Lesson 1: Skeeter Farm

Discovery Files

Discovery File
Mosquito Life Cycle

Do you know that mosquitoes are flies? Don't be embarrassed. Most people don't know that either.

Like all flies, mosquitoes belong to the Order Diptera, which means they have *two* (di-) *wings* (-ptera). And, like all flies, mosquitoes are insects.

There are more than 3,000 species of mosquitoes. North America is home to about 130 of them.

Mosquitoes and other flies have four stages in their life cycle: egg, larva, pupa, and adult. Since a mosquito's appearance changes with each stage—a young mosquito looks very different from an adult—the cycle is called *complete metamorphosis*.

During the first three stages, mosquitoes live in still water. As long as the water is not flowing you can find mosquitoes—the edges of ponds, in fresh- and salt-water marshes, permanent swamps, temporary pools, floodwaters - even water-filled containers.

Mosquitoes do not live in streams or oceans.

The egg stage -

Mosquito eggs need water to hatch. Some species lay one egg at a time on the surface. The *Anopheles* mosquito—the mosquito that transmits malaria—does this. *Culex* mosquitoes lay their eggs side by side in rafts. These floating egg rafts can have 100 eggs or more. Eggs laid on the water hatch in a few days.

Some mosquitoes do not lay their eggs on water. How can this be? These mosquitoes lay their eggs close to the water's edge or just above the water's surface. When it rains, the water rises and the eggs hatch. If it doesn't rain, the eggs stay dormant. In some species dormant eggs can survive for 3 to 5 years waiting for the water to rise.

Eggs are the overwintering stage for *Aedes* and *Ochlerotatus* mosquitoes.

The larva stage –

Once a mosquito egg hatches, a larva emerges. The larval stage lasts from 1 to 8 weeks, depending on the species. Time of year and water temperature also have an effect on the length of the larva stage.

The larva stage has four stages of its own. Each stage is called an *instar* and takes about 4 days to complete. All instars look alike, except the size of the larva increases with each new stage.

A newly hatched larva is the *first instar* and is almost invisible. It feeds on bacteria, algae, single-celled organisms, and debris in the water. As it eats and grows bigger, it *molts* to become a *second instar*. This continues for a total of three molts, until the *fourth instar*.

Mosquito larvae (plural of larva) play an important role in aquatic food webs. Many are eaten before they reach the pupa stage—predators include fish, other aquatic insects, and crustaceans. Larvae that survive long enough to become pupae (plural of pupa) often find protection in the vegetation living in the water.

Although larvae must live in water, they breathe air. Most species have a *siphon* at the base of the abdomen. Larvae wiggle up to the surface and take in air through their siphons. You can even identify some species by how their larvae lie at the surface. *Culex* and *Aedes* larvae keep their heads down away from the surface as they breathe through their siphons. *Anopheles* larvae don't have siphons. They lie parallel to the surface and take in air through tiny pores.

At the end of the *fourth instar,* a larva rises to the surface, sheds its last larval skin and becomes a *pupa*. This is the same process a caterpillar goes through to become a chrysalis.

Larvae have three body sections: *head, thorax,* and *abdomen*. Each section is covered with brushy hairs that help the larva swim and float. These hairs also help sweep food to the larva's mouth.

Larvae move by wiggling their bodies back and forth through the water or along the bottom of the water. Because of this, they are called *wigglers*.

The pupa stage –

It only takes a mosquito about 3 to 5 minutes to *pupate*—to become a pupa. During the pupa stage amazing changes take place under the skin. The mosquito's body changes from a worm-like larva into a winged adult. A pupa must stay in water and breathes air just like a larva. But there are important differences, too. Unlike the wiggling larva, the pupa looks just like a comma—it has a very large head and thorax that are combined. The pupa rises to the surface to breathe through two new breathing tubes called respiratory trumpets. These are on the topside of the combined head and thorax. Another important difference—the pupa does not feed.

For most species, the pupal stage lasts from 1 to 3 days. The length of this stage depends on water temperature. The warmer the water, the faster a pupa develops into an adult. At the end of the pupal stage it stops swimming and floats to the surface. Its skin splits open and the adult mosquito climbs out. First the head and thorax emerge, followed by the abdomen and new legs. The process takes about 5 minutes. Although the new adult now has wings attached to its thorax, it must float on the water until the wings expand and dry.

Mosquito *pupae* are very active. They may even be the most active of any insect pupae. They swim with tail paddles that move up and down and send them quickly through the water.

Since most pupae are lighter than water, as soon as they stop moving their tails, they float to the top. Because they look like they are tumbling, pupae are often called *tumblers*.

The *adult* stage –

An adult mosquito is built like a typical insect. It still has three body parts: head, thorax, and abdomen, and six legs. And although some insects have four wings, mosquitoes have two.

There are two other small structures behind the wings, called *halteres*. The *halteres* vibrate rapidly when the mosquito flies and

The abdomens of different species often have special shapes or markings that scientists use for identification. For example, *Aedes* mosquitoes have a pointed abdomen, but *Culex* have a more rounded one.

are thought to help it balance. Scientists think *halteres* may be all that is left of another wing pair that no longer exists.

Adult mosquitoes can live in different places. Most adults prefer places that are dark and damp. They can be found under bushes, in forest undergrowth, and among tall weeds or grasses. Other common sites are in tree holes, rock holes, caves, and animal burrows. Mosquitoes also live in human-made shelters such as barns, basements and buildings. Although many species prefer a particular habitat, they must not be far away from water.

About equal numbers of males and females are produced. Males usually emerge first, feed, and wait for the females. Mating takes place soon after the females emerge and happens once for most species. Females store sperm in a special organ called a *spermatheca*. They use this sperm for the rest of their lifetime.

The mouth of an adult mosquito is called a *proboscis*. It is made for taking in nectar, honey-dew, and fruit juices from plants. It is not true that mosquitoes use blood for food.

Males may only live for a week or so after emerging and mating. Female mosquitoes live longer. This is a problem because females can become more dangerous the longer they live. The longer a female mosquito lives and feeds, the more possible it is for her to transmit microorganisms that cause disease.

Adult mosquitoes may hibernate over the winter. This occurs in *Anopheles* and *Culex* mosquitoes. They often enter houses in the fall for this purpose.

Only females take a blood meal, which they need to lay fertile eggs. Using her special piercing mouthparts, a female first finds a host to bite. It takes her two or more days to digest the blood meal. Then she lays a batch of eggs and goes off for another blood meal.

A female can repeat this cycle of blood feeding and egg laying about every two weeks. Once the eggs are laid, the cycle begins again when the new larvae emerge.

In the natural world, the average adult mosquito lives 1 to 3 weeks. But, when conditions are perfect in a laboratory a female mosquito may live up to 5 months.

Discovery File
Anatomy of a Bite

It's a beautiful warm summer evening, just after dusk.

You and your friends are hanging around outside when you hear her…bzzzzzz…bzzzzzzz. If there is enough light, you may even see her—a female mosquito has found you, and wants her blood meal!

How does she find you? What happens during the bite? Why does it itch? And what's that buzzing sound?

Since males do not take a blood meal, only female mosquitoes will try to bite you. You will probably never even notice a male mosquito. And if you do, how will you tell him from a female?

The best way to tell them apart is to look at them side by side. First, the male is usually smaller than the female. His proboscis is only used to drink plant nectars, so it is different from the proboscis of the blood-sucking female.

But the easiest way to tell the difference between the sexes is to look at the **antennae** (plural of antenna). Antennae are sensory organs, used for hearing and smelling. The female's antennae are covered with short hairs. The male's antennae are also covered with hairs, but they are much longer and bushier.

Most male mosquitoes only get one chance to mate and pass on their genes. They use their antennae to hear the wing vibrations of the females of their own species.

Female mosquitoes can beat their wings from 300 to 600 times per second. This is the movement that makes the buzz we all know so well.

Many mosquito species prefer to take blood from a particular animal. Some mosquitoes bite birds. Others bite horses. Some like frogs. Unfortunately for us, some mosquitoes prefer humans. The animal source of the blood meal is called the **host**.

But it is not unusual for a mosquito to take advantage of a nearby animal that is not its main host. This is especially important in vector-borne diseases.

Female mosquitoes find their hosts in a number of ways:

- most mosquitoes can tell when there is a warm body nearby
- scientists think that mosquitoes also are attracted to exhaled carbon dioxide
- mosquitoes also seem to prefer dark colors.

If you are breathing and wearing dark clothing and there is a mosquito nearby, you make a perfect target!

The female's proboscis is very special. It is made of six parts called **stylets**. The stylets are surrounded by a cover called a **labium**. Two of the stylets are serrated like a steak knife. The female uses these stylets to saw a hole through skin, tissues, and blood vessels. Another stylet is used

Mosquito saliva sets off a reaction from your body. Your immune system knows that this stuff should not be there. Even a tiny bit of saliva is enough for your body to launch an attack.

It is your immune system that sends cells to fight the saliva. It is those cells that cause redness and itching.

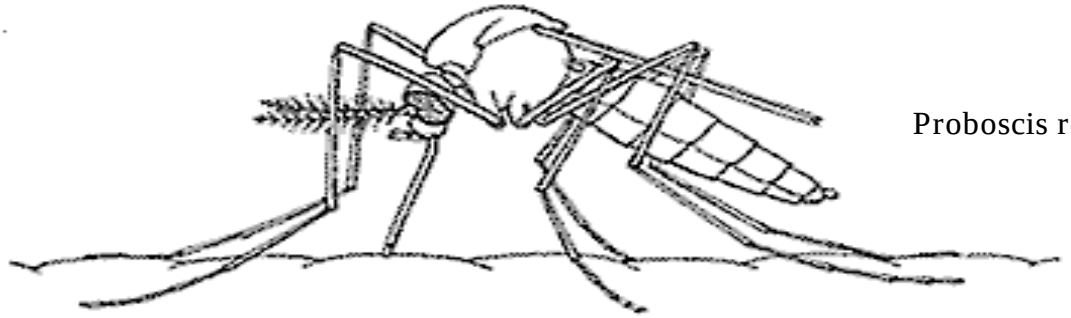
Try not to scratch. The more you scratch, the more your body reacts and the worse the itching becomes.

to inject saliva into the hole she made. The saliva keeps blood from clotting during the blood meal.

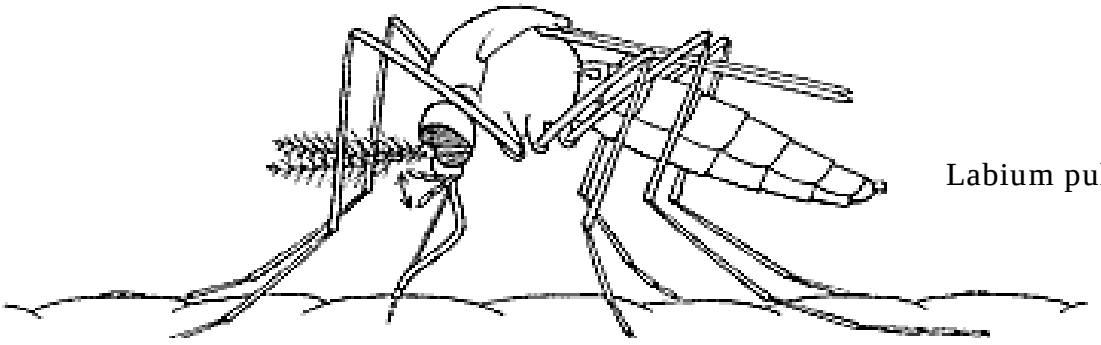
Mosquitoes do not suck blood from a blood vessel. The blood collects in a small pool around the hole under the skin. The female uses all six stylets to form a tube to suck the blood from the pool. It takes from 60 to 90 seconds for her to take a full blood meal.

Mosquito bites can be very annoying. But the worst things about mosquitoes are the diseases they carry (malaria, yellow fever, dengue fever, and West Nile virus). When a mosquito carries disease germs, she can pass them along in her saliva. In fact, mosquitoes are the most powerful vectors in the world. They cause more human deaths than any other animal!

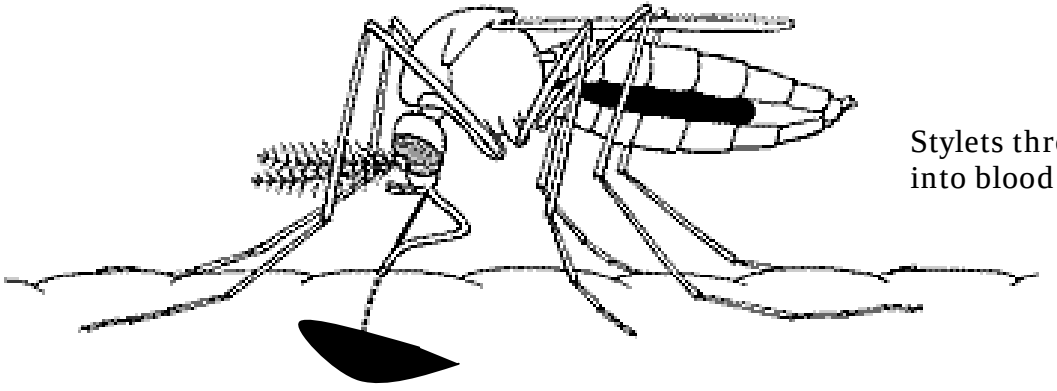
Summer is the season when you are at the greatest risk for a mosquito bite. The best way to protect yourself is to use an insect repellent. It is also a good idea to avoid areas with mosquitoes at dawn and dusk when they are most active.



Proboscis ready to bite



Labium pulling back



Stylets through skin into blood pool

Discovery File
Bacteria Join the Fight

*Bacillus thuringensis (Ba-**sil**-is ther-in-**jen**-sis)* is a ***gram-positive***, spore-forming bacterium.

B. thuringensis—also known as ***Bt*** (say bee-**tee*)*—is used all over the world to help control pests—mainly caterpillars.

In 1976, a new type of ***Bt*** was found in a pool of dead mosquitoes in Israel. Scientists named this ***B****acillus* ***t****huringensis* serovariety ***i****sraelensis* - also known as ***Bti*** (say bee-tee-**eye**).

Gram staining makes gram-positive bacteria appear dark blue or violet. (Gram-negative bacteria are not affected by Gram stain).

Gram staining is used to tell similar looking bacteria apart.

Today *Bti* is widely used throughout the world to kill mosquito larvae. Mosquitoes spread more diseases than any other vector. *Bti* also kills black flies, which transmit river blindness in Africa.

Bti cells produce a spore and several ***toxins*** as they develop. A *toxin* is a poison made by a living organism. When a mosquito larva eats *Bti*, the toxin becomes active. It causes the contents of the gut to spill into the insect's body cavity.

Poisoned mosquito larvae die quickly within 1 to 2 days.

All commercial *Bt* products are made in large industrial fermentation tanks. *Bt* products in general make up about 1% of the world's "agro-chemical" market. These are chemicals used in agriculture, like fungicides (fungus killers), herbicides (plant killers) and insecticides (insect killers). *Bt* products are powders containing a mixture of dried spores and toxin crystals.

Bt products are used much like other insecticides. It can be sprayed or dusted on plants. It can also be applied to ponds and other bodies of water where mosquito larvae develop. *Bti* does not reproduce or stay in the environment very long. *Bt* treatments stop working within 1 -3 days in many outdoor situations. Repeated applications may be necessary for some crops and pests.

Using *Bt* products, including *Bti*, are environmentally safe ways to attack pests.

You can buy *Bt* in many different forms. Some *Bti* is molded into "dunks" – little doughnuts that you can throw into a pond or birdbath. The *Bti* is safe because it doesn't harm most other water organisms.

Discovery File
West Nile Virus

What do you do when a disease appears in a new place for the first time? This is what U.S. public health doctors had to know when West Nile virus first arrived in North America.

It came in August 1999. A man with a high fever and very bad headache went to the hospital in New York City. Doctors there found he had an **inflammation** (say: in-flam-**a**-shun) of his brain called **encephalitis** (say: en-sef-a-**lite**-us). He was very sick. Soon, 62 more people in and around New York City had the same symptoms. Some of them recovered, but by the end of December 1999, seven people died. Public health doctors were on the case soon after the first diagnosed cases. Could this be a new disease? Might it become a terrible epidemic?

	States with human and non-human* WNV	States with only non-human* WNV
1999	1	3
2000	3	13
2001	10	19
2002	39	5
2003	45	1
2004	40	7
2005	43	5
2006	45	3
2007	43	4

The public health doctors first thought the cause was the St. Louis virus – a virus already known in North America. This virus is spread by the bite of infected mosquitoes and is especially deadly to horses. It causes an encephalitis just like the one they were seeing. It also infects birds. And many dead crows were being found in the areas where people were sick. Health departments were getting lots of phone calls from worried citizens who had dead birds around their homes.

By December 1999, the public health doctors had found the cause—**West Nile virus** (WNV) was in the US for the first time. The puzzle was solved!

How did they know? A team of doctors from the Connecticut Agricultural Experiment Station (CAES) in New Haven, Connecticut found WNV in infected birds and mosquitoes nearby. Another team from the Centers for Disease Control (CDC) in Atlanta, Georgia, found the same virus in the brain of an infected flamingo from the Bronx Zoo. The CDC researchers also found that the virus from the flamingo closely matched the virus taken from a goose that died the year before in Israel.

The spread of West Nile: WNV was first diagnosed in Africa in 1937. Since then, it has spread to Asia, Europe, and the Middle East. West Nile virus is an example of an **arbovirus** (say: **are**-bow-vi-rus). This name is a combination of three words: **ar**thropod **bo**rne **virus**. These are diseases carried by arthropod vectors, like ticks and mosquitoes. West Nile virus contains a single strand of RNA and can only reproduce inside a host.

By 2001, WNV reached the middle of the United States. A year later, it had jumped to the West Coast. You can follow the movement of the disease across the country. There are colorful maps at http://www.cdc.gov/ncidod/dvbid/westnile/index.htm

Scientists still don't know how West Nile virus came here. Did that first sick man in New York City get a mosquito bite in Africa before he came here? Did an infected mosquito get into an airplane from the Middle East? Was an infected goose shipped to a New York restaurant? What we do know is that it is here to stay.

*** NOTE:** "non-human cases" means horses, birds and mosquitoes that tested positive for WNV.