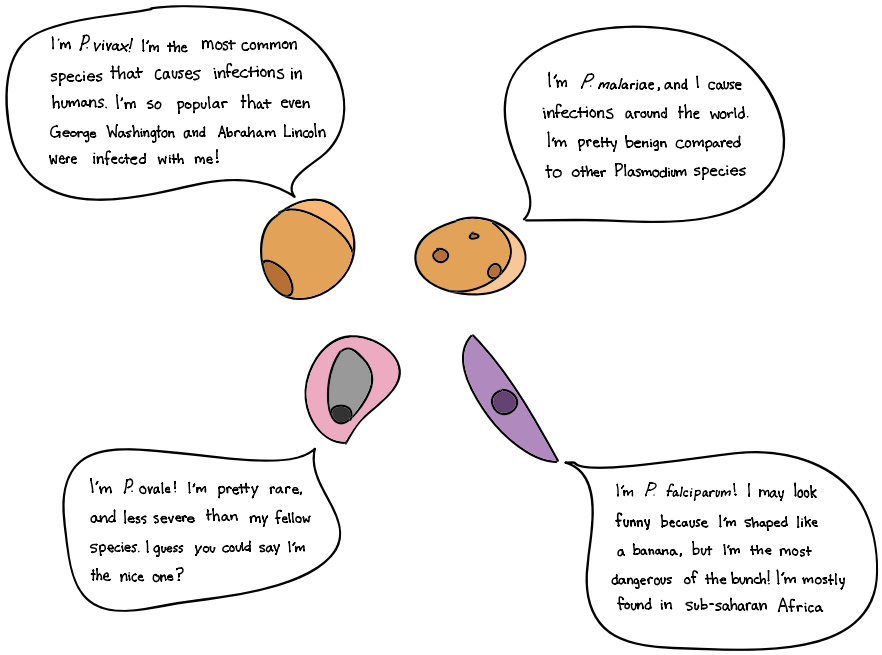
What is malaria?

When you think of the most deadly creature in the world, your instinct is probably to imagine a shark, bear, crocodile, or some other massive animal with big claws or huge teeth. In fact, when it comes to killing people, the most deadly animal in the world is a tiny insect: the mosquito! Unlike other dangerous creatures, mosquitoes do their deadly work by spreading diseases - one of the worst of these is malaria.

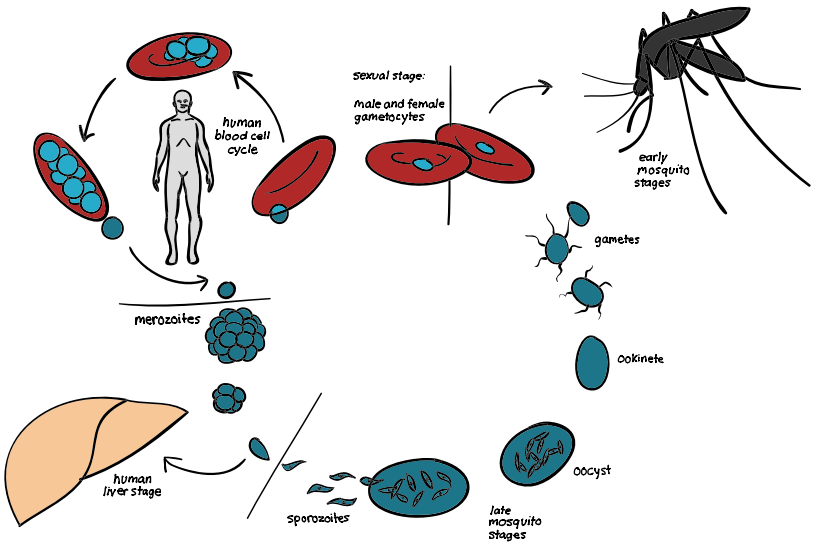
Malaria is an infectious disease caused by a parasite, called Plasmodium that invades red blood cells and liver cells. The parasites are transferred to humans by the bite of an infected *Anopheles* mosquito.

How does malaria cause disease?

Four different species of Plasmodium parasites cause most of the malaria in humans: *Plasmodium vivax*, *Plasmodium falciparum*, *Plasmodium ovale*, and *Plasmodium malariae*, with some species causing more severe symptoms than others.



If you are unlucky enough to get bitten by an infected mosquito, it not only gives you a nasty bite, but also transfers the malaria parasites from its saliva directly into your blood. To better understand the symptoms of malaria, we need to take a look at the life cycle of the malaria parasite.



1. If you are bitten by a mosquito carrying malaria parasites, it injects them into your bloodstream in the form of sporozoites (a spore-like form). Sporozoites travel in your blood until they reach and infect your liver cells.

2. Over 5-16 days, the time depends on which species of malaria you have, the sporozoites multiply and mature, producing tens of thousands of young adults, called merozoites, inside each liver cell. For some species, the merozoites remain dormant, but may reactivate weeks or months later.

3. When they are ready, the young adult parasites leave your liver cells for your bloodstream where they infect red blood cells. This begins a cycle of asexual reproduction in which broods of thousands of newly formed merozoites are produced and released over 1-3 days (again, the time depends on which species of malaria you have). It is the cyclical release of broods of merozoites into your bloodstream during this stage that causes the periodic feverish symptoms of malaria. Importantly, not all merozoites are destined for an asexual existence, some develop sexually instead. This produces male and female forms (gametocytes) that your blood cells carry around in your bloodstream.

4. Now when another mosquito bites you, it ingests blood cells containing gametocytes. The mosquito digests the blood cells, releasing the male and female gametes, which fuse together and burrow into the mosquito's gut wall, where they mature inside oocysts.

5. After 8-15 days (depending on the species) the oocysts burst and sporozoites are released into the body cavity of the mosquito. From there, they travel to the salivary glands, leaving the mosquito primed to transmit malaria parasites to new hosts.

What are the symptoms of malaria?

When you get bitten by an infected mosquito, it will most likely seem like any other mosquito bite. However, usually after a week or two, as the infection has takes hold, the first noticeable symptoms start to appear. All four species

of malaria can cause early, or prodromal “flu-like” symptoms such as headache, slight fever, muscle pain, and nausea, which coincide with increasing numbers of parasites in your bloodstream. A few days later these symptoms are often followed by periodic febrile attacks, also known as malarial paroxysms. Paroxysms typically last 4-8 hours and have 3 stages; a 15-to-60 minute cold stage when you shiver and feel very cold, a 2-6 hour hot stage when your fever may reach as high as 41^{o}C, and finally, a 2-4 hour sweating stage during which your fever drops rapidly. The febrile attacks are likely to leave you feeling exhausted, although after some sleep, you may feel quite well, until the next paroxysm.

In all types of malaria, paroxysms occur when many infected blood cells burst at the same time, releasing thousands of merozoites into the bloodstream all at once (stage 3 of the lifecycle). Malarial paroxysms occur periodically - 48 hours for P. vivax, P. ovale, and P. falciparum, and 72 hours for P. malariae. The 72 hour cycles with P. malariae is due to its slower growth and maturation.

The severity of malaria symptoms depends upon the species. Although P. vivax, P. ovale, and P. malariae may make you quite ill, and sometimes cause additional complications, unlike P. falciparum, they are rarely lethal. Although you usually develop some immunity to malaria that may make the paroxysms less severe, this does not provide full protection, so all forms of malaria tend to be chronic. This means that regardless of species, if you don’t get treatment, your malaria may relapse weeks or months later, due to activation of dormant merozoites in the liver, and these relapses may continue for decades.

Situations that increases your chances of getting malaria

Although mosquitoes can be found on every continent, malaria is only found in specific parts of the world - mosquitoes that transmit malaria like warm, wet tropical and subtropical regions. The biggest risk factor is to live in, or visit places where malaria is common. Places with the highest malaria risk and infection rates include:

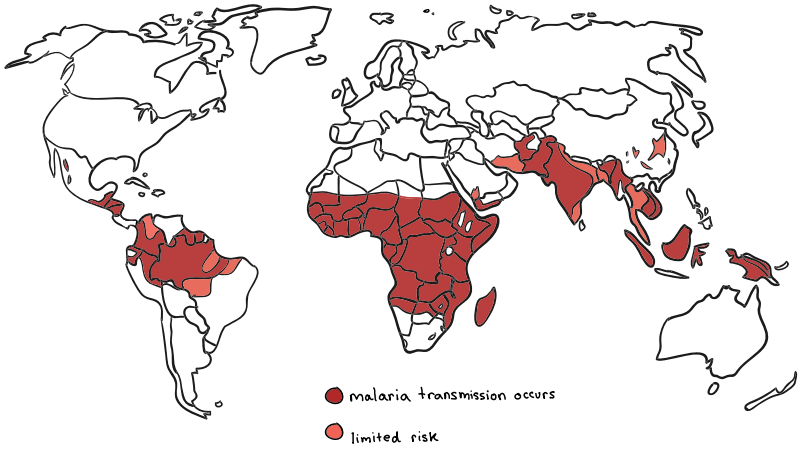
- Sub-Saharan Africa,
- The Indian subcontinent
- South Pacific Islands (Solomon Islands, Papua New Guinea)
- Haiti (in the Caribbean)

Every year, tens of millions of people from malaria-free countries travel to countries where it commonly occurs, and tens of thousands of people go home with malaria.[1] Certain groups of individuals are particularly susceptible, including young children, pregnant women, and people with weak immune systems, as well as people who have no immunity to malaria parasites.

How likely are you to get malaria?

Worldwide estimates tell us that over a billion people are currently at high risk of malaria, and around 600,000 people die of this disease every year.[1] Many people who are exposed to malaria live in regions where poverty, lack of knowledge, and a shortage of healthcare are barriers to life-saving treatment.

Risk of malaria around the world



What steps can you take to prevent malaria?

We do not yet have an effective vaccine that protects against malaria parasites. Nevertheless, if you live in, or are visiting tropical or subtropical regions, there are several ways you can protect yourself from this pervasive, potentially life-threatening disease.

- *Assess your risk*. The chances of getting malaria are largely based on when and where you are going – May to December are prime months for contracting malaria, particularly in sub-Saharan Africa, the Indian subcontinent, and Southeast Asia, and especially during and after the rainy season. Before you leave, check out your local disease control center for disease prevention information. You need to know the level of risk and the recommended type of prevention to deal with the risk. Then, get prepared.

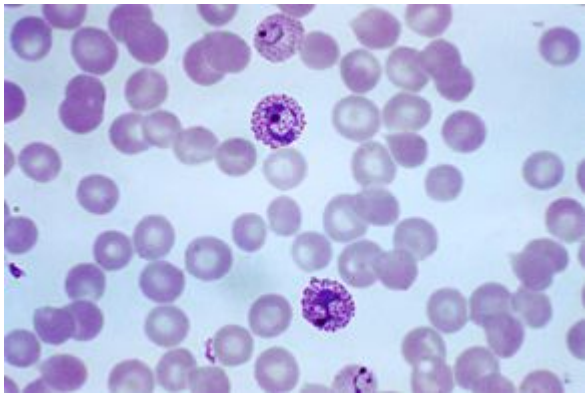
- *Take personal protection*. Your first lines of defense against mosquito bites are mosquito repellent and mosquito nets. These are recommended wherever and whenever there is any risk of malaria. Apply insect repellent in the early evening, before the mosquitos are out looking for dinner, and sleep behind insecticide-treated bed nets. These are around twice as effective as untreated nets, and this combination approach gives you the maximum personal protection against mosquito bites.[2, 3]

- *Take additional measures*. Not all malaria parasites are created equal, so if you are traveling to a region that is known to have mosquitos with the more prevalent and dangerous types (*P. vivax* and *P. falciparum*) you will need additional defenses to protect you. These come in the form of preventative medications that can stop the parasites in their tracks after they get into your bloodstream. You may have to take these medications before, during and after you return from your travels, and to have them work properly, you need to be sure to take them as directed.

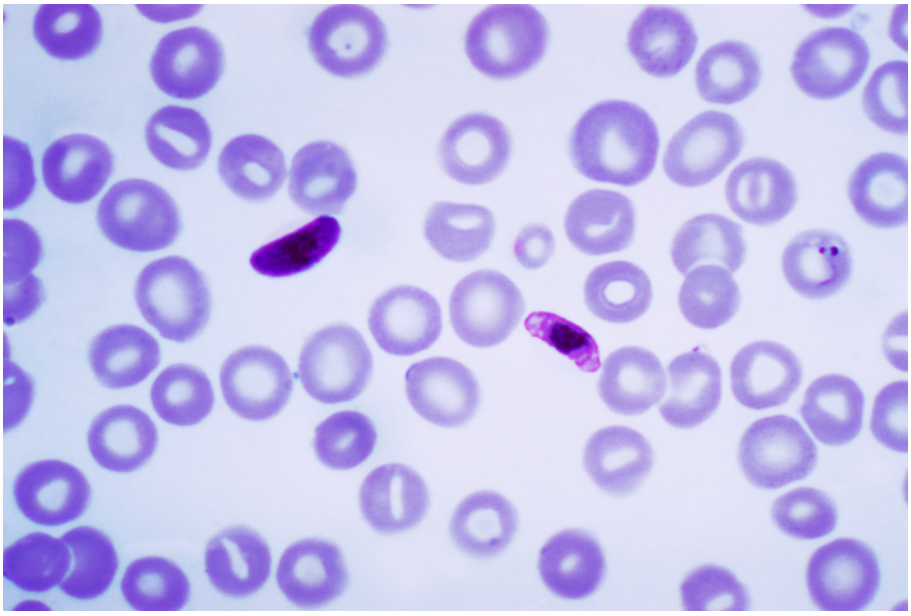
What treatments are available for malaria?

Flu-like symptoms are very common and may be caused by all sorts of infectious diseases, but if you have been in country where there is malaria, your doctor will likely want to test for it. The simplest and most common way to do this is by looking in your blood. The *Plasmodium* parasite can be visualized by adding a special stain to a drop of your blood on a microscope slide. Using a microscope, a trained healthcare professional can often identify which type of Plasmodium you are infected with.

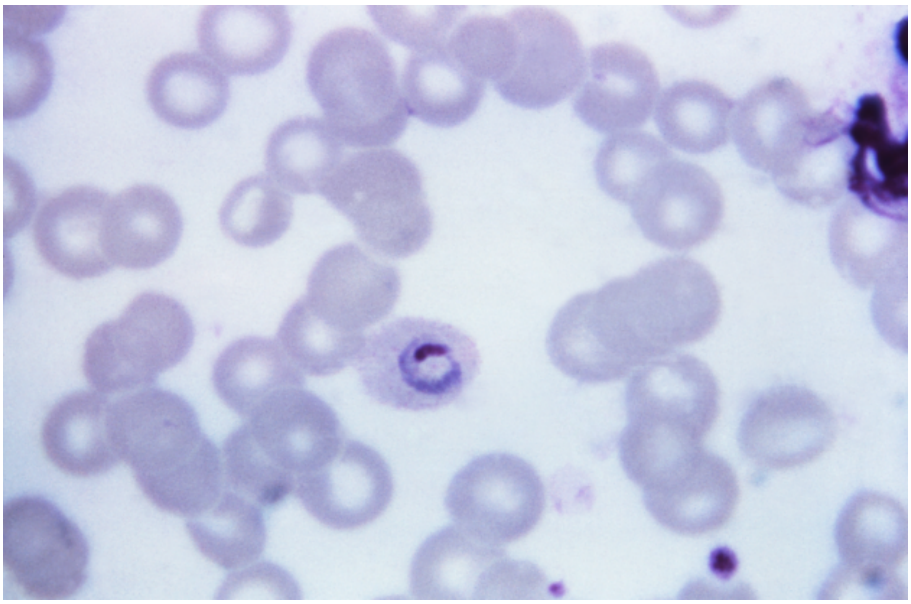
Malaria parasites under the microscope



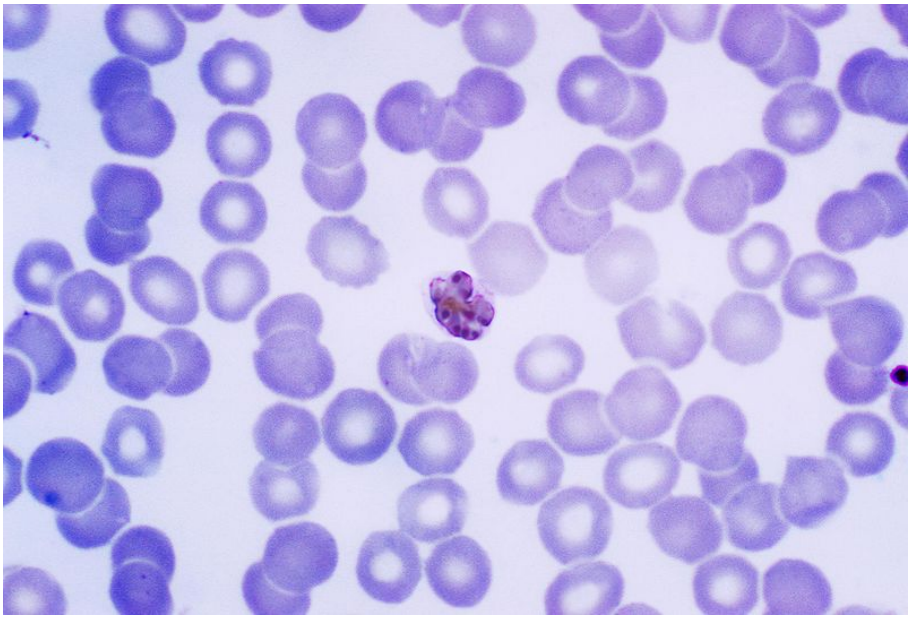
P. vivax[4]



P. falciparum[5]



P. ovale[6]



P. malariae[7]

The best treatments for malaria are combinations of antimalarial drugs known as artemisinin-based combination therapy, or ACT, to which other drugs may be added if necessary. Deciding which drug combinations to use to treat your malarial infection depends on a number of factors:

- the type of parasite you are infected with
- where and when you got infected
- how severe your symptoms are
- if you have other illnesses or conditions, are taking other medication, and/or have drug allergies
- whether or not you are pregnant
- whether or not the parasites in the region where you were infected are resistant to any of the available antimalarial drugs (*is the parasite resistant to treatment?*).

Early diagnosis and treatment of malaria can reduce your symptoms and prevent death, so if you do develop a fever, and have been in a malaria risk area at any time during the previous 12 months, you need to go to the doctor for a proper diagnosis just in case.

Consider the following:

- People who were born and raised, or who lived as a child in a region where malaria occurs, but who as adults are living in a malaria-free country, are often at extremely high risk of getting malaria when they return for a visit. Why would that be? First, any immunity to malaria that they may have gained through childhood exposure decreases with time. Although they may not realize it, this means that like other non-immune travellers they are very vulnerable to the disease if they get bitten by an infected mosquito. Second, people visiting friends and family are more likely to travel to remote regions where malaria transmission rates may be particularly high. Lack of awareness of the need to take precautions against mosquito bites puts travelers visiting friends and family at particularly high risk of disease.

- If you are bitten with *P. vivax* malaria, you may feel fine between attacks, and even without treatment, the paroxysms will most likely subside in a few weeks. However, if you get *P. falciparum* malaria, you are likely to feel unwell even between attacks and, without treatment, you may die. Why do you think this might be? One explanation is that the *P. falciparum*malaria infects red blood cells, regardless of whether they are young or old, producing very high numbers of parasites in the blood. *P. vivax*, on the other hand, only infects young red blood cells, which limits the number of parasites that can accumulate.