

THE MYSTERIOUS WORLD OF MOSQUITOES AND DISEASE

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ARASI

AGE: 11



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If someone were to ask you, “What is the deadliest animal in the world?” you might not think the answer would be an insect smaller than a thumb tack! However, the deadliest animal in the world is in fact the mosquito! While “mosquito” means “little fly” and may sound harmless, mosquitoes can actually transmit devastating diseases to humans, resulting in over 600,000 deaths worldwide every year. This is almost as high as the number of deaths from cancer, the second leading cause of death in the United States. Mosquitoes are found all over the world and, chances are, you have encountered them (and their itchy bites!) yourself. Keep reading to learn more about these creatures, including how they live, the many types of mosquitoes that exist, and the dangerous diseases they can transmit to humans.

THE LIFECYCLE OF MOSQUITOES

Have you ever sat outside on a warm summer’s night, maybe by a pond or lake, and heard something buzzing around you? Maybe later you felt

itchy and noticed one or more swollen bumps on your arms or legs. You were probably bitten by a mosquito!

Mosquitoes go through four distinct stages as part of their life cycle: egg, larva, pupa, and adult (Figure 1) [1]. Female mosquitoes lay eggs on or near water, and even inside items like discarded tires or parts of plants that can hold water. After eggs hatch (in as little as 48 h), the larvae and pupae live in the water for about 1–2 weeks. Adults emerge from the pupal cases and stand on the water's surface or hang on to nearby vegetation until their wings dry and they can fly away. The life cycle from egg to adult to a new egg typically takes about 2 weeks in warm climates. The lifespan of a mosquito varies by species and can be affected by environmental factors including humidity and time of year, but it is generally around 20 days.

Figure 1

Life cycle of a mosquito. The life cycle begins when eggs are laid on or near the water's surface. Eggs develop into larvae. Larvae develop through four growth stages, getting bigger and bigger! The pupa forms, and the mosquito emerges from the water as an adult. The adult is the form that you have likely encountered: the mosquito that can fly! Approximate times are shown for each stage, but times may vary across mosquito species.

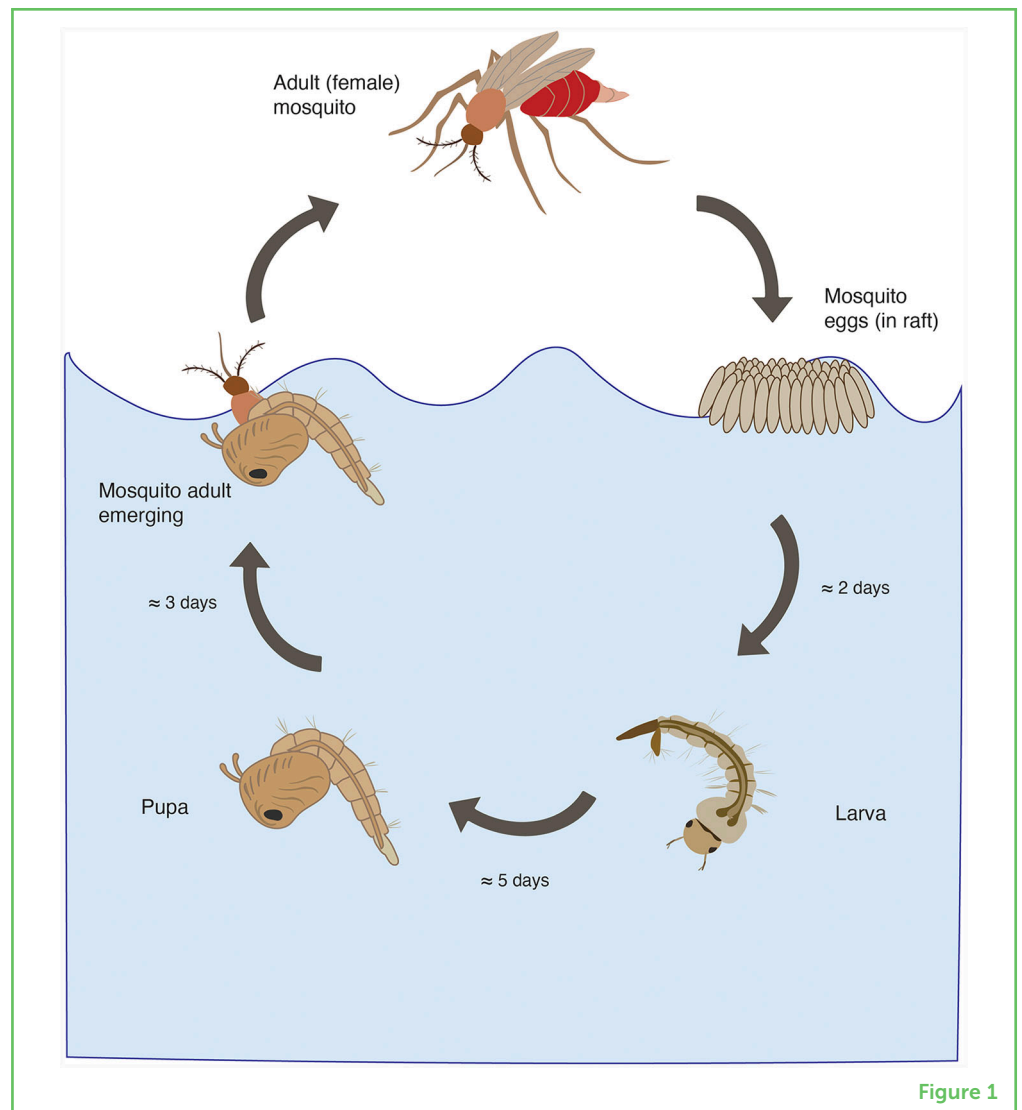


Figure 1

Did you know that only female mosquitoes can bite humans? Females lay eggs to create the next generation of “little flies”. To do this, they require protein, which they get from feeding on the blood of humans

or other animals. Female mosquitoes also feed on sugar as a source of energy, which they get from floral nectar, tree sap, or fruits. However, for male mosquitoes, sugar is their only food. Female mosquitoes are a bit like tiny vampires!

THERE ARE MANY TYPES OF MOSQUITOES

Mosquitoes belong to a family of organisms called Culicidae, which comes from the Latin word for “gnat”. There are three subfamilies, Anophelinae, Culicinae, and Toxorhynchitinae, which contain up to 112 smaller groups. There have been over 3,600 species of mosquitoes identified and described, but only some of these are involved in spreading diseases to humans—mostly mosquitoes in the Anophelinae and Culicinae subfamilies. Mosquitoes live in nearly every habitat on the planet. Some species are not picky eaters and will feed on the blood of many types of animals, while others are very selective, with strong and consistent preferences (for example, the species *Aedes aegypti* feeds almost exclusively on people).

MOSQUITOES AND DISEASE

Mosquitoes are known as **vectors**, or transmitters, that carry devastating disease-causing organisms called **pathogens** and spread them to humans and other animals through their bites. Yet, mosquitoes themselves do not usually experience negative effects from the diseases they transmit because they have evolved methods to combat them [2]! **Mosquito-borne diseases**, or diseases spread by the bite of infectious mosquitoes, are caused by viruses like West Nile, Zika, yellow fever, and dengue. Mosquitoes can also transmit other types of pathogens, including the parasites that cause malaria and tiny roundworms that cause lymphatic filariasis (Table 1). These diseases all have a significant impact on humans, with diseases like malaria resulting in 247 million global cases each year, and others, like yellow fever, with about 200,000 yearly cases. Malaria itself caused over 600,000 deaths globally in 2022, which is similarly high to the number of deaths caused by cancer in the United States.

PROTECTING YOURSELF FROM MOSQUITOES

Now that you know about many diseases mosquitoes can transmit, you may be thinking, “Why not just eliminate all mosquitoes?”. While that is a valid question, eradicating any organism would have cascading negative consequences for ecosystems. For instance, natural predators of mosquito larvae, such as fish or bats, would lose a major source of food. Therefore, we can instead think about steps that can prevent mosquito-borne diseases. The easiest way for people to protect themselves from these diseases is to prevent mosquito bites,

VECTORS

Living things, such as insects or animals, that act like vehicles to transport/transmit diseases to other animals or humans.

PATHOGENS

Disease-causing organisms such as bacteria, viruses, fungi, or parasites.

MOSQUITO-BORNE DISEASE

Illnesses spread by the bites of infected mosquitoes.

Table 1

Mosquito-borne diseases with their pathogens and vectors.

Pathogen type	Disease name	Most common symptoms in humans	Most common regions	Primary type of mosquito vector
Parasite	Malaria	Fever, chills, headache, muscle aches, fatigue	Large areas of Africa and South Asia, parts of Central and South America, Caribbean, Middle East, Oceania	<i>Anopheles</i>
Parasite	Lymphatic filariasis	Fluid collection, inflammation, and swelling of lymph nodes or limbs (legs and other body parts), fever	Tropics and sub-tropics of Asia, Africa, Western Pacific, parts of Caribbean and South America	<i>Anopheles</i> , <i>Culex</i> , <i>Aedes</i> , <i>Mansonia</i> , <i>Ochlerotatus</i> , <i>Coquillettidia</i>
Virus	West Nile	Fever, headache, body aches, skin rash, joint pain	Africa, Europe, the Middle East, North America, West Asia	<i>Culex</i>
Virus	Zika	Fever, rash, joint pain, red eyes, headache, muscle pain	Tropical Africa, Southeast Asia, Pacific Islands	<i>Aedes</i>
Virus	Chikungunya	Fever, joint pain and swelling, headache, muscle pain, rash	Africa, Southeast Asia, Indian subcontinent, Pacific Region, tropical regions of the Americas	<i>Aedes</i>
Virus	Dengue fever	Fever, body aches, nausea, vomiting, rash	Africa, the Americas, the Middle East, Asia, the Pacific Islands	<i>Aedes</i>
Virus	Yellow fever	Fever, headache, muscle pain, nausea, vomiting, fatigue, jaundice	Tropical and subtropical areas of Africa and South America	<i>Aedes</i> , <i>Haemagogus</i>
Virus	Encephalitis (Eastern equine, St. Louis, La Crosse, etc.)	Headache, fever, muscle and joint aches, fatigue	North America, Asia, Oceania	<i>Culex</i> , <i>Aedes</i>

Table 1

since this is how the pathogens spread to humans. As you now know, not all mosquitoes carry pathogens, but people who live in areas where mosquitoes are known to transmit malaria and other mosquito-borne diseases can shield themselves from these bitey bugs in various ways (Figure 2).

Figure 2

Preventing the spread of mosquito-borne diseases. Ways to prevent contact with mosquito vectors or to prevent the transmission of disease include protective clothing like long sleeves and pants that cover your skin, insecticide-treated nets, indoor residual spraying to kill mosquitoes that land on surfaces, insect repellents that can be sprayed on clothing, preventive medicines, and vaccines.

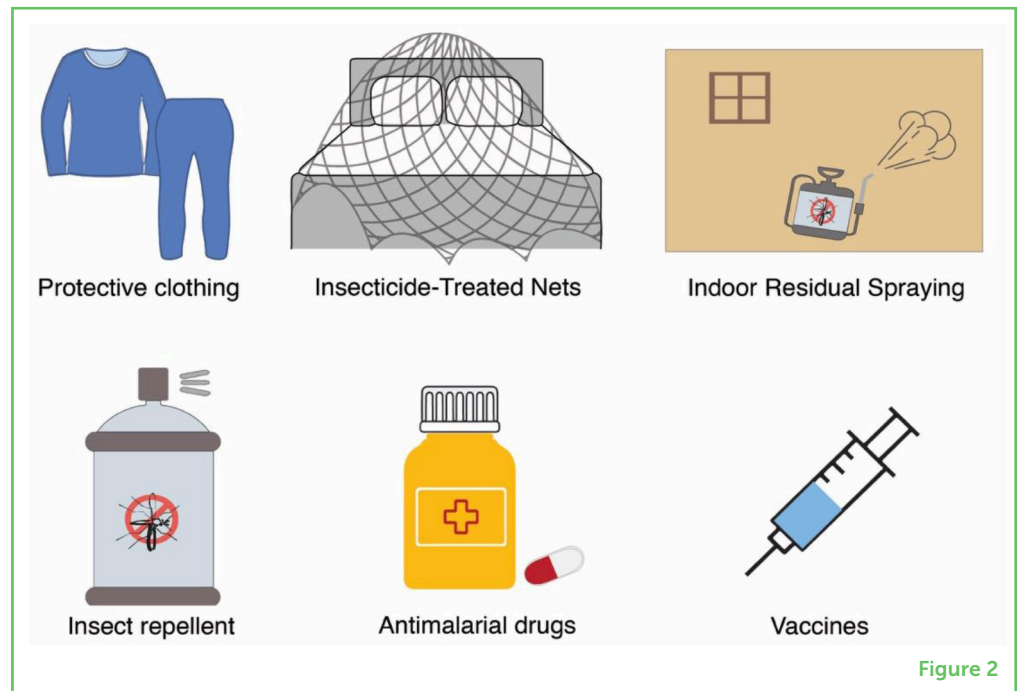


Figure 2

INSECTICIDE

Chemical that is sprayed or otherwise applied to kill insects.

REPELLENTS

Substances that are used to deter insects or keep them away.

VACCINE

A medical treatment given to help the body fight diseases by training the immune system.

ANTIMALARIAL DRUG

Medicine used to treat and/or prevent malaria.

For instance, one of the best ways to prevent mosquito bites is personal protection, such as minimizing exposed skin by wearing long-sleeved shirts and long pants [3]. People can also sleep under **insecticide**-treated nets containing chemicals that are harmful to insects, to prevent contact with mosquitoes during the night. There are also insecticides that can be sprayed in homes, which kill mosquitoes when the insects rest on sprayed surfaces after they have fed. All these insecticides have been tested extensively, and while they pose little threat to humans, they should be used as directed to limit excessive exposure and any negative effects on humans and the environment. There are even mosquito **repellents** that can be used in homes or on clothing. Because mosquitoes lay eggs in or near standing water, it is also recommended to remove items like tires, discarded cups, and other objects that may collect water, and to cover other water sources such as rain barrels to decrease habitats where female mosquitoes can lay eggs.

After many years of studying mosquito-borne diseases, scientists have created **vaccines** to prevent some diseases from spreading from mosquitoes to humans. There are currently vaccines to prevent yellow fever and Japanese encephalitis, but scientists are still working to develop new and better vaccines against other diseases, including malaria and dengue. There has been progress in the area of malaria vaccines, with the first approved vaccine, called RTS,S/AS01, already available in some of the most impacted countries in Africa, such as Ghana and Malawi [4]. Another new malaria vaccine called **R21/Matrix-M** has recently been recommended by the World Health Organization. There are also **antimalarial drugs** that can be taken to prevent malaria or to treat it once you have it. Medicines

are also available for some other mosquito-borne diseases, but in general, taking care of patients infected with many mosquito-borne viruses mainly consists of managing the symptoms. Finally, education about both mosquito-borne diseases and proper prevention tools is important, so that as many people as possible know how to protect themselves. Now that you have learned all about mosquitoes, the diseases they can cause, and how to prevent mosquito bites, you can educate others, too!

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YOUNG REVIEWERS



ARASI, AGE: 11

Hi! I am Arasi, a fifth grader who always stays on her toes! I love to dance, sing, and play sports. I also like to just sit down and read a good book. If you ask me what my favorite subject is, I will say everything! When I grow up, I want to become a pediatrician so that I can help kids.



ARCHIT, AGE: 13

My name is Archit, and I am an 8th grader. I love to read books and learn about past history. I play piano, and am in the percussion ensemble in my school. I also love to compose my own songs in my spare time! I am National Junior Honor Society President in my school's chapter and am also in the superintendent's student advisory council in my district. I run my own business with some of my friends too, where we aim to help birds.

AUTHORS



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Ilinca earned her Ph.D. at Purdue University, where her research spanned the fields of infectious diseases, with a particular focus on the malaria parasite and SARS-CoV-2. She earned her undergraduate degree in biological sciences from Columbia University and her master's degree in molecular microbiology and immunology at Johns Hopkins Bloomberg School of Public Health. In addition to her research interests, she is also passionate about teaching and fostering excellence in rigorous research, science communication, and mentoring future scientists. *iciubota@purdue.edu



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Doug is a professor at the Johns Hopkins Bloomberg School of Public Health in the Department of Molecular Microbiology. His research interests are primarily on

genetic diversity and the behavior and ecology of vector-pathogen populations. He is passionate about using novel technologies to understand the evolution and constraints of vector-disease systems, ranging from malaria, dengue, and tick-borne bacteria to arthropod trapping.