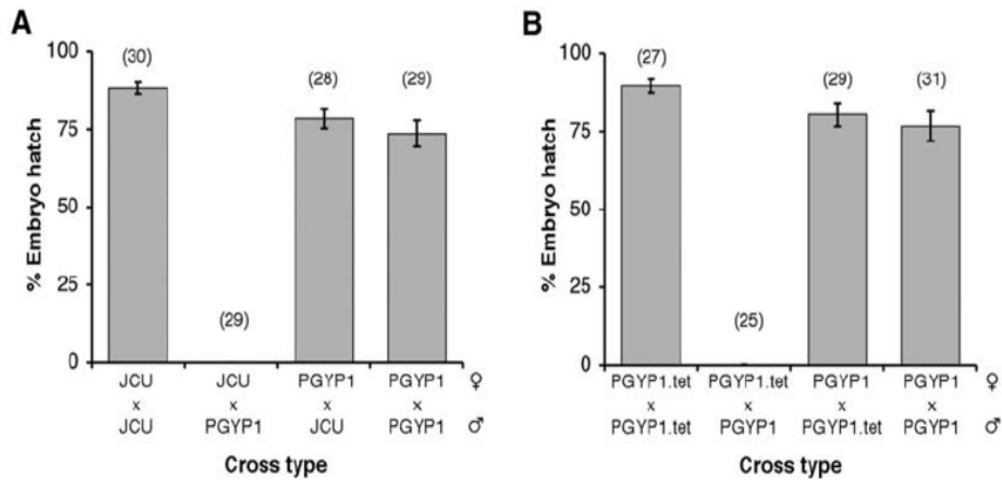
Infected strains showed significant lifespan reduction

Insensitive to fluctuating temperature and humidity

Genetic drift does not appear to be absent



Results



Strong C.I. was observed

PGYP1 had no significant differences in fecundity (PGYP2 19% decrease)

D. simulans

PGYP1 females showed 99%

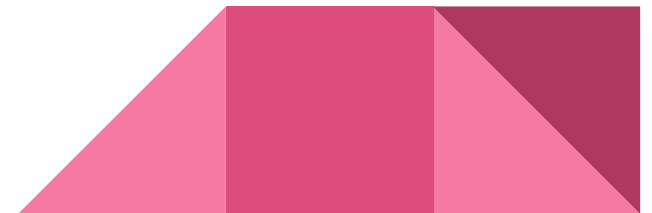
transmission rate of *Wolbachia* to offspring in first and third mating cycles

Implications

In other *Wolbachia*-insect associations, strong CI, high maternal inheritance, and low fecundity costs facilitate the initial spread.

McMeniman *et al.* has displayed these with *Wolbachia* in *A. aegypti*

So if *Wolbachia* can reduce mosquito lifespans and is predicted to have the potential for population invasion, can this be



Hoffmann *et al.* 2011: Can this be done in the wild?

YES! Results indicate *first* case in which wild insect populations were transformed to reduce their ability to act as vectors of human disease agents!



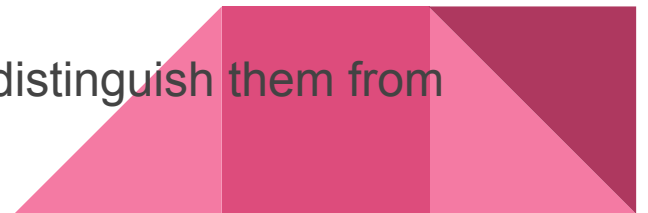
Methodology

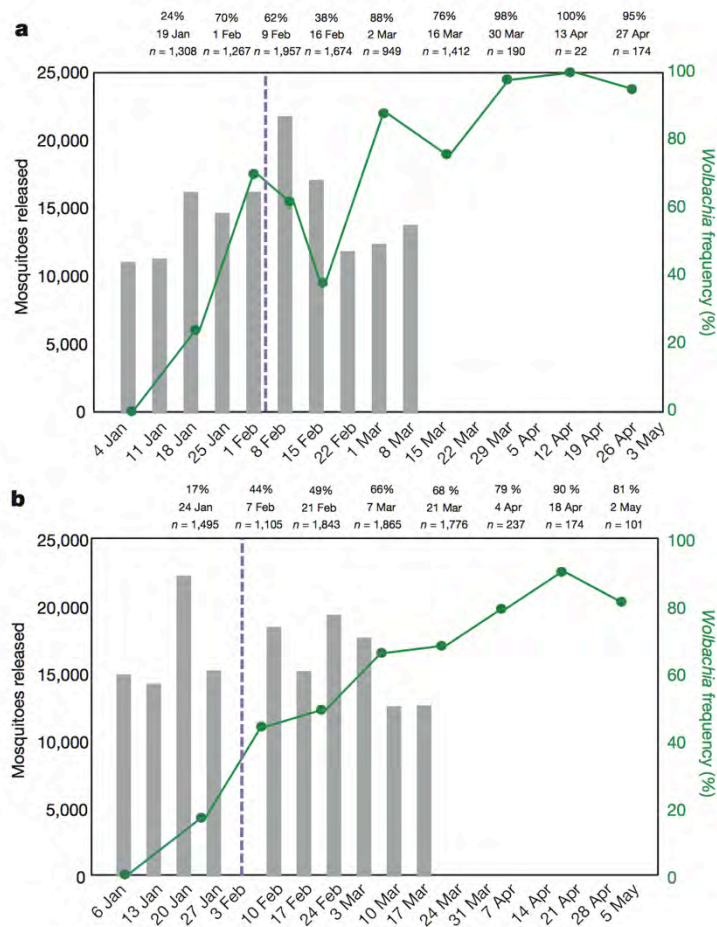
Deliberate introduction of *Wolbachia* with the wMel strain into wild Australian *A. aegypti* populations

Released adult males and females during the wet season at different sites throughout field locations

Monitored *Wolbachia* frequencies every 2 weeks

Used PCR assay to screen larvae for *Wolbachia* & to distinguish them from other *Aedes* species





Results

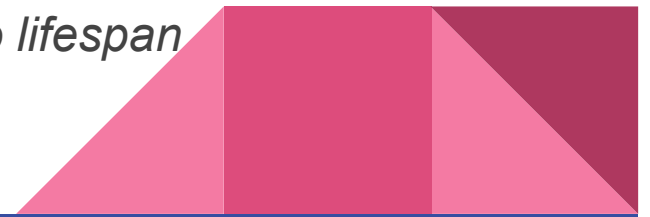
- Frequencies of infected *A. aegypti* increased to >60%
- Small decreases in frequency at both sites at the onset of the dry season
 - Why?
 - Decrease in size of mosquito population
 - Less water = less reproduction
- The *Wolbachia* strain was effective in reducing the transmission of dengue

The *wMel Wolbachia* strain from *D. melanogaster*

What did they find?

This strain could invade a population more effectively
than **WmelPop-CLA**

Originally introduced to *A. aegypti* with the goal of indirectly reducing
dengue transmission by *reducing mosquito lifespan*



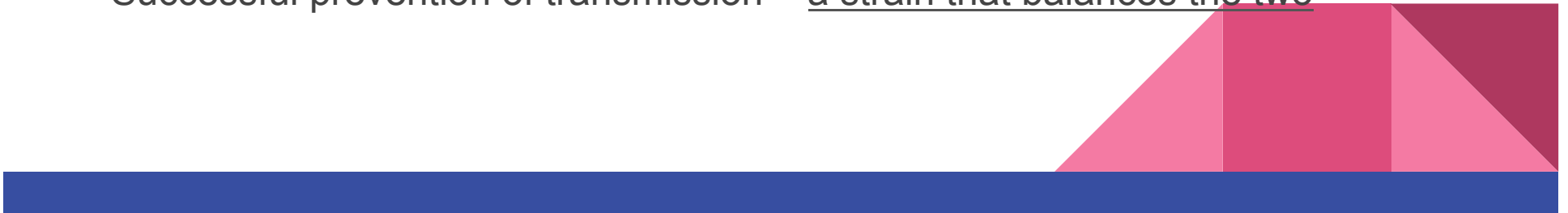
What about host fitness costs?

Strength of *Wolbachia* disruption of transmission depends on the strain used

Strains that provide greater disruption also confer greater fitness costs to host

Walker *et al.* (2011): As fitness costs increase, higher *Wolbachia* frequencies are needed for invasion

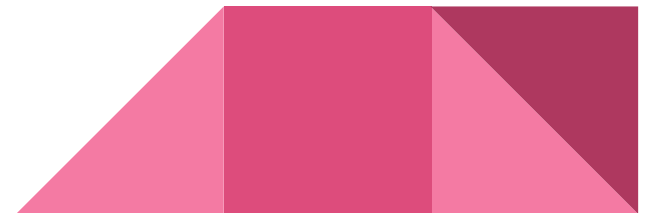
Successful prevention of transmission = a strain that balances the two



Discussion Question

Both papers mention that *Wolbachia* indirectly reduces the ability of insects to transmit pathogens by shortening their lifespan. Given that mosquitos have enormous ecological importance, could we potentially observe unintended ecological consequences if *Wolbachia*-infected mosquito populations are introduced into natural ecosystems for disease control purposes? If so, what might they be?

Since this has not been studied in the wild, no definitive answer exists. Further research is required.

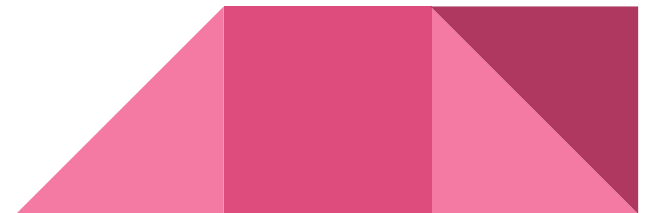


Discussion Question

Areas endemic with dengue fever receive frequent doses of insecticides and mosquitos often develop resistance. What effect do you think insecticide resistance has on the *Wolbachia* infection? Is this good or bad?

Berticat *et al.* (2002) has shown that in the common the house mosquito, *Culex pipiens*, individuals with resistance were more infected with *Wolbachia* than non-resistant individuals.

Propose that mosquitoes may control *Wolbachia* densities less efficiently when suffering from the physiological cost of insecticide resistance.



Discussion Question

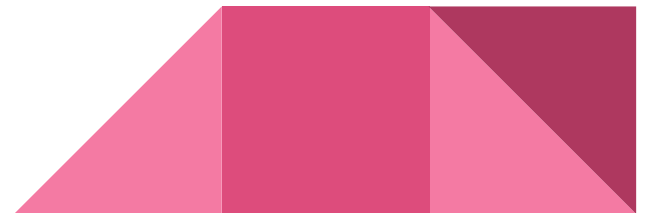
Are the mosquitoes infected with *Wolbachia* more likely to transmit other diseases?

Moreira *et al.* (2009) found that *Wolbachia* infections limit infection by Dengue, Chikungunya and *Plasmodium*.

Priming of the mosquito innate immune system

Competitive exclusion for host resources

Lipids; Cholesterols



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