Problem Based Learning Module

Background:

Zika virus is spread to people through mosquito bites. The most common symptoms of Zika virus disease are fever, rash, joint pain, and conjunctivitis (red eyes). The illness is usually mild with symptoms lasting from several days to a week. Severe disease requiring hospitalization is uncommon.

In May 2015, the Pan American Health Organization (PAHO) issued an alert regarding the first confirmed Zika virus infection in Brazil. The outbreak in Brazil led to reports of Guillain-Barré syndrome and pregnant women giving birth to babies with birth defects and poor pregnancy outcomes. Since the mosquito that transmits this virus is moving toward North America the following information should be kept in mind:

- No vaccine exists to prevent Zika virus disease (Zika).
- Prevent Zika by avoiding mosquito bites (see below).
- Mosquitoes that spread Zika virus bite mostly during the daytime.
- Mosquitoes that spread Zika virus also spread dengue and chikungunya viruses.

Problem:

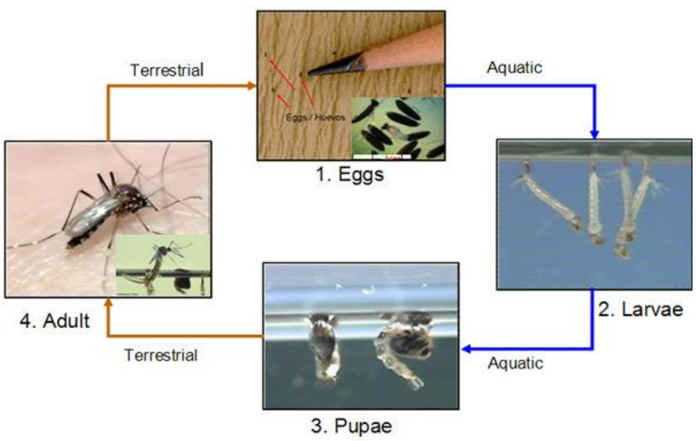
Since this mosquito and others are known to carry and transmit viruses and they tend to thrive and breed around water, what can be done to help prevent their spread?

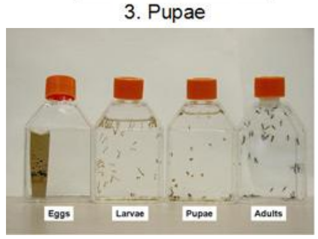
Component	Science	Math	Engineering
Background			
Propagation			
Non-Bio Solution(s)			
Organic/Bio Friendly Solution(s)			

Instructor Information:

Mosquito Life-Cycle

Aedes aegypti and other mosquitoes have a complex life-cycle with dramatic changes in shape, function, and habitat. Female mosquitoes lay their eggs on the inner, wet walls of containers with water. Larvae hatch (picture 1, inset) when water inundates the eggs as a result of rains or the addition of water by people. In the following days, the larvae (picture 2) will feed on microorganisms and particulate organic matter, shedding their skins three times to be able to grow from first to fourth instars. When the larva has acquired enough energy and size and is in the fourth instar, metamorphosis is triggered, changing the larva into a pupa (picture 3). Pupae do not feed; they just change in form until the body of the adult, flying mosquito is formed. Then, the newly formed adult emerges from the water after breaking the pupal skin (picture 4, inset). The entire life cycle lasts 8-10 days at room temperature, depending on the level of feeding. Thus, there is an aquatic phase (larvae, pupae) and a terrestrial phase (eggs, adults) in the *Ae. aegypti* life-cycle.
It is this life-cycle complexity that makes it rather difficult to understand where the mosquitoes come from. Similar complex life-cycles with aquatic and terrestrial forms are observed in amphibians. For educational and training purposes, it is rather useful to make life-cycle kits, so people have an opportunity to watch how the aquatic stages turn into terrestrial ones.





There is a very important adaptation of dengue vectors that makes controlling their populations a difficult task. Their eggs can withstand desiccation for several months, which means that even if all larvae, pupae, and adults were eliminated at some point in time, repopulation will occur as soon as the eggs in the containers are flooded with water. Unfortunately, there is no effective way to control the eggs in containers

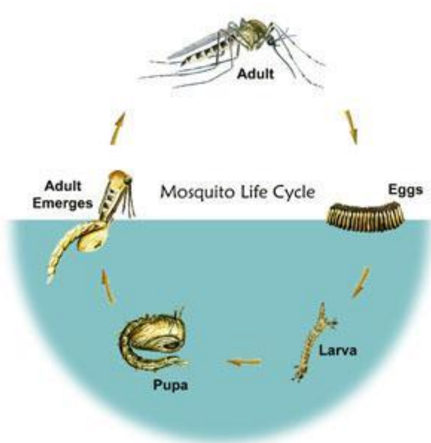
Knowing the different stages of the mosquito's life will help you prevent mosquitoes around your home and also help you choose the right pesticides for your needs, if you decide to use them. All mosquito species go through four distinct stages during their life cycle:

- egg - hatches when exposed to water
- larva - (plural: larvae) "wriggler" lives in water; molts several times; most species surface to breathe air
- pupa - (plural: pupae) "tumbler" does not feed; stage just before emerging as adult
- adult - flies short time after emerging and after its body parts have hardened.

The first three stages occur in water, but the adult is an active flying insect. Only the female mosquito bites and feeds on the blood of humans or other animals.

- After she obtains a blood meal, the female mosquito lays the eggs directly on or near water, soil and at the base of some plants in places that may fill with water. The eggs can survive dry conditions for a few months.
- The eggs hatch in water and a mosquito larva or "wriggler" emerges. The length of time to hatch depends on water temperature, food and type of mosquito.
- The larva lives in the water, feeds and develops into the third stage of the life cycle called, a pupa or "tumbler." The pupa also lives in the water but no longer feeds.
- Finally, the mosquito emerges from the pupal case after two days to a week in the pupal stage.
- The life cycle typically takes up two weeks, but depending on conditions, it can range from 4 days to as long as a month.

The adult mosquito emerges onto the water's surface and flies away, ready to begin its lifecycle.



Mosquitoes' Main Aquatic Habitats

Aquatic habitats are containers in which eggs develop into adult mosquitoes. Mosquitoes that transmit dengue lay eggs on the walls of water-filled containers in the house and patio. The eggs hatch when submerged in water and can survive for months. Mosquitoes can lay dozens of eggs up to 5 times during their lifetime.

There is a great variety of man-made containers on backyards or patios that collect rain water or that are filled with water by people where dengue vectors thrive. Disposing of unused containers, placing useful containers under a roof or protected with tight covers, and frequently changing the water of animal drinking pans and flower pots will greatly reduce the risk of dengue infections. Water storage containers should be kept clean and sealed so mosquitoes cannot use them as aquatic habitats.

Minimum survival temperature

The minimum survival temperature tolerated by the European eggs of *Ae. albopictus* after a diapause (Figure 1) was -10°C for long term exposures (12 and 24h), while they survived short term exposure (1h) at -12°C. Non-diapausing eggs of European *Ae. albopictus* were found to hatch even after a 4h treatment at -12°C. However, with mean and long term exposures (8, 12 and 24h) hatching only occurred at less extreme temperatures (-7°C). The tropical aedine species only differed in its hatch response for the 1h cold treatment: While tropical *Ae. albopictus* survived at -10°C, *Ae. aegypti* hatched at -7°C. In contrast to the short term exposure to cold temperatures, both species only tolerated the long term treatment at -2°C. The minimum survival temperature for different durations of exposure did not differ significantly between strains/species according to the Monte-Carlo permutation procedure of the slopes of the linear regression.

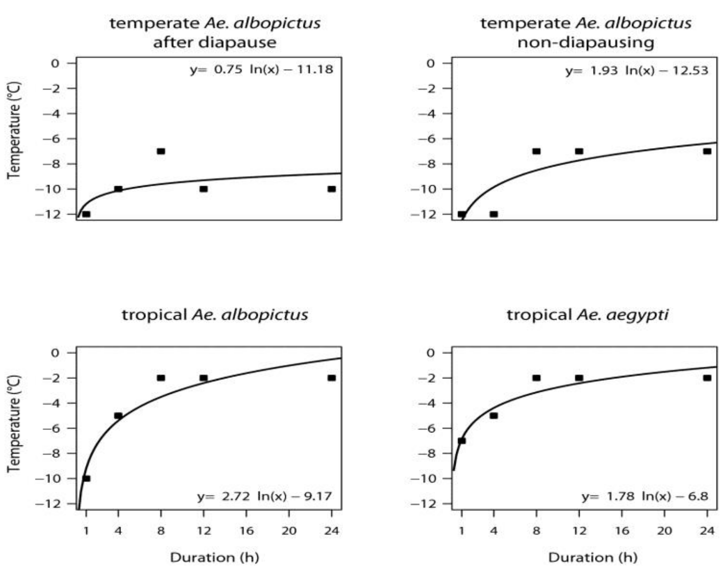


Figure 1

Minimum survival temperature of *Aedes* eggs after cold treatment. Minimum survival temperature in comparison to duration of treatment for European eggs which have undergone a diapause and non-diapausing eggs of *Ae. albopictus* and tropical eggs of *Ae. albopictus* and *Ae. aegypti*. Eggs of European *Ae. albopictus* which passed through a diapause survive lower minimum temperatures than non-diapausing eggs when exposed for more than 12h, whereas no differences occurred for short exposure (1h). Eggs of tropical *Ae. albopictus* survive lower minimum temperatures than *Ae. aegypti* eggs when exposed for 1h, whereas no differences occurred for longer exposure (>8h).

Math connections:

Modeling:

Once students determine a solution, they should derive an equation relating the independent variable (whatever solution they are implementing and how much/little of it) and the dependent variable (the amount of mosquitos/larvae remaining). This may result from research on the effects of their chosen intervention or small-scale testing. This will likely be an exponential/ logarithmic relationship. Students should demonstrate their equations in tables and graphs.

Implementation and Prediction:

Based on the models derived above, students should determine an appropriate input (temperature level, number of traps, number of birdhouses, etc.) that will result in the desired change to mosquito populations. This will require solving exponential and logarithmic equations (standards **MGSE9-12.A.SSE.3, MGSE9-12.F.IF.7&8, MGSE9-12.F.BF.5, and MGSE9-12.F.LE.4**).

Data Tracking:

As interventions are implemented, students will log data on their independent and dependent variables. After appropriate time intervals, students will construct scatter plots of the observed data and compare to the experimental model they originally came up with. By calculating residuals, students will determine the appropriateness of their models and help them make necessary adjustments to their intervention strategy.