



# Epidemiology and control of mosquito-borne diseases

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# Teacher Information

## LEARNING OBJECTIVES

- To learn the importance of mosquitoes and the viruses and pathogens they transmit
- To understand the multiple components that contribute to the epidemiology of mosquito-borne diseases
- To utilize the provided information to think about ways in which mosquito-borne diseases can be controlled

## GUIDING IDEAS

1. Students should understand the multiple components of mosquito-borne diseases that are common in the United States. Prepare the students by watching one or both of the following videos:
  - “One Mosquito Bite Can Change a Life Forever”  
<https://www.mosquito.org/page/imone?&hhsearchterms=%22am+and+one%22>
  - “Mosquito Control and Why It Is Important”  
<https://www.youtube.com/watch?v=fw4JvqSrbCc>
2. From the videos, the students should be able to understand that mosquitoes are still the number one most dangerous animal on the planet, and all it takes is just one mosquito bite to change a life forever.
3. Before starting the Minecraft activities, discuss the importance of mosquitoes and mosquito-borne diseases in the United States. Use the following questions to help guide the discussion:
  - Why are mosquitoes important?
  - What mosquito-borne diseases can you think of?
  - How important are mosquito-borne diseases in your own area?
  - Do you know where you can find information on mosquitoes and mosquito-borne diseases in your area?
  - In what ways are mosquito-borne diseases reduced?
  - How would you go about making sure that there wasn't an increased risk of mosquito-borne diseases (West Nile virus, EEE) in your area?
  - How many of your students are aware of the fact that the only way for your pets to get heartworm is through the bite of a mosquito?
  - What are some reasons why Zika virus was such a concern?

## STUDENT ACTIVITIES

### 1. DESCRIBE MATERIAL IN THE COLOR CHARTS

- a. What is epidemiology? (Prepare by reading “**Part 1: Epidemiology**”)
- b. Describe the concept of an epidemiological triangle/pyramid
- c. What are the different parts of the pyramid
  - **Red Chart** = mosquito vectors
  - **Blue Chart** = Disease agents
  - **Yellow/Orange Chart** = Hosts and reservoirs
  - **Green Chart** = Environment
- d. How do the pieces in the different charts fit together?
  - **Purple Chart** = Components of each disease
- e. How are each of the pieces important in mosquito-borne diseases?

### 2. DISCUSS WAYS IN WHICH DISEASES CAN BE CONTROLLED

- a. In what ways can you target some of these components for controlling or preventing the spread of disease?
  - Prepare by reading “**Part 2: Disease control**”
  - Use the charts to begin discussion
    - **Black Charts** = Different Control Strategies
  - Are there other strategies that were not in the charts?

### 3. IDENTIFY THE DISEASE ECOLOGY AT 6 SITES IN THE MINECRAFT WORLD

- a. Have the students tour through the Minecraft world. At each site (6 total), there will be a character that will help students teleport to different sites.
- b. Have students tour all 6 different sites (stations)
- c. Have the students fill out **CHART 1** as they visit each site
  - Which disease is represented, How do they know which disease?
  - How might they control disease in this area?

### 4. DIVIDE STUDENTS INTO 6 GROUPS

- a. Prior to opening Minecraft, have students fill out **CHART 2**, describing ways in which they will control the disease in the Minecraft World.
- b. Within the Minecraft world, have students do the following:
  - Have the students create their own epidemiological pyramid
  - Have students modify their Minecraft site location to control disease
  - Take before and after screen shots of the sites
- c. When complete, have students report their findings, and explain the benefits and the potential negative impacts of any of the control strategies used.

## **PERFORMANCE EXPECTATIONS**

- Students should be able to discuss the components of their disease, and develop a strategy to reduce risk to humans/animals.
- Students should fill out the part 1 chart, to show they understand the components of each of the 6 mosquito-borne diseases
- Students should use the chart in part 2 as a starting point on how to plan out their disease control strategy
- Students should present their findings in a report or presentation. Use the following format as a guideline:
  - Introduction: Have students/groups describe their mosquito-borne disease. Why is it important? What are the different components (agent, vector, host, environment). Have them include a screen shot of their epidemiological pyramid created in Minecraft.
  - Methods: Have them describe the control strategies they decided to implement. Provide any interesting details on HOW these strategies were conducted.
  - Results: Have them show their screenshots of their site before and after they implemented their changes.
  - Discussion: Have them describe in what ways their modifications can help reduce the risk of these mosquito-borne diseases. Have them also discuss other ways to help further reduce risk. Have them describe the advantages and disadvantages to each strategy.

## **SKILLS**

- Creativity
- Communication

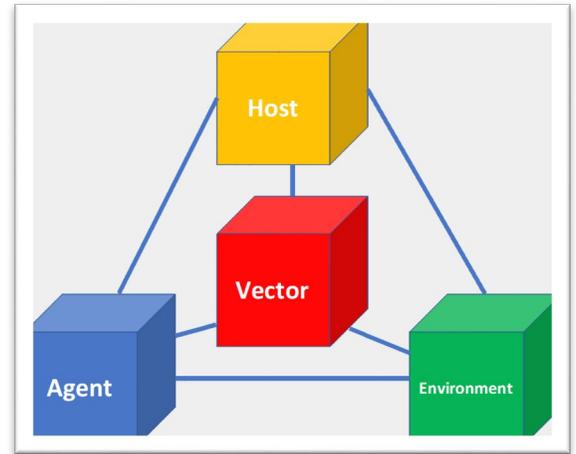
## **SUPPORTING FILES**

- Lesson plan outline
- Part 1: Epidemiology write up
- Epidemiology color charts
- Part 2: Disease control write up
- Control color charts
- Student work sheets
- Minecraft World file

# PART 1: EPIDEMIOLOGY

**Epidemiology** is the study of the distribution and causes of disease, and the application of this study to the control of disease. Scientists often describe a disease's components using an epidemiological TRIANGLE. In mosquito-borne diseases, it is more like a PYRAMID, because of the addition of the insect (vector) in transmission.

The pyramid of the disease is made up of the (1) agent, (2) host, (3) environment, and (4) vector.



- In mosquito-borne diseases, **agents** include West Nile virus, Zika virus, Malaria parasites, heartworms, or other pathogens.
- The insect or arthropod that transmits an agent is called a **vector**. A vector, such as a mosquito, transmits a pathogen from one host to another.
- The **hosts**, are those humans and/or animals that can become infected or house the agent.
- Lastly, the **environment** is an important part of the disease cycle. For example, some diseases are more abundant in urban environments, where as some might be more abundant in cool rural climates.



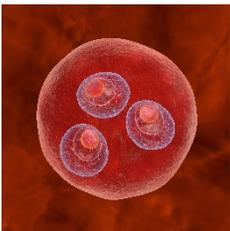
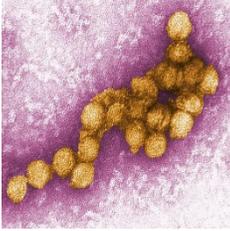
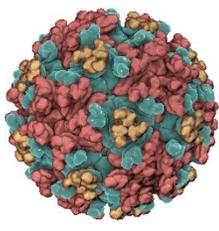
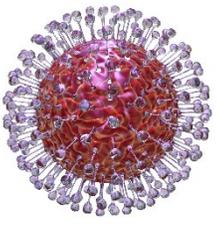
**In Minecraft**, you will be asked to construct your own pyramid for a particular disease agent. Connect 4 different blocks together, and use signs to describe each component of the epidemiological pyramid. Pick blocks that you feel best represent your different components, such as a blood red block to represent a mosquito.

## VECTORS

	MOSQUITO	Scientific name	Habitat preferences	Bloodmeal hosts
	U.S. Malaria mosquito	<i>Anopheles quadrimaculatus</i>	Prefers to lay eggs in larger more permanent bodies of water, such as swamps and small vegetated ponds. These are most often found in rural areas, and will readily come inside homes to find blood.	Prefers large mammals, such as humans and deer.
	Southern House mosquito	<i>Culex quinquefasciatus</i>	Lays eggs in polluted and human waters, such as septic and sewer systems. Also lays eggs in abandoned swimming pools. Prefers living close to humans. Readily comes inside homes to feed.	Prefers to feed on birds, but will readily bite humans and other animals when available. Often feeds on people when enters homes.
	Salt marsh mosquito	<i>Aedes sollicitans</i>	Lays eggs in wet areas that become flooded in salty marshes in coastal areas. Adults often fly long distances inland, where they can find cooler shady areas to rest.	Readily bite humans and large mammals (deer, horses). Will fly miles inland from salt marshes to find a source of blood.
	Asian tiger mosquito	<i>Aedes albopictus</i>	Lays eggs in backyard containers, such as buckets, trash cans, bird baths, water barrels, tires, and other small artificial containers that hold water for 7 days or more. Lives close to people.	Prefers to feed on humans and animals found in urban/suburban habitats, such as dogs, cats, raccoons, possums, and humans.
	Floodwater mosquito	<i>Aedes vexans</i>	Lays eggs in areas that will eventually become flooded. Good examples of this include small lawn depressions and flooded fields.	Prefers to feed on humans and other mammals
	Woodland pool mosquito	<i>Aedes canadensis</i>	Lays eggs in pools of water that hatch as snow melts in the spring, collecting water in these habitats. Later in the season, can be found in small collections of water in rural areas.	In the early spring, it is common to find this mosquito feeding on turtles. Later in the season, will feed on humans and larger mammals (deer)

\*Vectors are insects (or other arthropods) that transmit pathogens from one host to another. Fleas and ticks are also vectors.

## AGENTS

	Pathogen (Agent)	Scientific name	Symptoms caused by infection	Importance
	Malaria parasite	<i>A protozoa, including Plasmodium vivax and Plasmodium falciparum</i>	Intense periods of fever, chills, and sweating. These occur in consistent intervals.	Every 30 seconds a child in this world dies from Malaria. It was once abundant in the U.S., but was eradicated through large scale mosquito control efforts.
	West Nile virus	<i>A virus in the family Flaviviridae</i>	While most people are asymptomatic, others might have flu-like symptoms. Severe cases can have neurological complications, such as encephalitis.	Since it was first found in the U.S. in 1999, there continues to be human cases throughout the U.S. annually. The virus is cycled through birds from bird biting mosquitoes.
	Eastern Equine Encephalitis virus	<i>A virus in the family Togaviridae</i>	The most notable symptom of this disease is Encephalitis (a swelling of the brain).	While there are very few human cases reported annually, mortality rate is very high. It is cycled between birds and mosquitoes.
	Zika virus	<i>A virus in the family Flaviviridae</i>	While most cases are mild, the greatest concerns are neurological deficits to babies born from mothers with Zika virus infection. An example is microcephaly.	Prior to 2016, there was very little information on Zika virus. However, once it came over to the Western Hemisphere, we learned about the link between Zika and microcephaly.
	Jamestown Canyon virus	<i>A virus in the family Bunyaviridae</i>	Most often results in flu-like symptoms. Similar to other mosquito viruses, it can also result in neurological complications.	While it is less abundant than West Nile virus, there has been an increase in cases in recent years.
	Canine Heartworm	<i>A nematode worm called Dirofilaria immitis</i>	When a dog becomes infected, the worms reproduce over time and eventually take up space in the heart. This results in difficulty breathing and fatigue.	The only way for pets to get heartworm is through the bite of an infected mosquito. It can be prevented through monthly medicine.

\*NOTE: Antibiotics are used to kill **bacteria**. There are currently no antivirals for mosquito-borne **viruses**. There are antimalarial drugs available. For both Malaria and heartworm, they are treatable (after getting sick). However, there are also preventative medicines, which can be taken to prevent the disease before getting sick.

## BLOOD MEAL HOSTS AND RESERVOIRS

	Host	Why they are important	pathogens
	Humans	Humans can become ill from mosquito-borne diseases. They can also serve as reservoirs for pathogens causing Malaria, Zika, Dengue, Yellow fever, and Elephantiasis.	Malaria and Zika virus can cycle between humans and mosquitoes. While West Nile virus, Eastern Equine encephalitis virus, and Jamestown canyon virus can all make humans sick, humans are not reservoirs for these.
	Birds	West Nile virus and Eastern Equine encephalitis are both cycled between birds and mosquitoes. They are the primary reservoir for both viruses.	Reservoirs for both West Nile virus and Eastern Equine encephalitis virus
	Horses	Are not important reservoirs. But often get sick and die from infection from many mosquito-borne viruses.	While they are not reservoirs for West Nile virus or Eastern Equine encephalitis virus, they can become very ill and die from the viruses. There are vaccines available for horses to prevent this.
	Turtle	Turtles provide an early source of blood for many early season mosquitoes, such as woodland pool mosquitoes.	There is some evidence to suggest they might hold viruses during the winter.
	Ruminants, such as cows, sheep, and deer	Are an important food source for many large mammal feeding mosquito species	Serve as reservoirs for Jamestown Canyon virus.
	Dogs and wolves	Dogs are an important reservoir for canine heartworm. The worm cycles between mosquitoes and wild canines and dogs.	Heartworm is a very important mosquito-borne disease to dogs.

\*A reservoir is a type of animal that carries a pathogen, and accumulates it at high enough levels that a vector can pick it up and pass it along to a different host.

## ENVIRONMENT

	Habitat	Why is it important	Which pathogens may be important?
	Swamp	Produces a variety of mosquitoes. Holds water for long periods of time	Malaria, Eastern Equine Encephalitis virus, or Jamestown Canyon virus
	Saltmarsh	Produces very large numbers of mosquitoes that fly inland and can be potential vectors of viruses. Large numbers are produced during heavy rainfall events, or when monthly lunar tides are at their highest.	Produces some potential vectors of Eastern Equine encephalitis virus
	Urban/Suburban	In addition to having people in close contact with each other, many species of mosquitoes prefer to lay eggs in backyard habitats. These include bird baths, buckets, trash cans, tires, pools, and more.	West Nile virus, zika virus, heartworm
	Polluted waters	This type of habitat is very attractive to northern and southern house mosquitoes.	House mosquitoes are the primary vectors of West Nile virus
	Vernal Pools	This type of habitat occurs from snow melting in the spring and filling small pools. This creates a habitat for woodland pool mosquitoes.	Jamestown Canyon virus
	Fields	Small depressions in fields can hold water after rains. These mosquitoes are vicious biters. These sites are also problematic after heavy rain or storms, such as hurricanes, producing large numbers of biting mosquitoes.	Heartworm

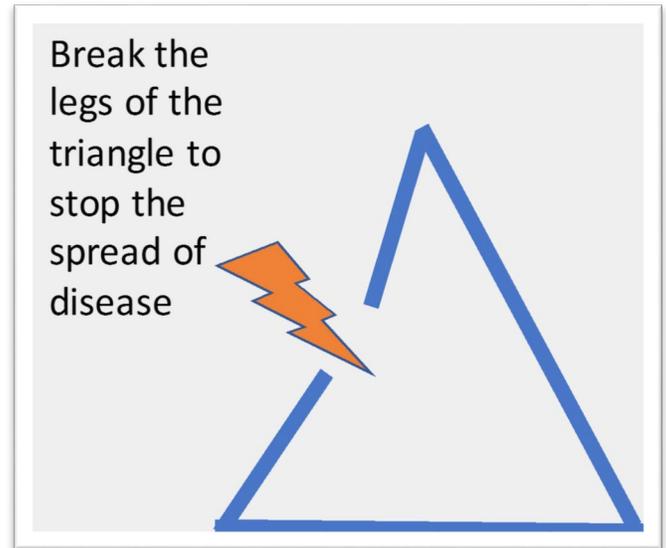
## DISEASES IN THE U.S.

DISEASE	AGENT	VECTOR	HOST	ENVIRONMENT
<b>MALARIA</b>	<i>Plasmodium falciparum</i> Protozoa	U.S. Malaria mosquito, <i>Anopheles quadrimaculatus</i>	Humans cycle the protozoa between mosquitoes. Many humans also die from the disease	Malaria is much more common in areas where it is difficult to prevent mosquitoes from entering homes
<b>WEST NILE</b>	Flavivirus (type of virus) in the family Flaviviridae	Northern and Southern House mosquitoes ( <i>Culex pipiens</i> and <i>Culex quinquefasciatus</i> ) cycle it between birds and can also bite humans	The virus is maintained in birds (reservoirs). Humans can become sick if infected.	West Nile virus is common in suburban areas where you have the mosquitoes and birds in contact with each other
<b>EASTERN EQUINE ENCEPHALITIS</b>	Alphavirus (type of virus) in the family Togaviridae	Primary vector is the black tailed mosquito ( <i>Culiseta melanura</i> ), which cycles the virus between birds. However, the saltmarsh mosquito is a potential vector when both mosquito and virus levels are high.	The virus is maintained in birds. The disease gets its name because horses (and humans) can occasionally become infected and die.	The most important vector lives in swampy habitats. However, this mosquito only bites birds. The risk to humans occurs when other mosquito species, such as salt marsh mosquitoes, are high in number during high virus activity
<b>CANINE HEARTWORM</b>	Nematode worm, <i>Dirofilaria immitis</i>	There are numerous species of mosquitoes that are important vectors, including <i>Aedes vexans</i> , our floodwater mosquito	Canines, including dogs, coyotes, and wolves are important reservoirs	Heartworm occurs throughout the U.S High risk areas include where dogs live outside, especially where there are ample mosquitoes and other infected canines.
<b>JAMESTOWN CANYON</b>	Bunyavirus (type of virus) in the family Bunyaviridae	Some of the early season woodland pool and snow melt mosquitoes, such as <i>Aedes canadensis</i> , are important vectors	The virus is maintained in ruminants, such as deer and cow. Humans can become sick if infected.	Both the mosquito vectors and reservoirs occur in more rural areas.
<b>ZIKA</b>	Flavivirus (type of virus) in the family Flaviviridae	The most important vectors are those that live close to people in backyard containers. One potential concern are Asian tiger mosquitoes, <i>Aedes albopictus</i> .	Humans are the primary host, as the virus is cycled between humans and mosquitoes.	Zika virus is more common in suburban and urban areas where the mosquitoes occur, and where there are more humans to pick up the virus from.

## PART 2: DISEASE CONTROL

While part of epidemiology is about learning what causes disease, it also involves targeting ways of controlling disease. One of the ways we can control disease and prevent further spread, is by evaluating different parts of the epidemiological pyramid.

For example, if we want to eliminate the spread of the same disease that killed over 1/3 of Napoleon's army, we would target control of body lice (**the vector**). While they weren't available in Napoleon's time, today we can also use antibiotics to target the bacteria (**the agent**) that causes Epidemic typhus (**the disease**). We can also promote good hygiene in humans (**the host**) to further reduce the spread. This is important, because poor hygiene and living in close contact (**the environment**) contributes to the spread of epidemic typhus.



***Think about the following before moving onto the Charts describing different control methodologies.***

- In what ways can we control different AGENTS, such as bacteria, viruses, worms, fungi, and protozoa? Are there medicines for each? Are there vaccines available? Do we target humans or animals?
- In what ways can we control VECTORS? How do mosquito control programs target mosquitoes in your area? Did you know that many provide educational resources to schools to learn more?
- In what ways can we limit the disease in HOSTS?
- How does our ENVIRONMENT contribute to the spread of these diseases? Are there ways we can modify our environment to control disease?

***NOTE: THE INCLUDED CHARTS ARE NOT ALL INCLUSIVE. STUDENTS ARE FREE TO USE THEIR CREATIVITY TO THINK OF ALTERNATIVE WAYS OF CONTROLLING THE DISEASE.***

## CONTROL STRATEGIES (PAGE 1)

	STRATEGY	EXAMPLES IN MINECRAFT	HOW DOES IT CONTROL?
	<p>Biological Control (using natural predators)</p>	<p>Spawn various types of Fish, Turtles, Bats, or other insectivorous animals within your habitat</p>	<p>Add fish to sources of standing water to control immature mosquitoes (mosquito larvae). While Bats do not consume a significant number of adult mosquitoes, they can be used to help eat night flying insects in general.</p>
	<p>Removing sources of water</p>	<p>Get rid of any containers holding (or that might hold) standing water, such as cauldrons, plant pots, bowls, and other small containers). You can also remove water using an empty bucket.</p>	<p>Since mosquitoes lay eggs in water that is flooded or becomes flooded, removing the source of water can help reduce mosquitoes from laying eggs in the area</p>
	<p>Filling in areas that collect water</p>	<p>Use dirt and grass blocks to fill in smaller bodies of water, such as depressions in lawns and puddles.</p>	<p>Since mosquitoes lay eggs in water that is flooded or becomes flooded, removing the source of water can help reduce mosquitoes from laying eggs in the area</p>
	<p>Repairing windows and doors</p>	<p>Add glass or glass panes to create windows, or add doors. Make sure there are no open areas that would allow mosquitoes to enter a house</p>	<p>Many important species of mosquitoes like to come inside to take blood meals from humans. You should prevent them from entering homes. This also protects sick individuals from spreading the infection to other mosquitoes.</p>
	<p>Insecticides to control mosquito larvae (larvicides)</p>	<p>Use a dye in a cauldron full of water to demonstrate that you have applied larvicides. Also, you can utilize splash potions of poison added into the water.</p>	<p>Immature mosquitoes will ingest this larvicide, preventing them from becoming mature adult mosquitoes. Most mosquito larvicides only kill mosquito larvae, and do not affect any other insects or animals.</p>
	<p>Insecticides to control mosquito adults</p>	<p>Splash poison potion or splash harming potions</p>	<p>In reality, insecticides are sprayed at very low levels (like spreading a table spoon of salt over an entire acre). Some of the insecticides used are actually less toxic to humans than table salt. Fortunately, these very small amounts will effectively kill adult mosquitoes when there is high risk.</p>

## CONTROL STRATEGIES (PAGE 2)

STRATEGY	EXAMPLES IN MINECRAFT	HOW DOES IT CONTROL?
	<p>Bed nets</p> <p>Place banners around beds to prevent mosquitoes from biting people while sleeping. These are often treated with insecticides that kill mosquitoes resting on the net.</p>	<p>The bed nets help to protect the person in bed from sleeping. This not only helps prevent the person from getting bitten by an infected mosquito, but also prevents a mosquito to pick up a pathogen from an infected human.</p>
	<p>Education</p> <p>Place chalkboards and signs throughout the area explaining the risk and things people can do to reduce the spread of mosquito-borne diseases.</p>	<p>Education is very important. We need to remind people of the importance of mosquito-borne diseases and things they can do to reduce the risk (like vaccinating horses, or applying repellents, or preventing heartworm in dogs)</p>
	<p>Vaccines</p> <p>Demonstrate that you have vaccinated your horse using a special potion, or by placing a nametag or armour on horse</p>	<p>Luckily, we have vaccines available for horses to protect them from Eastern Equine encephalitis virus and West Nile virus. There are currently no vaccines available for humans.</p>
	<p>Personal protection</p> <p>Select a character that wears long sleeves and long pants. Do not go outside at night when mosquitoes are most active.</p>	<p>You can reduce your risk of acquiring a mosquito-borne pathogen by preventing mosquito bites. This also includes the use of EPA registered repellents.</p>
	<p>Heartworm preventative medicines</p> <p>Indicate that you have provided preventative medicines through feeding (meats/bones), or by placing a name tag over a pet. You can also consider using a potion.</p>	<p>Heartworm can be prevented by providing your pet with monthly preventatives. These are safe for your pets. When pets are not provided with these, many will become infected with heartworm, get very sick, and have to have long, painful treatments to remove adult worms.</p>
	<p>Repair streams to make sure water flows.</p> <p>If there is a river or stream in your habitat, clear out anything blocking the flow of water</p>	<p>Mosquitoes only like standing water. Immature mosquitoes cannot survive in running water, such as streams and rivers.</p>

## CONTROL STRATEGIES (PAGE 3)

	STRATEGY	EXAMPLES IN MINECRAFT	HOW DOES IT CONTROL?
	Apply repellents to self and animals	Use potions or a bow and arrow to apply invisibility potion to yourself and your pets. This will make you invisible to biting mosquitoes.	Repellents work by confusing mosquitoes, so they can no longer figure out how to feed. While some mosquitoes may land on you, they will not feed because they are confused. Therefore, these repellents help by making you appear invisible to mosquitoes.
	Provide necessary resources nearby	Perhaps you can build a pharmacy, vet clinic, or hospital nearby	By increasing access to these resources, people can better protect themselves and their pets, through the use of vaccines, preventative medicines, and other supplies
	Clean up dirty pools	Another option to dirty pools, is making sure they are clean, do not have algae and debris inside. If the pool looks green, you can try to make sure it looks bright blue.	Since mosquito larvae feed on small organisms and nutrients in water, cleaning up pools (removing algae) will eliminate the food source, and mosquito larvae can no longer develop
	Trap mosquitoes	Can you configure your own mosquito trapping device? Perhaps a light trap? Or a cup containing poison potion that an unknowing mosquito lays its eggs in?	Trapping mosquitoes is a way of physically removing mosquitoes without the use of insecticides. However, they only work in small areas where the trap is used.
	Protect your horses and livestock by keeping them indoors	Build a barn for your livestock, and make sure that windows and doors are closed	Prevents mosquitoes from biting your animals, by limiting their access to a blood meal source. This is especially important at night when mosquitoes are most active.
	Modify the saltmarsh, so fish have access to wet areas	Dig a stream that goes from the ocean to the water holding areas on the marsh	You can naturally get fish to mosquito areas by creating natural streams.

### CHART 1 (WHAT DISEASE IS REPRESENTED AT EACH OF THE 6 SITES?)

	<b>WHAT IS THE DISEASE?</b>	<b>WHAT ARE SOME THINGS YOU DISCOVERED THAT HELPED MAKE THAT CONCLUSION?</b>	<b>LIST ONE THING YOU DISCOVERED THAT YOU CAN CHANGE TO HELP REDUCE THE RISK OF DISEASE</b>
SITE 1			
SITE 2			
SITE 3			
SITE 4			
SITE 5			
SITE 6			

## CHART 2: DEVELOP YOUR CONTROL STRATEGY

- (1) USE THIS OUTLINE TO PLAN OUT YOUR CONTROL STRATEGIES (Must have 5)
- (2) DECIDE ON HOW AND WHERE TO PLACE YOUR EPIDEMIOLOGICAL PYRAMID
- (3) BE SURE TO TAKE BEFORE AND AFTER PHOTOS
- (4) REPORT YOUR RESULTS USING THE FORMAT PROVIDED BY YOUR TEACHER

Target	Control strategy	Action performed	Benefits and Negative Impacts
<i>Example:</i> AGENT = bacteria	<i>Example:</i> Provide antibiotics	<i>Example:</i> Create a pharmacy nearby to provide better access to medicine	<i>Example:</i> <u>Benefit:</u> kills the bacterial agent that causes disease, <u>negative impacts:</u> potential bacterial resistance with improper use, also killing off of beneficial bacteria in gut