



Female *Anopheles* mosquito – Copyright Dennis Kunkel Microscopy, Inc.

MALARIA AND MOSQUITOES: A DEADLY DUO

In many parts of the world, mosquitoes aren't just a nuisance;
they're a real threat to life.

Anopheles mosquitoes carry the malaria parasite,
and through the saliva in their bite, they can
transfer the malaria parasite from person to person.

Mosquitoes are definitely vector villains!

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THE BUZZ ON MALARIA

The good news is that people **CANNOT** catch malaria from each other by direct contact! The bad news is that, with the help of mosquito bites, malaria can be passed from person to person. Malaria is caused by microscopic parasites called **plasmodia** that live in the blood of infected people. There are many different kinds of mosquitoes, but only one type, the **Anopheles (an OFF uh lees)** mosquito, transmits malaria.

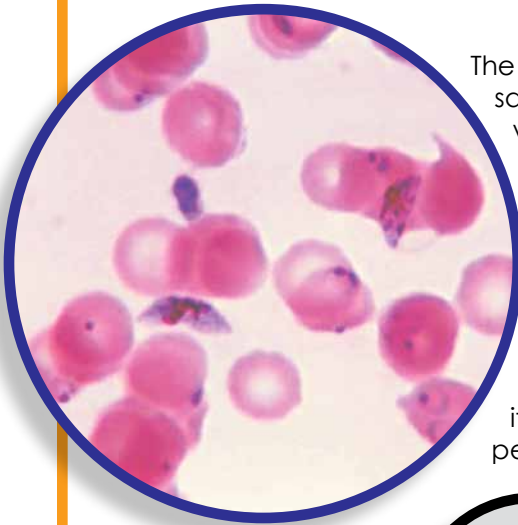
DID YOU KNOW?

The word **PLASMODIA** is plural, meaning there's more than one of them around.

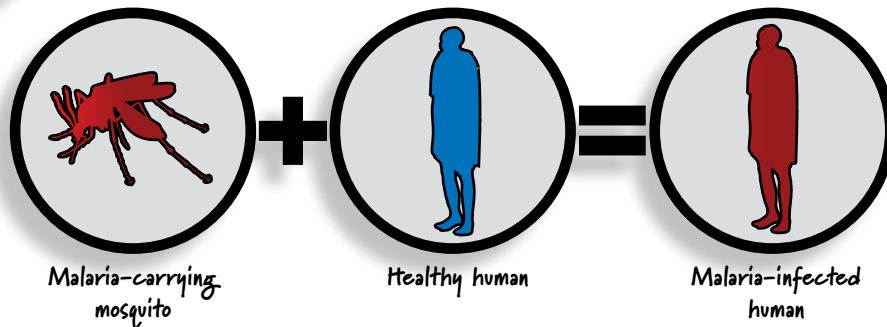
The singular form is **PLASMODIUM**.

Here's how malaria works

The parasite that causes malaria is transmitted in a mosquito's saliva. If an infected mosquito bites an uninfected person, watch out! The mosquito transfers the parasite to the person, and the parasite migrates to the person's **liver**. Once the parasite has had time to develop, it leaves the liver by entering the **bloodstream** and invades the **red blood cells**. If another mosquito then bites the infected person, the mosquito will pick up the parasite from the infected person's blood. The parasite doesn't hurt the mosquito at all; the mosquito is just a **vector**, an organism that carries the parasite from one person to another. The parasite moves from the mosquito's stomach to its salivary glands, and, the next time the mosquito bites another person, the infection process starts all over again.



Red blood cells infected by *Plasmodia* organisms – Courtesy of www.cdc.gov



Mosquitoes and plasmodia prefer warm climates, which is why many warm parts of the United States used to be malaria "hot spots." Fortunately, because people have made massive efforts to eradicate malaria, the disease is now almost non-existent in the United States. However, malaria is still a problem for **41%** of the world's population—especially those who live in Africa, Asia, and certain parts of Central and South America. In many of these areas, especially those close to the equator, malaria is a life-threatening problem year-round.

When malaria is **endemic** (constantly present) in an area, it can affect people of all ages, but children under the age of five are the group most likely to die from the disease. Three out of every four (75%) of the estimated two million people who die from malaria each year are African children.



Children line up for malaria testing in Kenya – Courtesy of www.rollbackmalaria.org

DID YOU KNOW?

Only female mosquitoes bite.

This is because female mosquitoes need a meal of blood before they can lay their eggs.

Symptoms and Treatment of Malaria

People with malaria can have symptoms like **mild shaking chills**, a **high fever**, and **sweating**. The fever rises and falls repeatedly in a relatively predictable pattern. Typically, the sick person has a day of fever followed by one or two days without fever, followed by fever again.

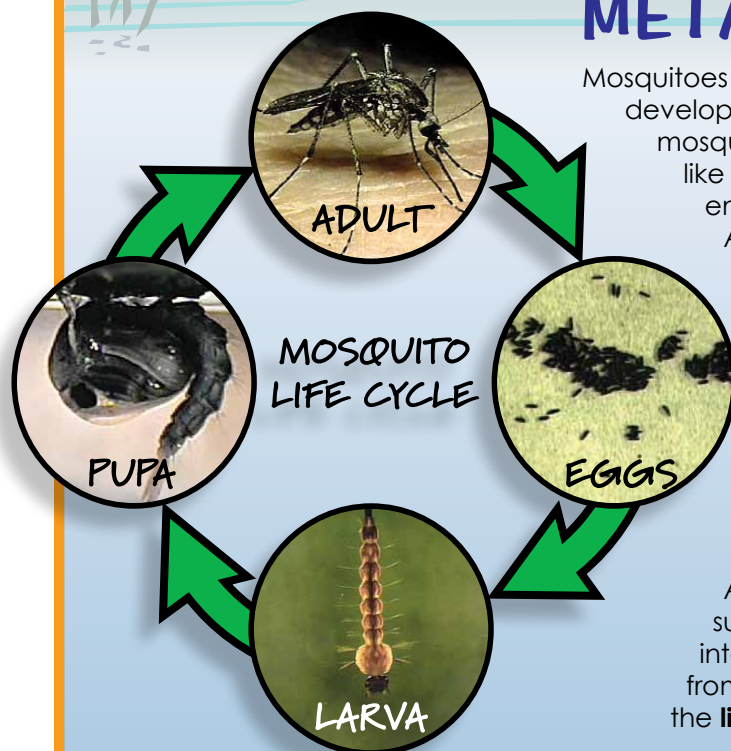
The periods of fever are directly related to the parasite's life cycle in the body. Malaria can also cause **nausea, vomiting, headaches**, and **body aches**. The symptoms of **severe malaria** include an **inability to eat or drink, diarrhea, convulsions**, and **confusion**. Although a person's symptoms may indicate that they have malaria, a blood smear viewed under a microscope confirms the diagnosis because the malaria parasites can be seen inside the red blood cells of a person with the disease.

Mild malaria can be treated with **oral** (taken by mouth) medicines that kill the parasite inside the body. Severe malaria, however, must be treated at a hospital so that doctors can put anti-malarial medications directly into the bloodstream. Blood loss due to the rupture of blood cells leads to **anemia**, an abnormally low level of red blood cells. Patients with anemia may need blood transfusions and can experience kidney failure.



Child with advanced malaria—
Courtesy of WHO/Pierre Viot

MOSQUITO METAMORPHOSIS



Mosquitoes go through four different stages as they develop: **egg**, **larva**, **pupa**, and **adult**. Most species of mosquito lay their eggs on top of standing (still) water, like the water in small ponds, drainage ditches, or empty containers left around in yards or gardens. A mosquito can lay up to 200 eggs at one time! The eggs then float on top of the water for a few days before hatching into **larvae**.

After hatching, the larvae float just under the surface of the water. The larvae have a tube that sticks up out of the water so that they can breathe, and they eat microscopic plants that float toward them.

The mosquito larvae grow and turn into **pupae**. At this point they still float just below the water's surface. A few days later, the pupae develop into fully grown **adult** mosquitoes and emerge from the water. Then they fly off to mate, and the **life cycle** begins again.

Images courtesy of www.cdc.gov

MALARIA HAS A LONG HISTORY

Malaria has afflicted humans for thousands of years. Long before people knew what caused the disease, it influenced where they lived and worked, and even where they fought! Although people described malaria over 2,000 years ago and suggested that it was linked to mosquitoes, the connection between man, malaria, and mosquitoes wasn't firmly established until the 1800s through the work of **Charles Alphonse Laveran**, **Sir Ronald Ross**, and **Patrick Manson**. Laveran and Ross earned the Nobel Prize in Medicine in 1907 and 1902, respectively.

DID YOU KNOW?

The **Yellow Fever** virus is a tropical disease that attacks the liver. It gets its name because it makes the skin and the whites of the eyes turn yellowish.

Mosquitoes and the Panama Canal

In 1881, the French began work on a canal which would cut across Panama to connect the Caribbean to the Pacific Ocean. At this time, the link between mosquitoes and diseases like **malaria** and **yellow fever** was not fully understood, so the project planners didn't take steps to protect their workers against mosquito-borne diseases. When the workers arrived, they moved into homes without screened windows. Even their gardens were a danger if they contained standing water where mosquitoes could breed. Before long, at any given time 30 out of every 100 workers on the Panama Canal were sick in the hospital because of malaria or yellow fever. By the time the French abandoned the building project, over 30,000 European workers in Panama had died from these diseases.



Workers building Panama Canal –
Courtesy the Library of Congress



Dr. William Gorgas
– Courtesy of the Panama Canal Authority
and www.afonsooroy.com

Gorgas Tackles Panama's Mosquito Problem

The United States took over the project in 1904, placing an army physician, **Dr. William Crawford Gorgas**, in charge of sanitation in the canal work zone. Drawing upon his experience eliminating yellow fever in Cuba, Gorgas began draining gardens and applying oil to standing water to kill mosquito larvae. Additionally, he housed the victims of yellow fever and malaria in screened rooms so that mosquitoes could not bite them and further transmit the disease. As a result of Gorgas' efforts, only 2 out of 100 workers were sick in the hospital at any given time. In two years, Gorgas had eliminated yellow fever from the canal zone. The mosquito transmitting malaria proved more difficult to eliminate than the one transmitting yellow fever, but the incidence of malaria was also greatly reduced.



Beating Back an Invasion in Brazil

In 1930, a malaria-transmitting African mosquito was discovered in a pond in Brazil. The mosquito had probably hitched a ride on a ship traveling between Africa and South America. Numerous other African mosquitoes also arrived in Brazil, and by 1938 they had triggered the largest malaria outbreak in the Western hemisphere. In the course of the outbreak, 100,000 people caught malaria; of these, 14,000-20,000 died. Because many victims lived in isolated rural communities, the true death toll will never be known.

The Brazilian government called in **Fred Soper**, a scientist associated with the Rockefeller Institute, to eliminate the invading African mosquito. Soper set up anti-malaria teams in every region of Brazil. He even treated trucks, planes, and trains after he discovered that mosquitoes were using them to hitch rides throughout the country. Soper became a hero to the Brazilians since, with his help, the Brazilian authorities eliminated the malaria-transmitting mosquito within a year.

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Fred Soper

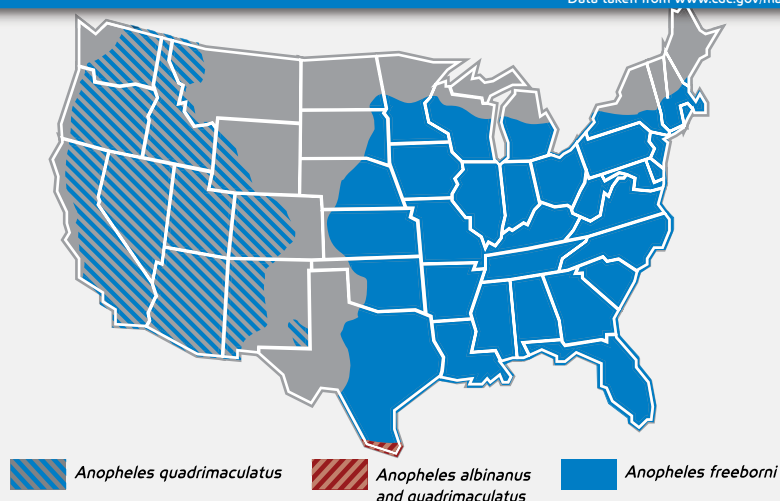
MALARIA IN THE U.S.

Malaria was largely **eradicated** from the United States in the 1950s, but it still reappears occasionally. According to the **Centers for Disease Control and Prevention (CDC)**:

- 1,337 cases of malaria, including 8 deaths, were reported for 2002 in the U.S. Of the total number of malaria cases, all but five were imported—that is, people got the malaria parasite while in another country.
- Of the ten species of **Anopheles** mosquitoes found in the United States, **Anopheles quadrimaculatus** and **Anopheles freeborni**, the two species that were vectors for malaria before the disease was mostly eradicated, are still widespread. This means that there is a constant risk that malaria will be reintroduced in the U.S.

Potential Vectors of Malaria in the United States

Data taken from www.cdc.gov/malaria



- In 2003, seven people in Palm Beach County, Florida, came down with malaria in a single month. Laboratory tests showed that the infections were related. Each person reported doing outdoor work or recreation activities, but none of them had traveled recently. The cases were eventually attributed to "airport malaria": infected stowaway mosquitoes had infected people near the airport.

USING DDT TO FIGHT MALARIA

DDT is a chemical that can be sprayed lightly on interior walls, around windows, or on ceilings to combat mosquitoes effectively for a year or more. It is extremely cost effective and is a powerful tool in the prevention of malaria.

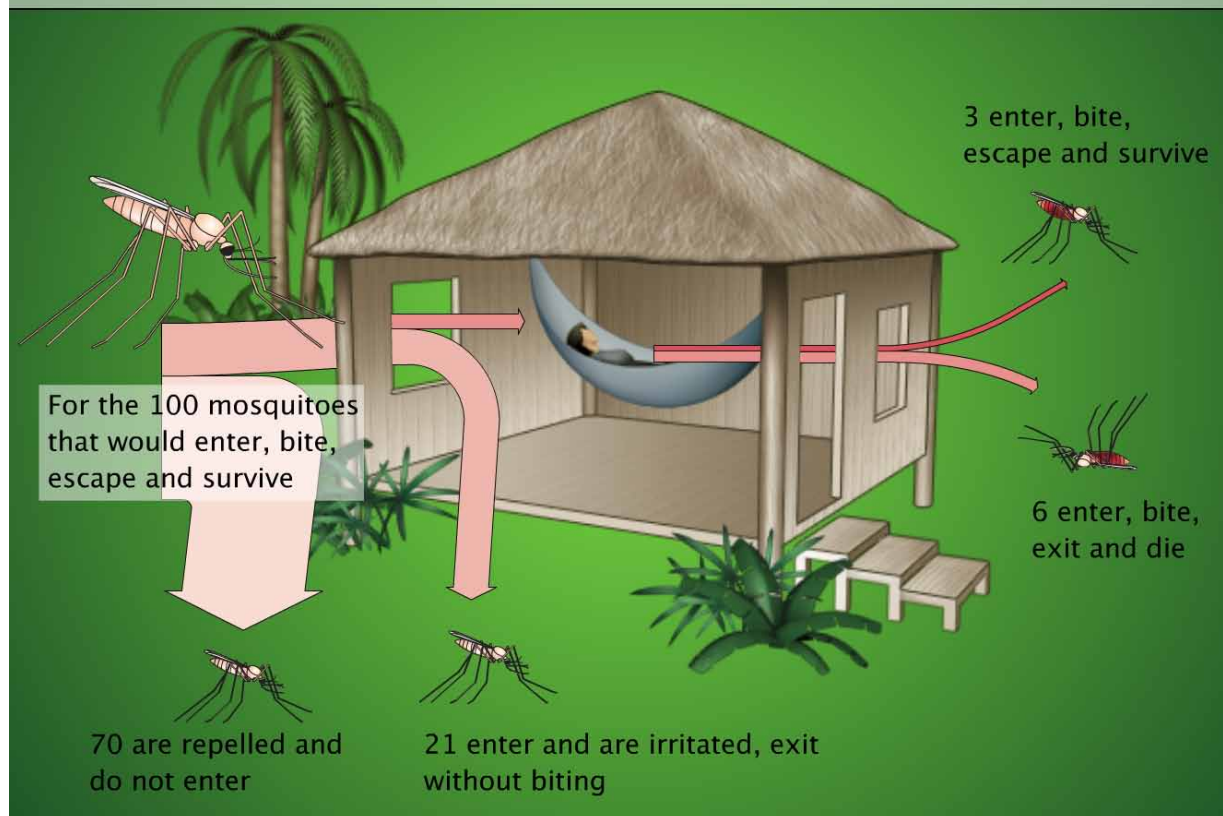
The countries where malaria is especially severe are also among the world's poorest nations. Homes tend to be quite primitive and open-air, so it is not a matter of closing the doors and turning on the air conditioner to keep out mosquitoes.

DDT (whose scientific name is *dichloro-diphenyl-trichloroethane*) was the first of the modern insecticides. It was developed by a Swiss chemist early in World War II as a means of controlling clothes moths. It was quickly adopted by the military as a way to prevent the spread of insect-borne diseases such as malaria and typhus among the troops. However, during the 1950s and 1960s the widespread and uncontrolled use of DDT in many Western countries for all sorts of insect control, particularly with crops, led to opposition to its use in the environment. Now DDT is banned in many industrialized nations.

But without DDT, many poorer countries would be defenseless against malaria. Scientists who study malaria have shown through extensive research and field work that DDT can repel and prevent entry of as much as 95-97% of mosquitoes that would otherwise enter a house. Check out the impact of DDT on malaria at <http://www.malaria.org/teachingmodules/ddt-malaria-container.html>

Adapted from research by Dr. Donald Roberts, Professor of Preventive Medicine at the Uniformed Services University of the Health Sciences

**if house were sprayed with chemical that is 70% effective
for each: repellent, irritant and toxic actions...**



Roberts, et al. 2000.
Journal of Vector Ecology 25:48-61.

DID YOU KNOW?

Four different species of parasite can cause malaria: *Plasmodium falciparum*, *Plasmodium vivax*, *Plasmodium ovale*, and *Plasmodium malariae*.

These species are collectively called the *Plasmodium* parasites. Most cases of malaria are caused by *P. falciparum* or *P. vivax*.

A PESKY, PERSISTENT PROBLEM!

Maybe you're wondering why people living in areas where malaria is common don't just put on **bug spray** to protect themselves from mosquitoes. The trouble is that, wherever there's **stagnant water**, mosquitoes will breed. Also, people from poorer countries often cannot afford **insect repellent**. The best approach for most of the people in these countries is to sleep under **bed nets** that have been treated with **insecticides**. These nets are "double trouble" for mosquitoes since they keep the mosquitoes from physically reaching people, and they also kill mosquitoes that land directly on the net.



A typical bed net – Courtesy of WHO/Pierre Viot

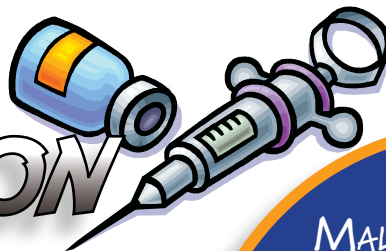
Getting bed nets to people in remote areas is not as easy as it sounds, and poor people may not be able to afford the cost of re-treating the nets with insecticide every few months. Luckily, organizations like the **Bill and Melinda Gates Foundation** and the **Acumen Fund** have recognized the problem and are working to provide bed nets and other defenses against insects for the people who need them the most.



INTERNATIONAL TRAVELERS, BEWARE!

Be sure you're prepared before you travel to parts of the world where malaria is found. Check with your doctor or with a travel clinic to find out how to protect yourself, since where you are going and how long you will stay will determine which sort of medicine you should take. Travelers are usually advised to **take malaria-preventing medicine** before they leave home, to **use insect repellent** and **netting**, and to **avoid using fruity perfumes** that may attract mosquitoes.

THE QUEST FOR A VACCINATION



Can we use a **vaccine** to prevent malaria? Maybe! If a mosquito infected with malaria bit a vaccinated person, the person's **immune system** would recognize and destroy the parasite as soon as it entered the body. The parasite would be eliminated before it could reproduce, and the person would not get sick with malaria. This would be a cost-effective and efficient way of preventing human disease. However, the malaria parasite is **complex**, so vaccine development is progressing very slowly. Scientists have been working to develop a malaria vaccine for over 20 years. Some vaccines are currently being tested in humans, but further research is still needed to develop a more dependable vaccine.

GIVING MALARIA A TASTE OF ITS OWN MEDICINE

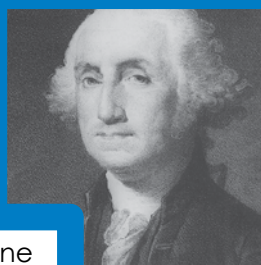
Most drugs used to treat malaria destroy the parasite once it's in the blood. One drug, **primaquine**, fights the parasite while it's still in the liver.

The specific drug used to treat the disease depends upon the species of parasite, where the infection was acquired (caught), and the overall health status of the patient.

SURPRISING FACTS ABOUT MALARIA

If you think that only people you've never heard of get malaria, think again! It not only affects famous people but has also played a role in important world events. Here are some interesting facts:

Several American presidents, including **George Washington**, **Theodore Roosevelt**, and **John F. Kennedy**, suffered from malaria.



George Washington



Teddy Roosevelt



John F. Kennedy

During the American Revolution, one of the first things that the Continental Congress bought was a supply of the drug **quinine** so that George Washington's troops would be protected from malaria.

During the **American Civil War**, 40-60% of Union soldiers had malaria, even though the army's physicians required soldiers to take a daily dose of **quinine** during mosquito season.

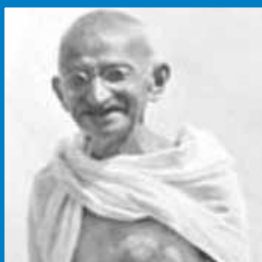
During **World War I**, the British Army, suffering from malaria in eastern Europe, asked the French for help before an anticipated battle. The commander of the French troops responded, "Regret that my army is in hospital with malaria." Fortunately for the British and the French, the German troops were too sick to launch an attack, having become infected with malaria themselves.



British soldiers during WWI



Union soldiers
— Courtesy of the Library of Congress



Mahatma Gandhi



Mother Teresa



Dr. Jane Goodall, DBE

— Courtesy of www.janegoodall.org
photography by Greg Schaler

Some other famous people who suffered from malaria include **Christopher Columbus**, **Davy Crockett**, **Ernest Hemmingway**, **Mahatma Gandhi**, **Mother Teresa**, and **Jane Goodall**.

Popes, emperors, kings, and Olympic athletes have also had the disease.

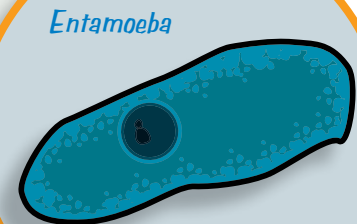
***per·ni·cious**
(pər-nī'-shəs) *adj.*

Tending to cause death or serious injury; deadly.

PERNICIOUS* PROTOZOA

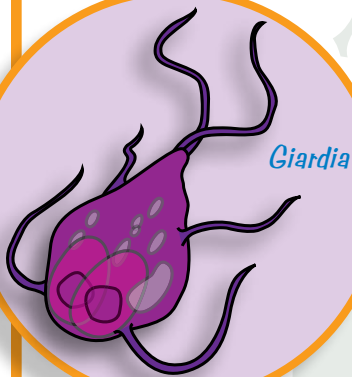
Protozoa are single-celled organisms and are parasitic. In other words, they need a host so they can survive and reproduce. Plasmodium, the parasite that causes malaria, is a protozoan. Protozoans use a variety of different methods to infect their hosts, and some of them are pretty sneaky! Meet some of the protozoal diseases you want to avoid:

I'm Entamoeba (en tuh MEE buh). My disease is amebiasis, and I like to infect people who live in unsanitary conditions. I usually affect the digestive system, causing diarrhea and cramps in whomever I infect, but sometimes I get especially nasty and infect people's livers, lungs, or brains, too. If you want to stay out of my way, watch out for unpasteurized dairy products, fruit and vegetables you didn't peel yourself, and unbottled water when you travel to developing countries!



My name is Giardia (jee AR dee uh).

I live in water and soil which have been contaminated by feces (solid wastes), and you can find me all over the world. The water I live in may look nice and clean, but the unsuspecting people who drink it might swallow a surprise: me! If they ingest me I'll give them diarrhea, and if they don't live in an area with proper sanitation, they will release me back into the environment so that I can infect someone else.



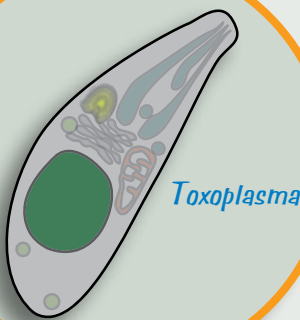
I'm Trypanosoma (try pan uh SO muh).

I cause trypanosomiasis, or sleeping sickness. You can only find me in Africa, where I am transmitted to humans through the bite of the tsetse fly. First I cause a skin rash and fever; then I invade the central nervous system. Over time, my victims will become progressively disabled by extreme fatigue and confusion, and finally they will die. Don't mess with me!



My name is Toxoplasma (tox uh PLAS muh).

My disease is Toxoplasmosis. Many people in the United States have me in their bodies but don't know it because they have no symptoms. I am transmitted to people through infected cats or contaminated meat, and I am dangerous to people with a weakened immune system. Pregnant women also worry about me because I can cause eye or brain damage in an unborn baby.



CAREER CORNER

It takes many different people to understand and control mosquitoes and to help prevent mosquito-borne diseases. Look at what some of these people do.

Yvonne Randle is a supervisor for Harris County Mosquito Control's virology laboratory in Houston, Texas. She tests mosquitoes to see if they carry protozoa or viruses such as the West Nile virus. If she finds an infected mosquito, she sends out mosquito control staff to take care of the problem. Ms. Randle has a background in science and has laboratory experience. She also has additional training from the Centers for Disease Control and Prevention (CDC) in using up-to-date techniques for testing mosquitoes.

You never know what you're going to find. Although the testing is routine, the results are not.

- Yvonne Randle



Dr. Jorge Muñoz works for the CDC in Puerto Rico. He grew up in Venezuela, where vector-borne diseases are a big problem. He majored in biology in college and began his career by working on Chagas disease, which is transmitted by "kissing bugs" that bite mainly at night. At the laboratory in Puerto Rico, he is now helping in the fight against dengue.

Vector-borne diseases are extremely diverse and of great interest to me. Working for the CDC Dengue Branch in San Juan is a dream come true.

- Dr. Jorge Muñoz



Tara Brant is a laboratory technician at the CDC in Atlanta, Georgia. She graduated from college with a degree in Biological and Environmental Science. Ms. Brant uses modern biological techniques to determine how mosquitoes that are resistant to insecticides differ from those that die from the insecticide.

When I was in the 8th grade I read the book The Hot Zone by Richard Preston and knew as soon as I finished that I wanted to study diseases. Growing up I always had a love for insects, so I figured that I would combine the two and study insect-vectored diseases.

- Tara Brant



MALARIA WORD SEARCH

S Q E E D M L M W E C N O M C
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BEDNETS

FEVER

LARVA

PARASITE

TRANSMISSION

BLOOD

INFECTIOUS

MALARIA

PROTOZOAN

VACCINE

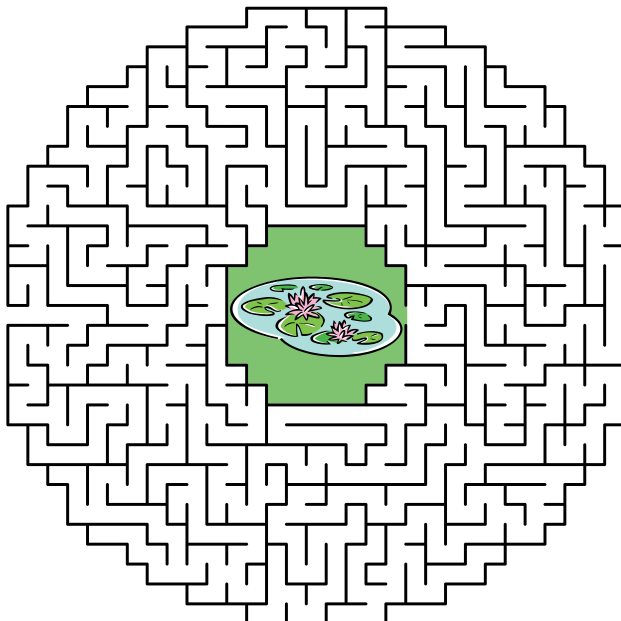
ENDEMIC

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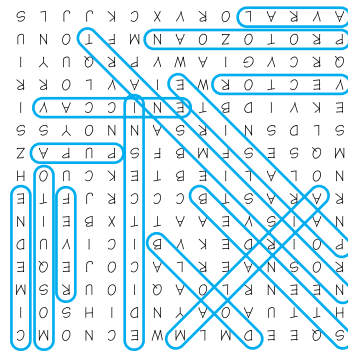
PUPA

VECTOR



MOSQUITO MAZE

Find your way to the mosquito breeding ground in the center of the circle. How quickly can you find the pond to drain it?



Solution for word search