AN INTRODUCTION TO MALARIA

A curriculum resource for secondary teachers

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MALARIA MINI-UNIT

DESCRIPTION

This mini-unit has been developed to provide secondary teachers with an introductory package of lesson plans about malaria. Malaria is a significant health and development concern facing millions of people — it is the largest cause of child mortality in Africa and its control and prevention are part of the United Nations Millennium Development Goals (MDGs). Controlling malaria is a critical key to breaking the cycle of poverty in developing countries. Malaria is increasing largely as a result of environmental degradation and change, but is preventable and treatable. As a critical global issue with curriculum links to environmental and world studies and science, malaria deserves some time and attention in the classroom. The lessons in this mini-unit can stand alone but are better used as a sequence of three so that students develop an understanding of both the science of malaria infection and the socio-economic impacts the disease has worldwide. Students can also pursue responsive action through UNICEF.

SAMPLE CURRICULUM LINKS (Ontario Secondary)

SOCIAL SCIENCES AND HUMANITIES

HPW 3C Living and Working with Children
- Propose solutions to problems that are detrimental to the healthy development of children

HIP 3E Managing Personal and Family Resources
- Identify resources that influence the wealth or poverty of communities and nations

HLS 3O Living Spaces and Shelter
- Describe the consequences of unsolved housing problems

HFA 4M Food and Nutrition
- Describe economic factors that have an impact on the food choices of families and individuals
- Identify the social conditions that contribute to the incidence of illness and disease

HHS 4M Individuals and Families in a Diverse Society
- Analyse changes in labour-force participation
- Demonstrate an understanding of the effect of various aspects of social systems on individual development

HHG 4M Issues in Human Growth and Development
- Explain the relationship between maternal health and well-being and brain development in the child
- Demonstrate an understanding of the effects that various economic, political and social factors can have on human development
- Identify and evaluate ways to prevent these factors from negatively affecting human growth and development

HSB 4M Challenge and Change
- Discuss cultural, psychological and sociological barriers to accessing health care
- Analyse the social structures that support, and those that weaken, global inequalities

HEALTH AND PHYSICAL EDUCATION

PPZ 3O Health for Life
- Analyse the environmental factors that affect personal health
- Describe environmental influences on health on the local, national and global levels

SCIENCE

SBI 3U Biology
- Compare and contrast the life cycles of representative organisms from each life kingdom

SBI 3C Biology
- Evaluate the effects of large-scale use of fungicides and pesticides on the diversity of micro-organisms

SBI 4U Biology
- Outline the advances in medical care and technology that have contributed to an increase in life expectancy and relate these developments to demographic issues

SNC 3M Science
- Demonstrate, through their own research and its presentation, an understanding of ethical, environmental and economic issues that involve various viewpoints on the use of technologies in everyday life
- Assess the costs and benefits to society of recent technologies

SNC 3E Science
- Describe how bacteria, protists, viruses and fungi cause diseases in humans
- Formulate scientific questions about practical problems and issues related to micro-organisms
- Display in an appropriate format and report on information/evidence gathered concerning the benefits and/or costs to society of micro-organisms
- Gather, integrate and interpret information from print and electronic sources on a related health topic and report the findings

SNC 4M Science
- Analyse the costs and benefits of using organic products and assess their global impact on the environment
- Identify and describe strategies for pest control other than the use of organic products
- Describe the modes of transmission of diseases including those that are insect-borne
- Describe some of the means used by agencies and governments to control the spread of disease, both locally and globally
- Assess the possible positive and negative effects of a scientific discovery on society and the environment

BUSINESS STUDIES

BBB 4M International Business Fundamentals
- Evaluate the advantage and disadvantages in both developed countries and developing countries with regard to business opportunities
- Analyse the ways in which international development agencies and non-governmental organizations promote economic progress in developing countries

CANADIAN AND WORLD STUDIES

CGC 1P Geography of Canada
- Evaluate Canada's effectiveness and commitment in responding to global challenges

CGG 3O Travel and Tourism
- Identify the economic, cultural, political and environmental components of selected issues related to travel and tourism
- Explain how various factors contribute to the growth or decline of tourism around the world

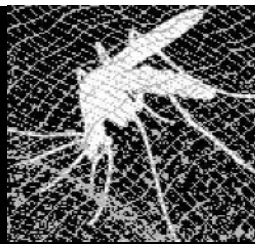
CGW 4U Canadian and World Issues
- Analyse problems of hunger and poverty in selected countries and explain how certain practices may aggravate the problem
- Explain the relevance of governmental and non-governmental organizations to work on poverty, disease and the environment

UNIT OVERVIEW

The mini-unit begins with an introductory online video clip from the global Roll Back Malaria (RBM) campaign, http://www.rollbackmalaria.org/multimedia/video.html**,** that introduces students to the disease as a whole and to some of the socio-economic issues associated with the disease. Following the viewing of this video, students are encouraged to formulate questions about the disease that may help to drive further discussions throughout the unit.

The unit continues with activities on the life cycle of the *Plasmodium* parasite; mapping exercises that plot overall global malaria transmission trends; group discussion activities that examine various case studies related to the impacts of malaria, and closes with a culminating activity where students are challenged to respond to their learning by formulating an awareness and action campaign for their school.

MALARIA LESSONS 1 & 2
THE LIFE CYCLE AND TRANSMISSION OF MALARIA



Established Learning Goals

- Develop a basic understanding of malaria as a human disease
- Demonstrate an understanding of the life cycle of *Plasmodium*, the malaria-causing parasite
- Demonstrate an understanding of the scope of the malaria epidemic and be able to identify major areas of risk around the globe

Assessment Evidence

- Students will be able to describe the general life cycle of the *Plasmodium* parasite.
- Students will be able to describe the general trend in malaria infection around the world through mapping relevant statistical and diagrammatic data.

Teacher Background Information

Malaria is a disease that affects millions of people, of all ages, around the world. While it is preventable and curable, a child dies of malaria every 30 seconds, and more than one million people die of the disease every year. Most of these deaths are in Africa and most of them are infants and children under the age of five. Pregnant women are also at high risk. Over 40 per cent of the world's population live in the regions where malaria is most prevalent, around the equatorial zone, although climate change may be promoting the spread of malaria to adjacent regions.

Quick Facts:

- Malaria affects approximately 500 million people every year.
- Malaria kills more than 1 million people ever year.
- Malaria deaths account for 20 per cent of all deaths among children under the age of five in sub-Saharan Africa.
- Most cases of malaria are in sub-Saharan Africa.
- Many African families spend up to a quarter of their annual income on malaria treatment and lose several weeks or months of income per year due to related illness.
- In many parts of Africa and most of Asia, the malaria parasite has become increasingly resistant to traditional treatments like chloroquine and sulphdoxine-pyrimethamine. Artemisinin-containing combination therapy (ACT) is a more effective therapy but costs 10 to 20 times more than the traditional methods at US$ 2 to 3 per adult dosage.
- Using insecticide-treated bed nets is an effective and affordable method of malaria prevention, reducing transmission of malaria by 50 and reducing mortality from all causes by 20 per cent, but at the end of 2004, fewer than 5 per cent of African children were sleeping under bed nets.
- Pregnant women (especially those with no immunity) are at a high risk for malaria infection.
- Malaria is caused by a parasite (of the Kingdom Protista) of the genus *Plasmodium* that is spread from person to person through the bite of an infected female mosquito (of the genus *Anopheles*). First symptoms, including fever, headache, chills and vomiting, typically appear 10 to15 days after infection. If left untreated, malaria can cause severe illness and is often fatal. Transmission differs in intensity depending on factors such as local rainfall patterns, location of mosquito breeding sites and presence of various mosquito species. Some areas are malaria zones throughout the year, while others have malaria "seasons" that usually coincide with the local rainy season.
- There are four species of *Plasmodium* that result in human malaria – *Plasmodium falciparum* (*P. falciparum), P. vivax, P. malariae, and P. ovale.*
- *P. falciparum* is the most deadly form of malaria.
- A full World Health Organization (WHO) fact sheet on malaria can be found in Appendix 1 of this resource. See www.who.org, www.malarianomore.org/kids/educational-materials.php or http://rbm.who.int for more information. A detailed set of answers to "Frequently Asked Questions" can be found at the bottom of www.rollbackmalaria.org.

Planning Notes

- Preview and prepare introductory video for download and viewing, from http://www.rollbackmalaria.org/multimedia/video.html, in *Publications and Multimedia*, *Video: Kill or Cure: The World's Deadliest Diseases — Malaria, Part 1, a BBC production*. (Real Audio Player or Flash is required.)

- Students will need Internet access for Activity 3 (a non web-based version is also provided but students will need access to atlases for this option).

- Prepare overheads of:
  — Black Line Master (BLM) 1 — *Kill or Cure: The World's Deadliest Diseases — Malaria, Part 1*
  — BLM 2 — The Basic Life Cycle of a Malaria Infection
  — BLM 3 — Detailed Life Cycle of *Plasmodium*

- Prepare student copies (1/student) of:
  — BLM 1 — *Kill or Cure: The World's Deadliest Diseases — Malaria, Part 1*
  — BLM 2 — The Basic Life Cycle of a Malaria Infection
  — BLM 3 — Detailed Life Cycle of *Plasmodium*
  — BLM 4 — The Spread of Malaria

Lesson Overview

- **Teaching/Learning Strategies:**

— Activity 1: Introduction to Malaria
Preconceptions and on-line video from the Roll Back Malaria project

— Activity 2: Disease Life Cycle and Transmission

— Activity 3: The Spread of Malaria
Using a Web site (and/or data tables) to identify key areas of infection globally

LESSON 1 — TEACHING / LEARNING STRATEGIES

Activity 1. Introduction to Malaria

(with short video shown online from Roll Back Malaria Web site).

- Distribute **BLM 1 — *Kill or Cure: The World's Deadliest Diseases — Malaria, Part 1*.**
- Ask students to complete the preconception activity about malaria before viewing the video. You may opt to have students share and discuss these preconceptions as a class or in small groups before the video begins.
- Use the remainder of BLM 1 as guiding questions during viewing of the online video: *Kill or Cure: The World's Deadliest Diseases — Malaria, Part 1* from http://www.rollbackmalaria.org/, under *Publications and Multimedia*, *Video, Kill or Cure: The World's Deadliest Diseases — Malaria, Part 1, a BBC production*. (Real Audio Player or Flash is required.)
- Discuss those issues from the video identified by students.
- Ask students to complete the last column of the preconception chart and encourage students to share their learning from the video.
- Distribute blank copies of **BLM 2 — The Basic Life Cycle of a Malaria Infection** (or reproduce as an overhead for referral during the lesson) and lead students through a basic discussion about malaria infection and major factors driving infection.
- Ask students the following questions upon completion of this basic life cycle on BLM 2:

Knowing what you do now, suggest some simple preventative measures that could be used to reduce the risk of malaria infection.

Examples: sleeping in an area where there are not many mosquitoes, getting rid of standing water where mosquitoes breed, sleeping under a bed net, using insect repellent, some students may also know that there are preventative drugs that can be taken before going to a malaria zone, etc.

Why do you think is it difficult for many people in the hardest hit areas of the world to access these simple methods of prevention?

Examples: limited access to health care in general, limited resources to purchase and/or maintain bed nets, medication too costly, poor health system infrastructure due to conflict/emergencies, proximity to health centre or clinic, etc.

Activity 2. Disease Life Cycle and Transmission

- Distribute copies of **BLM 3 Student – Detailed Life Cycle of *Plasmodium*.**
- Use **BLM 3 Teacher** as an overhead or for discussion to work through a more detailed life cycle for *Plasmodium.*

Activity 3. The Spread of Malaria

Note: This activity could also be assigned for homework or as an independent assignment outside of class time.

- Distribute copies of **BLM 4 — The Spread of Malaria** and ask students to complete the exercise independently or in pairs. This activity has been developed so that it can be completed with or without online access to malaria data. Please distribute the appropriate version of BLM 4 to suit your technology needs. The offline version of the activity will be a good challenge in terms of country identification and geography skills!

KILL OR CURE: THE WORLD'S DEADLIEST DISEASES — MALARIA, PART 1

(BBC Production)

Preconception Activity

Complete the first two columns of the chart before viewing the online video *Kill or Cure: The World's Deadliest Diseases — Malaria, Part 1.*

TOPIC: MALARIA

What I Know	What I Want to Know	What I Learned

Observing the Video

1. Record brief notes about any **biological** information presented in the video (e.g. what causes malaria infection and how it spreads).

2. Record brief notes about any **sociological** information (e.g. how the disease is affecting people and communities beyond the medical implications) presented in the video.

3. Identify **at least three** themes or challenges related to malaria presented in the video.

4. At the end of the video, complete column 3 of the chart.

KILL OR CURE: THE WORLD'S DEADLIEST DISEASES — MALARIA, PART 1

(BBC Production)

Preconception Activity

Complete the first two columns of the chart before viewing the online video *Kill or Cure: The World's Deadliest Diseases — Malaria, Part 1.*

TOPIC: MALARIA

What I Know	What I Want to Know	What I Learned
Will vary	*Will vary*	*Will vary – may include:* • *A child in Africa dies from malaria every 30 seconds* • *Biggest killer of children — 90 per cent of deaths are children* • *Bed nets are a good prevention method*

Observing the Video

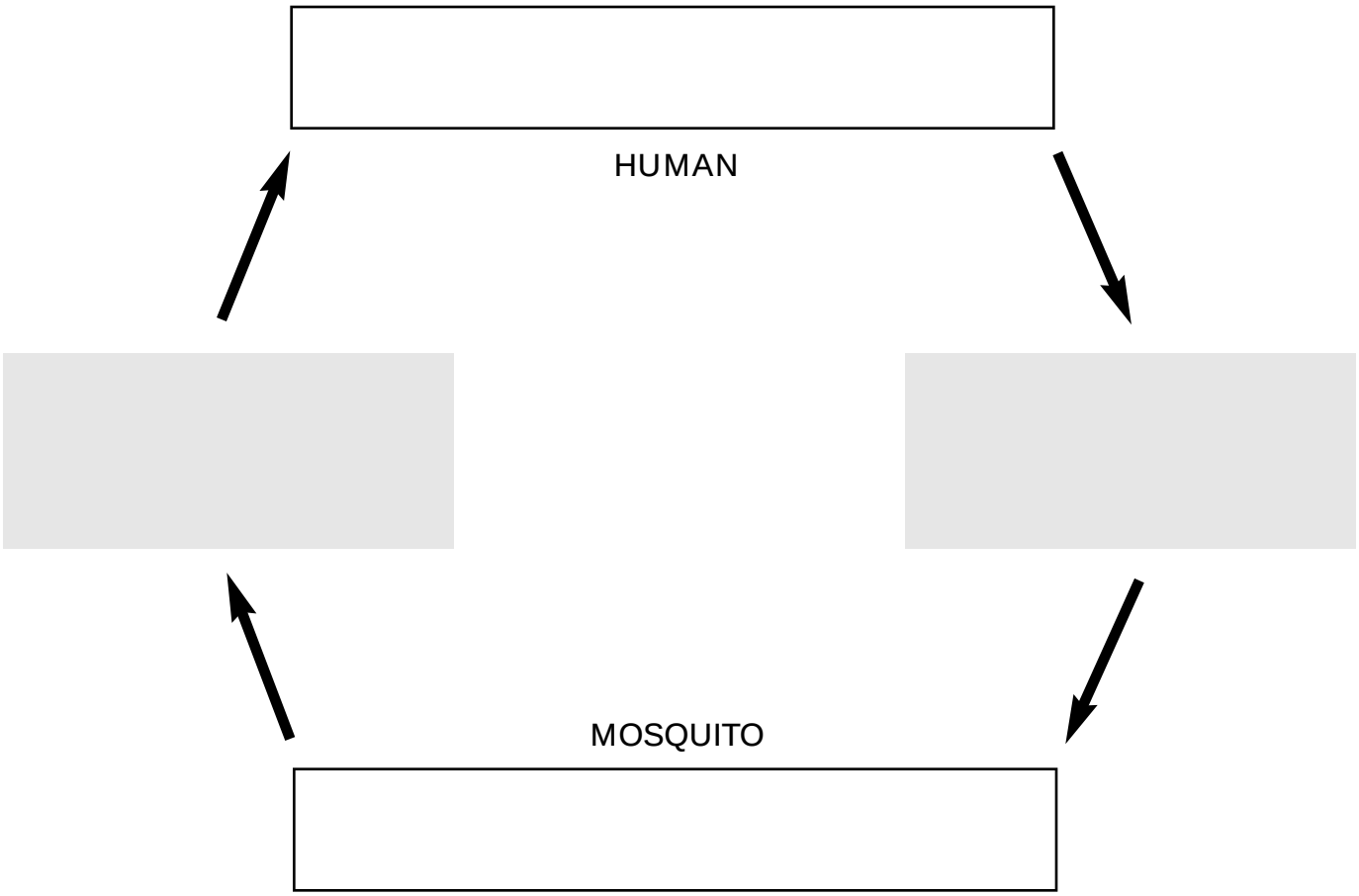
1. Record brief notes about any **biological** information presented in the video (e.g. what causes malaria infection and how it spreads).
   - *Malaria is largest killer of children in the world — infection is worse in small weak bodies*
   - *Malaria caused by a parasite that is passed to people through mosquito bites — parasite attacks liver and then red blood cells where it can travel to kidney and spleen, sometimes the brain*
   - *Can be deadly in 24 hours without treatment; causes one million deaths/year*
   - *Has been eradicated in more developed countries*
   - *Many children can have malaria several times in a matter of months — some receive treatment but still show signs of the disease*

2. Record brief notes about any **sociological** information (e.g. how the disease affects people and communities beyond the medical implications) presented in the video.
   - *There is a huge need for affordable drugs that are safe*
   - *The developing world has to rely on older drugs that are not always effective against the parasite (parasite has evolved to develop resistance to these drugs); one million deaths/year*

3. Identify **at least three** themes or challenges related to malaria presented in the video.
   - *There is a need for new and effective drugs that are affordable for all — and investment in continuing research on prevention and treatment*
   - *Malaria is rampant in sub-Saharan Africa*
   - *Drug resistance is a problem*
   - *Access to health care is not universal — unfair as the disease is treatable and preventable and yet millions are dying without access to preventative (i.e. bed nets) or treatment measures*

4. At the end of the video, complete column 3 of the preconception chart.

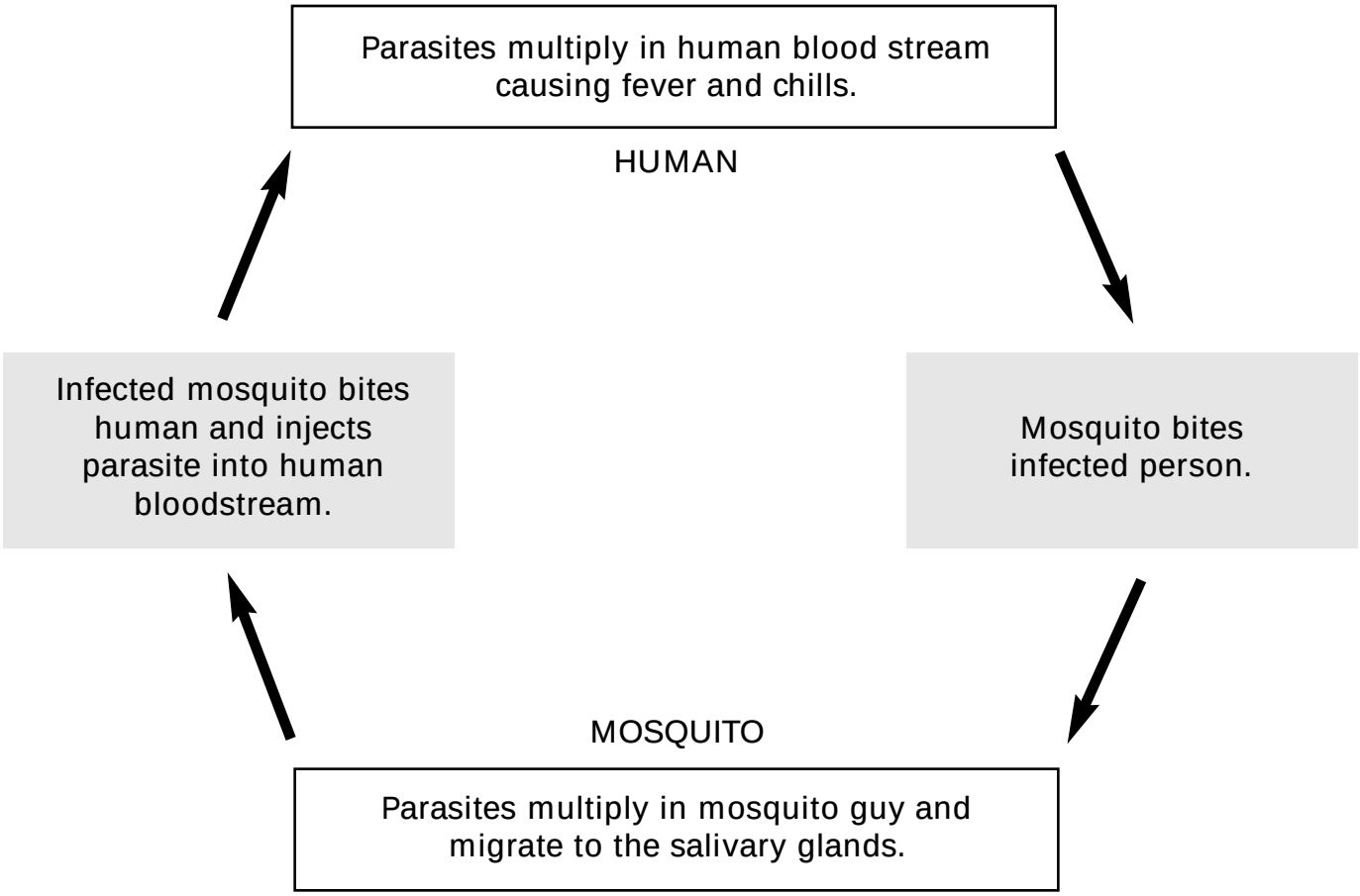
THE BASIC LIFE CYCLE OF A MALARIA INFECTION



Adapted from: *http://rbm.who.int/cmc_upload/0/000/015/372/RBMInfosheet_1.htm*

Key Factors in Malaria Infection:

THE BASIC LIFE CYCLE OF A MALARIA INFECTION



Adapted from: *http://rbm.who.int/cmc_upload/0/000/015/372/RBMInfosheet_1.htm*

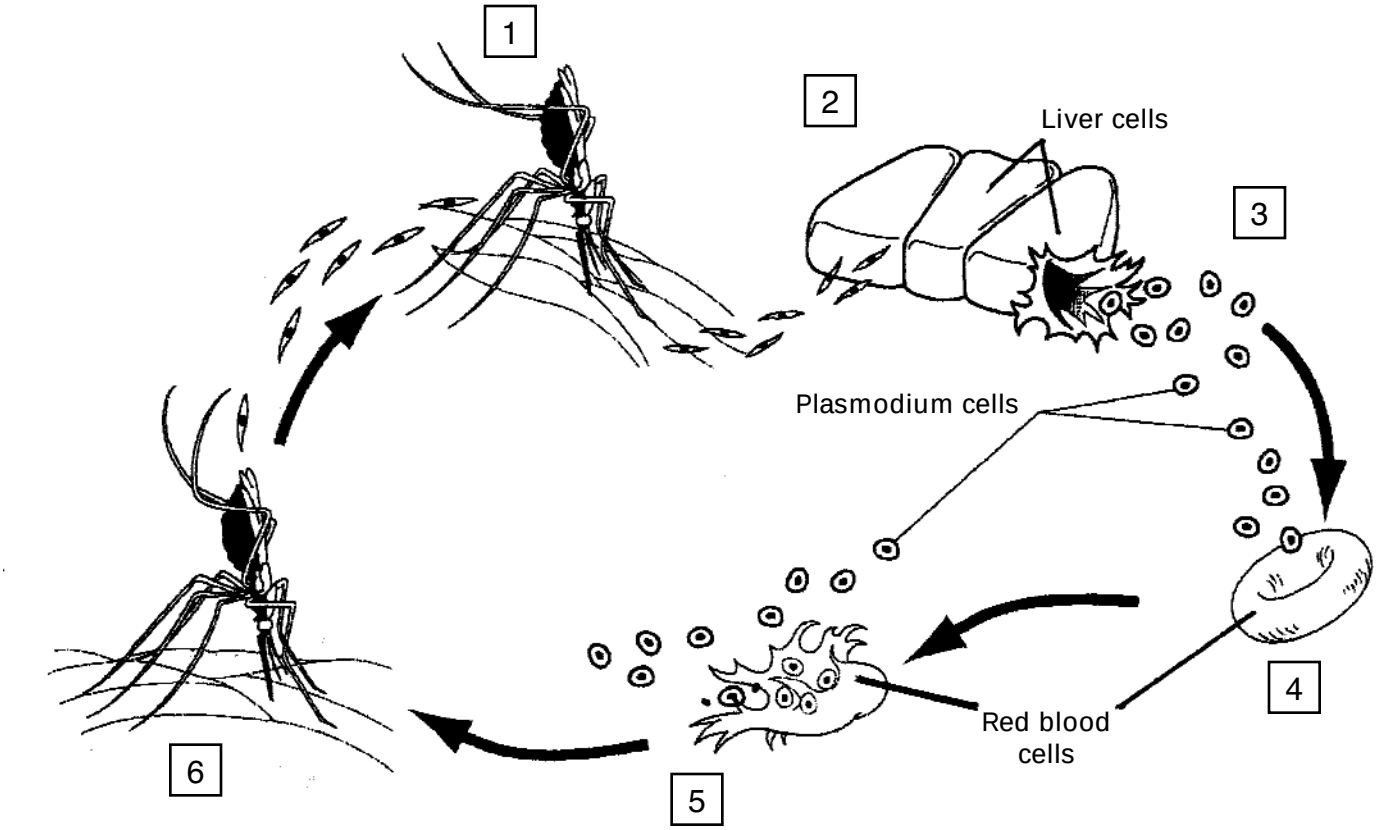
Key Factors in Malaria Infection:

- Mosquitoes tend to be active and feeding during the hours when people are asleep.
- Both humans and mosquitoes are used as hosts for the malaria parasite.
- Malaria goes from infection to onset of symptoms very rapidly; a matter of 9 days to a month, depending on the species of *Plasmodium.*
- Transmission differs in intensity depending on factors such as local rainfall patterns, location of mosquito breeding sites, and presence of various mosquito species. Some areas are malaria zones throughout the year, while others have malaria "seasons" that usually coincide with the local rainy season.

There are four species of parasite that lead to malaria in humans, all of the genus *Plasmodium.* Most malaria infections are caused by *Plasmodium falciparum,* the most severe and life-threatening form of the disease. Key malarial regions are also home to the most efficient, and therefore deadly, species of the mosquitoes of the genus *Anopheles*, the females of which transmit the disease.

DETAILED LIFE CYCLE OF *PLASMODIUM*

(Diagram *Life Cycle of Plasmodium* used with permission from Addison-Wesley Biology 11, Copyright © 2002 Pearson Education Canada Inc.)



1	
2	
3	
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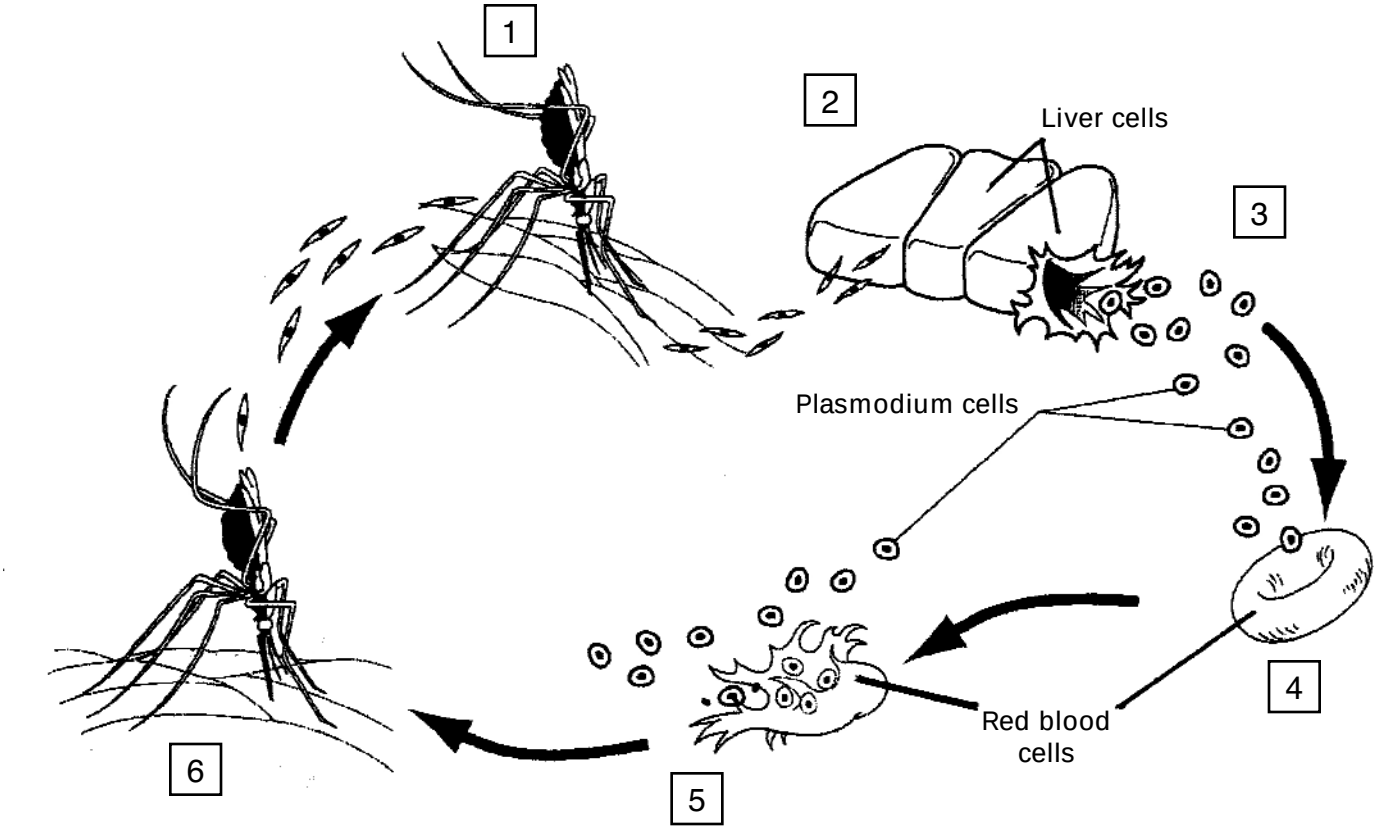
DETAILED LIFE CYCLE OF *PLASMODIUM*

(Diagram *Life Cycle of Plasmodium* used with permission from Addison-Wesley Biology 11, Copyright © 2002 Pearson Education Canada Inc.)



**Because this is a cycle, we will intentionally focus on the mosquito stage.*

1	A female *Anopheles* mosquito carries the sporozoites of the parasite *Plasmodium* (of the kingdom Protista) in her saliva. With a blood meal from a human, as with any mosquito bite, she injects a portion of her saliva into the skin. Normally when you get a mosquito bite, it is the saliva of the mosquito that makes the bite red and itchy. When *Plasmodium* parasites are left behind with the saliva, the bite causes a lot more damage than just being itchy.
2	The injected parasites go directly to the liver (the site of red blood cell production). The sporozoites multiply in the liver to become merozoites of the parasite.
3	Merozoites are released to infect red blood cells. (A single sporozoite can produce 30 000 merozoites in 6 days!) Red blood cells contain iron and carry oxygen throughout the body.
4	Merozoites rapidly reproduce over 48 hours within the red blood cells. *(As the white blood cells of the immune system recognize the infection, they begin to work hard and cause the body to go into fever.)*
5	Red blood cells eventually burst to release more of the parasite into the blood stream. Some of the Merozoites divide to become gametes, or sex cells of the parasite.
6	Another female *Anopheles* mosquito comes for a blood meal and during feeding, picks up some of the parasite from the human's blood (including both male and female sex cells of the parasite). In the gut of the mosquito, the gametes fuse together (to form sporozoites) and move to the salivary glands where they are re-injected into another human during the next blood meal. The cycle continues with both human and mosquito acting as **hosts**. The mosquito is the **vector** for the disease as it is the way that the parasite is transmitted.

THE SPREAD OF MALARIA

1. Students will work individually or in pairs to complete the following exercise. Each student must complete their own worksheet.

2. Go to http://www.rollbackmalaria.org/wmr2005/

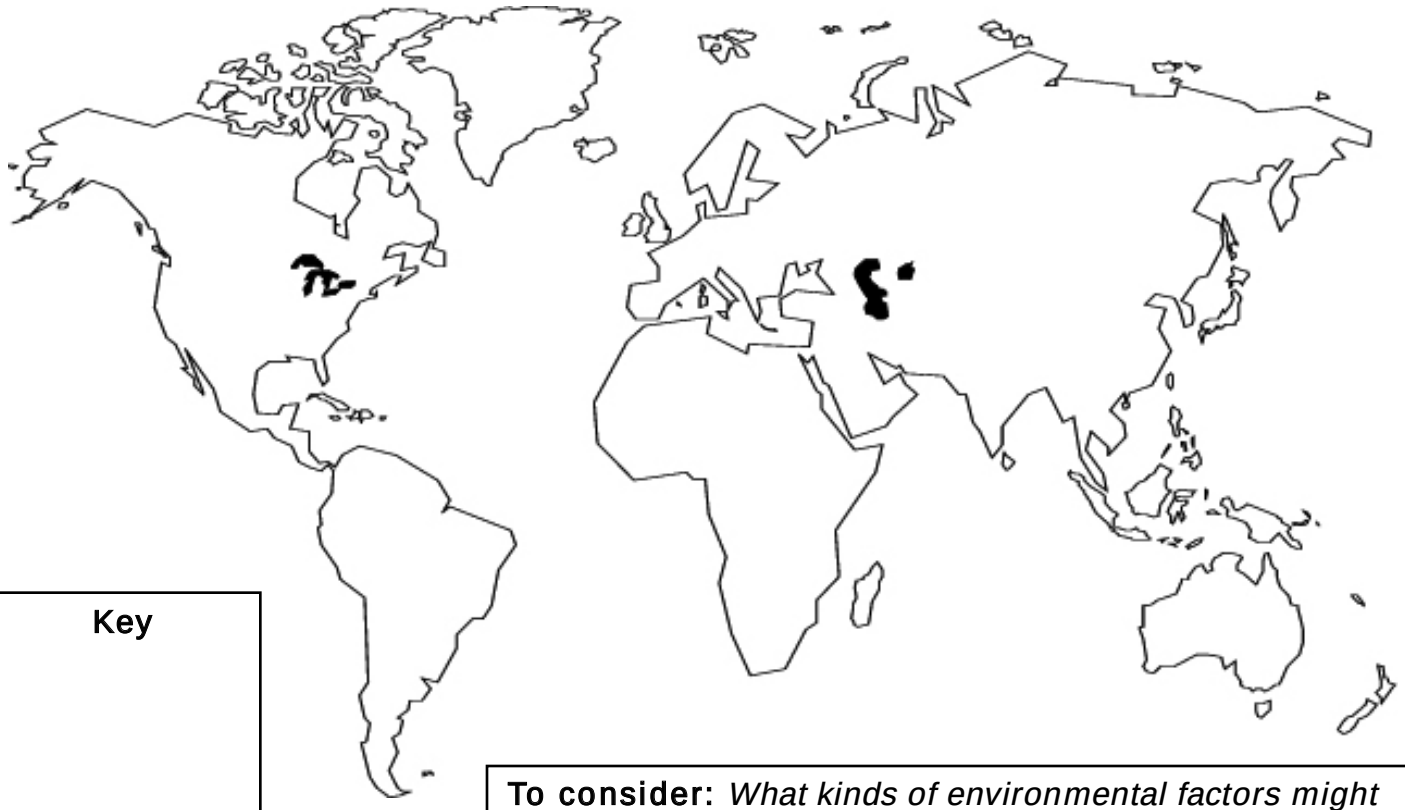
3. At the right side of the page, choose MAPS, MALARIA TRANSMISSION RISK. Use the map presented here to answer the following questions.

   a. ***In general, what parts of the world show the highest risk of malaria infection? Why do you think this might be?***

4. Use the world map provided below, and with an appropriate key/legend, shade the areas of the world according to **risk of malaria transmission**.

Map Title: _____

Source: http://www.abcteach.com/Maps/world.htm



Key

To consider: *What kinds of environmental factors might increase the rate of malaria transmission?*

THE SPREAD OF MALARIA

1. Students will work individually or in pairs to complete the following exercise (use an atlas to help identify country locations). Each student must complete their own worksheet. Use the data table below to answer the following questions. The countries listed here do not represent an exhaustive overview of malaria around the world. They are meant to provide examples only so that global transmission trends can be observed.

Table 1: Risk of Malaria Transmission

Country	Malaria Risk	Country	Malaria Risk	Country	Malaria Risk
Canada	none	Sudan—central	high	Namibia—remainder	none
USA	none	Sudan—north central	low	Algeria	none
Argentina	nnone	Sudan—extreme north	none	Morocco	none
Brazil—extreme north	low	Chad—south	very high	Egypt	none
Brazil—north central	moderate	Chad—north	none	Australia	none
Brazil—central	high	Niger—south	very high	Russia	none
Peru—north-east tip	moderate	Niger—north	none	New Zealand	none
Mexico—southern tip	very high	Nigeria	high	Iran—southern border	moderate
Honduras	very high	South Aftrica —extreme north-east	high	India—west coast and east coast (including central India	very high
Nicaragua	very high	South Africa —remainder	none	India—north-east along Nepal border	moderate
Guyana—south	very high	Mozambique	high	India—remainder	low
Guyana—north	high	Botswana—north	moderate	Myanmer	very high
Chile	none	Botswana—remainder	none	China (generally with some moderate pockets in south-east)	none
Uruguay	none	Zimbabwe	moderate	Indonesia (west islands)	low
Democratic Republic of the Congo	very high	Angola—north and east	moderate	Indonesia (east islands)	high
Central African Republic	very high	Angola—remainder	low	Countries of Europe	none
Sudan—south	very high	Namibia—extreme north only	moderate		

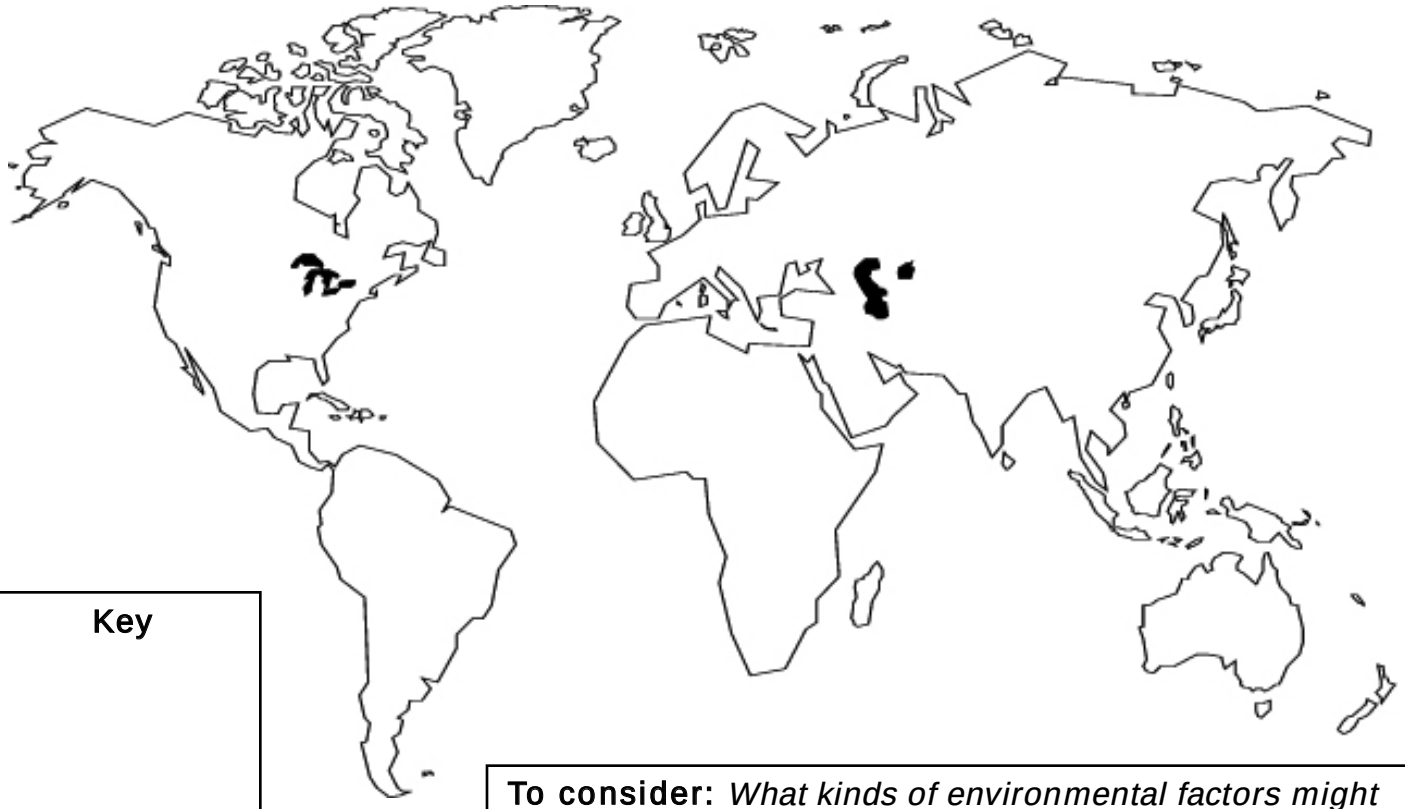
2. Extension: During class or as a homework assignment, students can research theories about the impact of global climate change on the spread of malaria and add appropriate shading to their maps to illustrate this.

   a. Using the world map provided below, and with an appropriate key/legend, shade the areas of the world according to **risk of malaria transmission**.

   b. ***In general, what parts of the world show the highest risk of malaria infection? Why do you think this might be?***

Map Title: _____

Source: http://www.abcteach.com/Maps/world.htm



Key

To consider: *What kinds of environmental factors might increase the rate of malaria transmission?*

THE SPREAD OF MALARIA

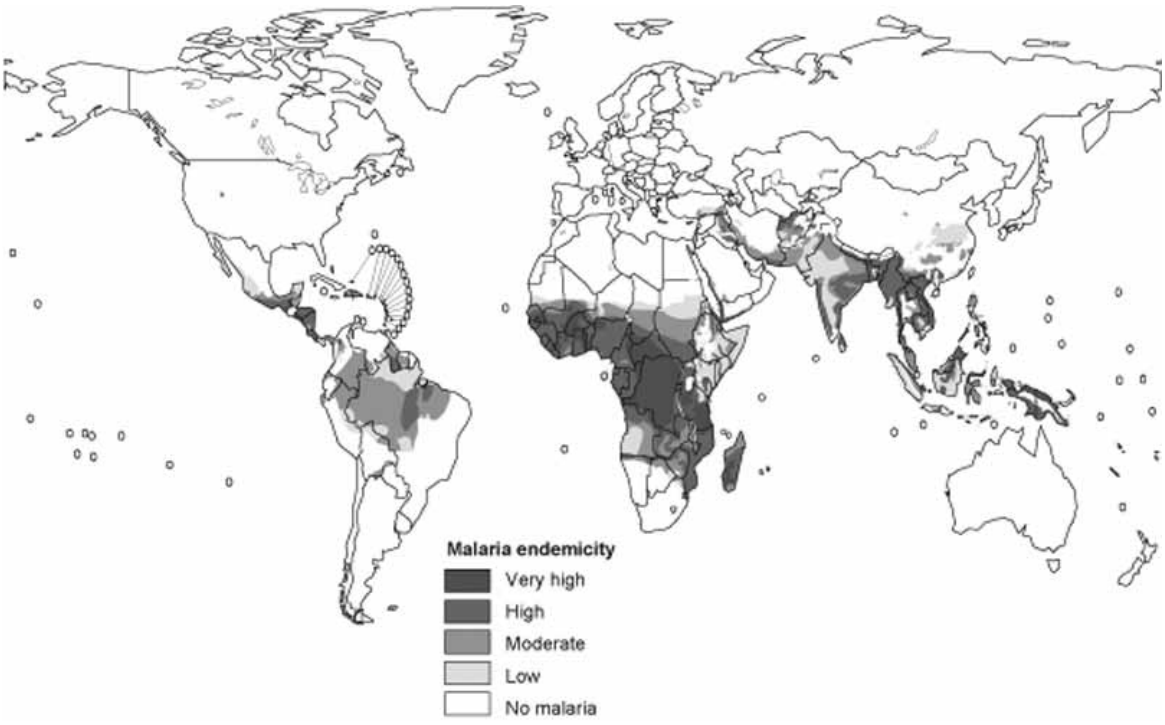
1. Students will work individually or in pairs to complete the following exercise. Each student must complete their own worksheet.
2. Go to http://www.rollbackmalaria.org/wmr2005/
3. At the right side of the page, choose MAPS, MALARIA TRANSMISSION RISK. Use the map presented here to answer the following questions.
   a. ***In general, what parts of the world show the highest risk of malaria infection? Why do you think this might be?***

      Climate is conducive to vector survival, mosquito breeding sites, form of malaria parasite most prevalent, location of world's poorest populations and limited access to preventative measures.

   4. Use the world map provided below, and with an appropriate key/legend, shade the areas of the world according to **risk of malaria transmission**.

Map Title: *Global Distribution of Malaria Transmission Risk*

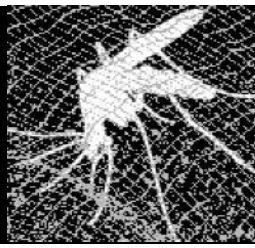
Source: rollbackmalaria.org



To consider: What kinds of environmental factors might increase the rate of malaria transmission?

Epidemics of P. falciparum are devastating if not controlled quickly; factors leading to malaria epidemic: natural (climate therefore more mosquito breeding sites or temperature changes that accoommodate vector reproduction, natural disasters) and man-made (conflict, war, agricultural projects, dams, mining, logging) — changing of the physical environment and increase capactiry of mosquitoes to transmit malaria; some factors are also due to massive movement of populations so that they are exposed to infection and may not have previous immunity.

MALARIA LESSON 3
IMPACTS OF MALARIA INFECTION



Established Learning Goals

- Develop a basic understanding of the symptoms of malaria and relate these symptoms to the life cycle of *Plasmodium*
- Demonstrate an understanding of the social and economic impacts of malaria infection around the world

Assessment Evidence

- Students will be able to relate symptoms of malaria to their previous knowledge of the life cycle of *Plasmodium.*
- Students will be able describe the socio-economic impacts of malaria.

Teacher Background Information

The Roll Back Malaria partnership estimates that malaria costs Africa alone approximately US$ 12 billion each year in lost Gross Domestic Product (GDP) but that controlling the disease would cost much less. The disease has serious economic impacts and slows economic growth and development in those areas hit the hardest. It further widens the gap between rich and poor as the disease is one that primarily affects the poor, who tend to live in malaria-prone areas in poorly-made dwellings that offer few barriers to infection and have the least access to prevention and treatment measures.

Malaria also has a massive impact on Africa's economy at the family level. The indirect costs of lost productivity and income associated with the disease can ravage a family's finances. Further, local investment can be negatively affected in malarial areas as tourist opportunities remain underdeveloped and traders become unwilling to travel to sell their wares in local markets. Local farmers, in an effort to avoid labour problems associated with malaria infection during harvest season, may move to favour subsistence crops rather than labour-intensive cash crops. Cumulatively, the impact translates to national economies through the loss of human resources and income generation. Malaria is responsible for much of the continent's absenteeism, death, illness, lost education time as children are ill or caring for ailing parents, and reduced social development in children because of illness.

At the same time, malaria places a huge burden on a country's health care system and represents about 10 per cent of Africa's overall disease burden, 40 per cent of public health expenses, 30-50 per cent of inpatient hospital admissions and 50 per cent of outpatient visits in regions of high transmission. Indirectly, there are also costs associated with transporting patients to and from clinics, maintaining the public health infrastructure as a whole and providing support for patients and families during hospital stays. There are also burdens associated with providing bed nets for prevention, managing mosquito control programmes

and providing education campaigns throughout a region. These may also be considered "opportunity costs"; diverting health investments from other diseases including HIV/AIDS.

Planning Notes

- Prepare and cut BLM 5 – Review of Malaria Life Cycle
- Prepare class set of BLM 6 – Summary of Case Study Findings

Prior Knowledge Required

- Students should have a basic knowledge of malaria as a disease and understand the life cycle of the *Plasmodium* parasite.

Lesson Overview

- Key words
- Teaching/Learning Strategies
  - — Activity 1: Consolidation of Previous Learning – Review of life cycle and terms from last lesson
  - — Activity 2: Symptoms of Malaria
  - — Activity 3: Social Impacts of Malaria – Case Study Analysis

TEACHING / LEARNING STRATEGIES

1. Consolidation of Previous Learning

- Recall as a class the definition of a **parasite**.

  *A **parasite** is an organism that cannot survive without a host, another living organism from which it gets nutrients, shelter and aid in its reproduction. An example of a common parasite is head lice.*

- What microscopic parasite is responsible for malaria? *Plasmodium sp.*

- The malaria parasite relies on two **hosts**. What are they?

  Mosquito and human; other animals can also host Plasmodium. The Plasmodium organisms are dependent on the hosts to reproduce. They cannot reproduce without the right environment, either in the liver of humans or in the belly of the mosquito.

- *Plasmodium* also needs a means of transmission, a way to get to a new host. What term is used to describe this mode of transmission?

  ***Vector;** recall that the Anopheles mosquito is the vector for Plasmodium. Without the vector to spread the parasite (and the infection), the parasite will die off when the host dies.*

- Make a copy of **BLM 5— Review of Malaria Life Cycle.** Cut the statements into individual pieces of paper and randomly distribute to students. (You may also opt to copy this enough times so that everyone has a statement and the class will form several "circles" to put the statements in order.)
  - — Ask students to read their individual statements and then circulate with other students to put the statements in order according to the malaria life cycle that was discussed previously.
  - — Have students form a circle according to the order of their statements (emphasize that this is a life CYCLE and the process repeats itself).
  - — When complete, begin with the statement: "*A malaria-infected female Anopheles mosquito takes a blood meal from a human"* and have students read their statements aloud to the rest of the class, in order, based on the successive life cycle stages. Encourage the class to make any necessary changes to the order.
- Correct solution:
  - — *A malaria infected female Anopheles mosquito takes a blood meal from a human.*
  - — *Plasmodium parasites in the form of sporozoites are injected into the human blood stream and travel to the liver (the site of blood cell production).*
  - — *Sporozoites rapidly divide in the liver cells to form 30,000 to 40,000 merozoites.*
  - — *Merozoites leave the liver and invade red blood cells.*
  - — *Merozoites rapidly divide inside the red blood cells.*
  - — *Red blood cells burst and merozoites are released into the blood stream to invade other red blood cells.*
  - — *Some merozoites divide to form gametes (male and female sex cells for Plasmodium parasite)*
  - — *A female Anopheles mosquito bites a malaria-infected human and ingests both male and female immature gametes (or sex cells) of the malaria parasite.*
  - — *Sex cells fuse in the mosquito gut and eventually develop into new malaria parasites (in the form of sporozoites).*
  - — *Sporozoites migrate to the mosquito salivary glands.*

Cycle continues…..

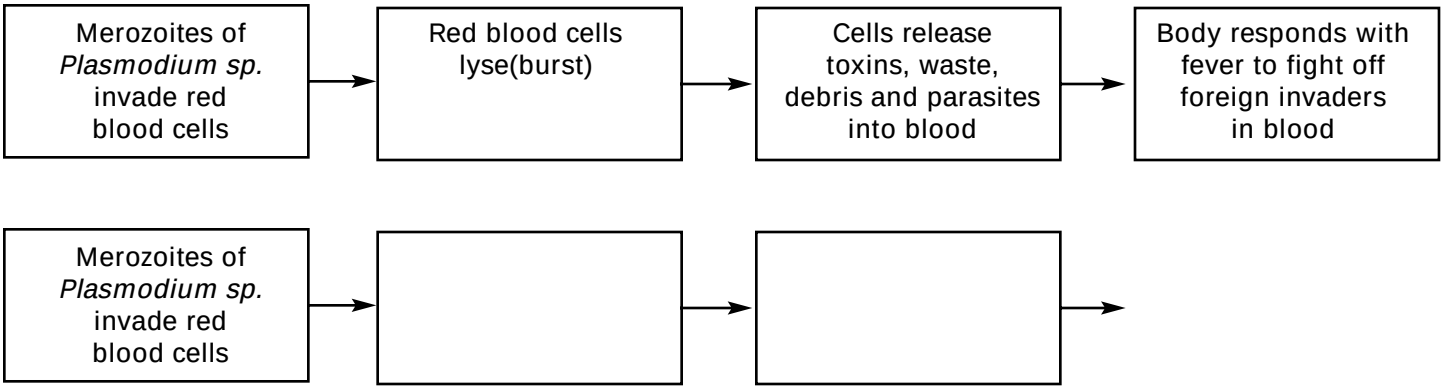
Variation: Form groups of four within the class, and distribute one package of statements to each group. Ask them to put the statements in order according to their learning from last class; OR use this activity as an assessment tool to gauge individual student understanding of the *Plasmodium* life cycle.

SYMPTOMS OF MALARIA

As a class, recall characteristics and functions of red blood cells (RBC).

- *Contain iron*
- *Bind oxygen*
- *Carry oxygen through body in blood*

Draw a blank flow chart model on the board or overhead to describe the symptoms of malaria related to the life cycle of the parasite. Student may also add the symptoms to their copies of **BLM 3 — Detailed Life Cycle of *Plasmodium***.



Extra notes about symptoms:

- Fevers are intermittent and correspond with merozoites attacking and destroying red blood cells.
- A typical malaria "episode" usually starts with sudden, violent chills followed by an extreme fever (as white blood cells attack infection) and sweating (to bring body temperature back to normal).
- Repeated infection can lead to anemia (decrease in concentration of red blood cells in the blood) and exhaustion.
- If a person is exposed repeatedly to malaria, they may develop immunity, in much the same way an individual can develop immunity to certain cold viruses with previous exposure. However, if a person has never been exposed to the malaria parasite, the impact of the infection is much worse; this is especially true for young children. Travellers from non-malaria zones are therefore also highly vulnerable. Large and devastating epidemics can occur in areas where people have had little contact with the malaria parasite, and therefore have little or no immunity. These epidemics can be triggered by weather conditions and further aggravated by complex emergencies or natural disasters. It is important for people in such areas to have quick access to malaria-fighting medicines in order to fight the symptoms, which can ultimately result in death.

NOTE: The pattern of fever and other symptoms varies with the species of *Plasmodium* responsible for the infection. A summary of the four malaria infections affecting humans can be seen below:

Species	Intermittent Fever	Other Comments
Plasmodium falciparum	every 48 hours	• very common • very severe; most deadly • can also cause severe headaches, convulsions and delirium • can also develop into cerebral malaria (where infected red blood cells attach to small blood vessels in the brain, cause inflammation and block the flow of oxygen and nutrients to the brain)
Plasmodium vivax	every 48 hours	• very common • merozoites in the liver can remain dormant (symptomless) for months (or up to 2 years!) and can trigger periodic relapses of malaria
Plasmodium ovale	every 48 hours	• merozoites in the liver can remain dormant (symptomless) for months (or up to 4 years!) and can trigger periodic relapses of malaria
Plasmodium malariae	every 72 hours	

IMPACTS OF MALARIA

Several case studies have been developed to provide students insight into the multi-faceted impact that malaria is having around the world. You may opt to:

- Divide students into groups to complete individual case studies and share their key findings with other students. A worksheet (BLM 6) has been attached here to organize the findings of each group.
- Assign all case studies as independent work for students to complete individually.

CASE STUDY 1

Busie is a paediatrician in southern Africa. As a doctor working with children, she is overwhelmed by the number of children who are brought to her clinic with high fevers, chills, sweats, head and body aches and nausea. She suspects that most of them have malaria. She also knows that many children do not get a chance to see a doctor and that many die before they can access proper medical care. At a conference last month in Rwanda, new statistics were revealed by UNICEF that confirmed Busie's observations: malaria infects nearly 500 million people every year, is the leading cause of death (representing about 20 per cent of all deaths – or 3,000 deaths/day) among children under the age of five in Africa. Further, her colleagues reported that malaria kills more than one million people globally every year and that 90 per cent of these deaths occur in Africa.

1. What is the main theme presented in this case study?
2. Is anything from this case study shocking to you?
3. Why do you think the transmission rates for malaria are so high in Africa? *(This question is a bit of a challenge – think of everything you have learned so far about malaria – biological, social, economic.)*
4. With numbers like those presented at the conference, what kinds of impact do you think malaria is having in Africa? (Think about social, biological, economic, health impacts etc.)

CASE STUDY 2

Jabulile and Sankara have been married for seven years and live close to Cape Town in South Africa, an area not typically affected by malaria. Jabulile is pregnant with their first child, and to spend some time together before their child is born, the couple is planning a vacation to Mozambique in March.
While Jabulile is making their last minute travel plans, she reads a newspaper report about Mozambique. The article, based on a UN report, indicates that while Mozambique's climate favours year-round transmission of malaria, peak transmission rates occur during the country's rainy season between December to April. The most common form of the infection in Mozambique is *Plasmodium falciparum* and accounts for about 90 per cent of all infections. Malaria infection rates are very high and it is the primary cause of death throughout the country – representing about 30 per cent of all recorded deaths. Some estimates suggest that nearly 90 per cent of children under the age of 5 in some areas are infected with malaria parasites. Pregnant women are also at risk, especially in rural areas where many people do not have access to health care and about 50 per cent of the population lives more than 20 km from the nearest heath care facility.

1. What factors described here contribute to the high rates of malaria transmission and mortality in Mozambique?
2. Knowing what you do about malaria infection, what makes Jabulile and Sankara especially at risk? What makes Jabulile especially more at-risk?
3. What precautions should the couple take before their trip?

CASE STUDY 3

Saadya is a health officer from Pakistan working for the World Health Organization and is preparing for an interview about malaria with a well-known television station. As she prepares her notes, she reminds herself of the most recent statistics regarding malaria: it infects 350 to 500 million people each year; it kills one million people, mostly children, and mostly in Africa (90 per cent of malaria deaths occur in Africa with 75 per cent of deaths affecting African children less than five years of age). Before the interview begins, she is confident that she has come prepared with all of the relevant data for her interview. During the interview, it becomes clear to her that the interviewer wants to know more about the socio-economic impacts of malaria around the world than the statistics of infection. The interviewer remarks that malaria is "a disease of the poor and a disease causing poverty." Saadya answers and shares the following:

"We already know that malaria is taking a tremendous toll on health care systems around the world. In many malaria-endemic countries, health care infrastructure is already weak and malaria now represents about 40 per cent of all public health costs in some countries. In some areas, it accounts for 30 to 50 per cent of all inpatient hospital admissions and 50 per cent of outpatient admission – the burden on the health care system is phenomenal. I am so angry because we know this terrible disease is preventable and treatable and yet the people who need help the most are not getting it!"

"Malaria is also playing a devastating role in driving poverty around the world. It slows economic growth and development and primarily affects the poor, further widening the gap between the haves and the have-nots. Our resource-poor populations tend to live in malaria-prone rural areas where poorly-constructed dwellings offer little protection against mosquitoes. Data suggests that malaria-infected countries experience slower economic growth than non-malaria countries and malaria is estimated to cost Africa alone nearly US$12 billion in lost GDP. We know that malaria can be controlled for much less than this."

"At a local level, we see the economic damage in other ways as people stop investing in malaria-prone areas: tourists don't want to visit for fear of infection, market vendors don't want to come to those areas to sell their wares in local markets and local farmers are even making changes. A farmer working in cash cropping relies heavily on the labour of other people, but, if during the harvest season many people are sick with malaria, crops go to waste and money is lost. As a result we see many farmers turning back to small-scale subsistence farming and not investing in the local economy."

"To make matters worse, impoverished communities place heavier demands on the natural environment and can't afford to protect it. For example, clear-cutting forests is causing the spread of malaria to new areas as well as contributing to global climate change, which in turn spreads the boundaries of malaria zones beyond tropical areas."

1. What is the major theme of this case study?
2. Were you surprised by anything here?
3. In what ways does malaria contribute to the cycle of poverty in the world?
4. Given the data provided here, what other social and environmental issues are influenced by malaria?
5. Malaria control is now seen as a major way to fight poverty. Explain.

CASE STUDY 4

Epidemics occur when a sudden and severe outbreak of a given disease is observed within a population and the number of infected individuals spikes higher than what would be typically expected.

Rajesh is a graduate student in India studying malaria epidemics and has a special interest in understanding how emergencies influence malaria outbreaks.

Emergencies can take many forms – some are environmental and others include the outbreak or spread of armed conflict or political instability. Whatever the form, an emergency results in tremendous change and upheaval in a region.

Some emergencies are labeled as "complex emergencies" because there is an absolute or considerable breakdown of social structures and infrastructure. People are displaced and forced to leave their homes, security threats are high, food shortages abound, health care systems are weakened or destroyed, families are separated and humanitarian activities are stopped or hindered by political or military forces.

Up to 30 per cent of malaria deaths occur in countries undergoing complex emergencies; in Africa alone, 120 million people are estimated to be currently living in complex emergency situations. In many cases, death due to malaria exceeds death caused by the conflict itself.

1. Can you think of two types of environmental emergencies? Can you think of two other types of emergencies that are the result of human activity?
2. Why are so many people affected by malaria during times of complex emergency? (Think about all of the ways that people and communities are affected by emergencies and how these might contribute to malaria transmission).

CASE STUDY 5

These three stories were written by three different children:

A. We call malaria the "palu" in our village. There used to be a family in our village and every day they threw out their washing water and empty food cans close to their house. One day, three of their children became very sick. The father prepared a local medicinal plant to help the children but their health got much worse - but the family had little money. The next day, the mother heard an announcement on the radio that talked about the same symptoms that her children were showing. The show said, "Malaria is a disease that can kill you and your children. Malaria is the number 1 killer of children under the age of five. If you have malaria, you must go to the hospital and get some help." She explained to her husband what she had learned on the radio and because the father was so afraid that he would lose his children, they were able to find some money to go to the hospital. At the hospital, they were able to get an injection and some medicines. They were also given an insecticide-treated bed net under which they were told to sleep to prevent further infections.

B. Malaria is the number one enemy in our villages. I am eight years old and my friend Cyrille had not been in school for a long time. He was a great student so we were all surprised that he was missing so many classes. After school one day, we decided to go to Cyrille's house to see for ourselves why he was missing school. When we got to his house, his mother told us that Cyrille was sick with malaria. We were all really worried and didn't know how this could have happened to our friend. His mother explained that the illness started with a hot body with headaches. He now had some medicine but it was going to take him some time to get better at home before he could come back to school.

C. There was a family in our village who did not have a lot of money so a local organization had given them a bed net to use at night. The father did not think the children needed to sleep under the net because he was the one who was out working all day for money and should be the one to stay strong. One by one, the children of the family got sick but still, the father did not believe that he was doing anything wrong. The mother got very worried and finally took her children to the clinic where she learned the children had malaria. But it was too late, and the youngest child die — she was only 7 years old. The mother and father were devastated and cried and cried about their lost child.

1. What is the main message shared by these three stories?
2. What simple method of prevention is described here? Why do you think this method of prevention works?
3. Beyond medical impacts, how does malaria affect the lives of children and their families?

CASE STUDY 6

Although between 300 and 500 million people are infected with malaria every year, and nearly one million people lose their lives to malaria, it is a *preventable* and *treatable* disease.

One way to reduce the spread of malaria is through **vector control** — that is, reducing the levels of malaria transmission by reducing the number and effectiveness of the vectors — the mosquitoes. There are several different methods used to control malaria-carrying mosquitoes. The World Health Organization (WHO) recommends that vector control methods be chosen based on knowledge of the local malaria situation and advocates for an Integrated Vector Management approach — that is, the combined use of several methods. Two of the most important are described here.

One method of controlling mosquitoes is the use of insecticide-treated bed nets (ITNs). Most malaria-carrying mosquitoes bite humans at night, so sleeping under an insecticide-treated bed net (when used properly) provides an inexpensive and effective way of controlling malaria infection. When used properly, ITNs can reduce malaria transmission by 50 per cent and reduce mortality (the number of deaths) by 20 per cent. ITNs not only offer a physical barrier against mosquitoes, but also provide a chemical barrier that lasts for five years. ITNs repel a mosquito from biting, and can reduce overall malaria transmission by killing the mosquito.

UNICEF is the world's largest provider of ITNs and provides families with information about their proper use and care. For the millions of people who are still not able to access ITNs, UNICEF is working hard with partners like Spread the Net to ensure that all children and pregnant women are able to sleep under ITNs. Spread the Net alone hopes to provide 500,000 bed nets to families in Rwanda and Liberia.

WHO also recognizes that, in certain situations and when the proper handling and disposal methods are followed, the indoor spraying of insecticides (chemicals that kill insects) can also be an effective tool for vector control in the fight against malaria (this is also called indoor residual spraying). Indoor spraying seeks to reduce the survival of malaria vectors and therefore reduces the number of mosquitoes entering houses and/or sleeping areas.

1. Compare and contrast the terms: PREVENTABLE and TREATABLE.
2. What two important methods of vector control are described here?
3. How do ITNs contribute to the overall reduction of malaria transmission and mortality?
4. How does indoor spraying contribute to the reduction of malaria transmission and mortality?
5. WHO recognizes that insecticides are effective in reducing overall malaria transmission rates under certain circumstances. What might these circumstances be?
6. There is ongoing debate around the world about the use of the insecticide DDT because of the negative effects it, and its breakdown products, have had on wildlife populations. It is a persistent chemical that exists in the environment many years after its initial use, and while it has been banned in Canada for many years, it spreads across borders and appears in the tissues of Artic mammals as a result of its use in other parts of the world. However, we know that, when used properly, it is an effective tool in the fight against malaria and has saved millions lives. What do you think about the use of chemicals like DDT for the prevention of malaria?

TEACHER NOTES FOR CASE STUDIES

CASE STUDY 1

Student Questions

1. What is the main theme presented in this case study?
   That Africa, and specifically children in Africa, are hardest hit by malaria

2. Is anything from this case study shocking to you?
   Answers will vary

3. Why do you think the transmission rates for malaria are so high in Africa?
   (This question is a bit of a challenge — think of everything you have learned so far about malaria.) Answers will vary but some suggested areas of discussion include: most malaria disease in Africa is caused by P. falciparum, the most severe/deadly form of disease; Africa is home to the most efficient and deadly species of mosquito that transmits the disease; many countries in Africa lack health infrastructure/resources needed to challenge malaria and many have not introduced vector eradication programmes.

4. With numbers like those presented at the conference, what kinds of impacts do you think malaria is having in Africa? (Think about social, biological, economic, health impacts etc.)
   Resulting absenteeism from work affects economy; malaria puts huge demands on the health system; many children are out of school due to illness or caring for sick parents, etc.

Additional Information:

- From UNICEF: malaria infects 350 to 500 million people each year; kills one million people every year, mostly children; 90 per cent of malaria deaths occur in Africa
- From RBM: estimated to cost Africa US$12 billion/year in lost GDP (can be controlled for much less)

Malaria is the leading cause of death among children in Africa under the age of 5 (accounts for 20 per cent of deaths) and represents 10 per cent of the continent's disease burden; 40 per cent of public health expenses, 30-50 per cent inpatient admissions, 50 per cent outpatient visits in high malaria transmission areas

Why are malaria rates/deaths so high in Africa? Most disease caused by P. falciparum – most severe/deadly form of disease; also home to most efficient and deadly species of mosquitoes that transmits the disease; many countries in Africa lack health infrastructure/resources needed to address malaria and many have not introduced vector eradication programmes

Malaria has a direct impact on Africa's human resources — absenteeism, death, illness, children's schooling is affected when teachers and students are sick, delayed social development of children because of ongoing illness, etc.

Huge problem with parasite resistance to chloroquine (cheapest and most widely used antimalarial drug) in Africa (especially in the south and eastern parts) – there is a need therefore to change drug approaches in some countries to use more expensive drugs

CASE STUDY 2

Student Questions

1. What factors described here contribute to the high rates of malaria transmission and mortality in Mozambique?
   Environment is conducive to vector survival, especially in rainy season (good habitat for mosquitoes to grow); most infection due to P. falciparum, the most deadly form of the disease; many people do not have quick and local access to health care centres

2. Knowing what you do about malaria infection, what makes Jabulile and Sankara especially at risk?
   They are from an area of Africa that is not typically a malaria area so they will not have any immunity — disease may be worse for them if they do contract the infection. What makes Jabulile alone more at risk? She is pregnant, which puts her at even higher risk for malaria-related complications.

3. What precautions should the couple take before their trip?
   Purchase an insecticide-treated bed net; take preventative medicines (as shown in beginning video); travel outside of the rainy season if possible.

Additional Information:

In most endemic areas, pregnant women represent the main adult risk group for malaria.

Symptoms and complications associated with malaria during pregnancy differ with intensity of malaria transmission and with the level of immunity acquired by pregnant women. In low epidemic areas, women may not have acquired a significant level of immunity and usually become ill with P. falciparum (the most deadly form of the infection). Pregnant women are two to three more times more likely to develop severe disease than non-pregnant adults in the same area. Maternal death can result from infection or from malaria-related anaemia. Infection can also result in spontaneous abortion, neonatal death and low birth weight (a leading risk factor for infant mortality and sub-optimal growth and development).

In areas of high malaria transmission, most adult women have enough immunity so that even in pregnancy P. falciparum does not usually result in fever or other symptoms. The principal effect in these areas is malaria-related anaemia in mothers with the presence of parasites in the placenta. This can result in fetal nutrition impairment and can lead to low birth weight.

CASE STUDY 3

Student Questions

1. What is the major theme of this case study?
   Malaria has severe socio-economic impacts on populations and is a contributing factor to poverty in endemic areas.

2. Were you surprised by anything here?
   Answers will vary

3. In what ways is malaria contributing to the cycle of poverty in the world?
   Slowing economic growth due to absenteeism and lost productivity; health systems must accommodate the huge demand due to malaria, families spend large portions of their income on malaria control and treatment (if they can); economic development in malaria-prone areas is slowed because of fear of infection among tourists, market vendors etc.

4. Given the data provided here, what other social problems do you think are influenced by malaria?
   Education affected as children are out of school due to illness or having to take care of parents or younger siblings while parents ill; parents and communities lack energy to provide highest level of care and protection for children

5. Malaria control is now seen as a major way to fight poverty. Explain.
   Keeping people healthy will keep people working, keep children in school and help to promote local investment in areas typically affected by malaria

Additional Information:

Malaria is a disease that primarily affects the poor, as they tend to live in malaria-prone rural areas in poorly-made dwellings that offer few barriers against infection. Malaria is a major constraint on economic development and further widens the economic gap between countries with malaria and those without. In Africa alone, malaria is estimated to cost US$12 billion/year in lost GDP (but can be controlled for a fraction of that sum).

Malaria-endemic countries have a lower annual economic growth than non-malaria countries (economists say that malaria imposes a "growth penalty" of up to 1.3 per cent/year in some African countries). If compounded over years, this results in a big difference in GDP between countries and can affect the economic growth of an entire region.

Malaria results in lost productivity and income associated with illness and death (including unpaid work in the home such as child care), contributes to human pain and suffering, affects children's schooling and social development (through absenteeism, permanent neurological damage associated with severe episodes of infection), and the risk of infection can deter local investment. Tourism industries remain underdeveloped for fear of infection, markets remain unpopulated because traders are unwilling to travel to malaria-affected areas and farmers show preference for subsistence farming over labour-intensive cash cropping (for fear of losing workers during the labour-heavy harvest season).

Families incur personal expenses related to bed net purchases and maintenance, doctor fees, anti-malarial drugs, transport to clinics and support for family members during hospital stays. The public sector must maintain health infrastructure, publicly manage mosquito control programmes if they exist and provide malaria education. In some countries, malaria accounts for up to 40 per cent of public health expenditures, 30 to 50 per cent of inpatient admissions, and 50 per cent of outpatient admissions.

Malaria control is now seen as in important element of poverty reduction as prioritized by the Millennium Development Goals (MDGs) and prevention is becoming more affordable with reduced/abolished taxes on insecticides, bed nets, etc. The private sector is seeing that supporting malaria control boosts labour, improves community/government relations and reduces absenteeism. Investment to control malaria increases the human productivity that will

eventually encourage market expansion, boost household spending and increase consumption patterns.

CASE STUDY 4

Student Questions

1. Can you think of two types of environmental emergencies?
   Hurricane Katrina, tsunami, earthquake in Pakistan etc.
   Can you think of two other emergencies that are a result of human activity?
   The ongoing conflict in Darfur; Sudan; war in Afghanistan

2. Why are so many people affected by malaria during times of complex emergency? (Think about all of the many ways that people and communities are affected by emergencies and how these might contribute to malaria transmission).
   The emergency causes chaos and destroys social services infrastructure (i.e. health care and education); cuts food supplies and exposes people to multiple risks of infection; displaced persons often live in refugee camps in poor conditions (may not have access to bed nets or protected housing to prevent mosquito entry) that favour water-borne vector reproduction and disease transmission.

Additional Information:

Up to 30 per cent of malaria deaths are in countries undergoing complex emergencies (characterized by war, civil strife, food shortages and civilian displacement). In Africa alone, 120 million people live in complex emergency situations. Deaths due to malaria during these times often exceed those caused by the conflict itself. The chaos of the emergency destroys health care systems, cuts food supplies and exposes people to multiple infections. Poor living conditions in refugee and/or internally displaced persons' camps and war-affected towns can promote the conditions necessary for mosquito reproduction, like standing water, and increase the rate of infection.

CASE STUDY 5

Student Questions

1. What is the main message shared by these three stories?
   That children are most at risk of malaria infection

2. What simple method of prevention is described here? Why do you think this method of prevention works?
   Sleeping under an insecticide-treated bed net – the bed net provides both a physical and chemical barrier to the mosquitoes carrying the malaria parasite. Because these mosquitoes usually bite at night, bed nets provide good protection while people sleep.

3. Beyond medical impacts, how does malaria affect the lives of children and their families?
   Pulls children out of school because of illness or because they have to care for sick parents; families have to find funds for prevention/treatment options; parents may not be able to work if they are sick, therefore reducing overall family income

Additional Information:

- Malaria infects 350 to 500 million people each year; kills one million people, mostly children and mostly in Africa; 90 per cent of malaria deaths occur in Africa (75 per cent of deaths occur in African children less than 5 years old due to P. falciparum); accounts for one of every five childhood deaths in Africa.
- More than 40 per cent of the world's children live in malaria endemic areas.
- Malaria is a major contributor to anaemia, poor growth and development – about 7 per cent of children who survive cerebral malaria (coma and convulsions common) are left with permanent neurological problems (weakness, spasticity, blindness, speech problems and epilepsy).
- Malaria during pregnancy often results in low birth weight, the leading risk factor for infant mortality and sub-optimal growth and development. Specialist care for low birth weight babies is also often limited.
- In some malaria-endemic areas, approximately 70 per cent of one year-olds have or have had malaria.

CASE STUDY 6

Student Questions

1. Compare and contrast the terms: PREVENTABLE and TREATABLE.
   Preventable means that we can stop malaria infection from happening; treatable means we can provide drugs and health care support if the disease if diagnosed early enough.
2. What two important methods of vector control are described here?
   Insecticide treated bed nets and indoor residual spraying.
3. How do ITNs contribute to the overall reduction in malaria transmission and mortality?
   They offer a physical barrier to mosquitoes and also contribute to the death of the vector themselves to reduce overall infection rates.
4. How does indoor spraying contribute to the reduction of malaria transmission and mortality? *Kills the vector so transmission is reduced, therefore reducing overall mortality.*
5. WHO recognizes that insecticides are effective in reducing overall malaria transmission rates under certain circumstances. What might these circumstances be?
   Answers will vary but official answer from WHO is: a high percentage of the structures have adequate sprayable surfaces and can be expected to be well-sprayed; majority of the vector population is endophilic, that is, rests indoors; vector is susceptible to (i.e., will be killed by) the insecticide. Spraying is usually reserved for severe outbreaks and in highly vulnerable places such as refugee camps.
6. There is ongoing debate around the world about the use of DDT because of the negative effects it, and its breakdown products, have had on wildlife populations in the past. It is a

persistent chemical that exists in the environment many years after its initial use and while it has been banned in Canada for many years, it spreads across borders and appears in the tissues of Artic mammals as a result of its use in other parts of the world. However, we know that, when used properly, it is an effective tool in the fight against malaria and has been able to save millions of lives. What do you think about the use of chemicals like DDT for the prevention of malaria?
Answers will vary

Additional Information:

- Integrated Vector Management (IVM) is advocated by WHO for the management and reduction of vector populations. It includes:
  - selection of methods based on knowledge of local vector biology, disease transmission and morbidity
  - use of a range of interventions, often in combination and synergistically
  - collaboration within the health sector and with schools and businesses
  - educating local communities and other stakeholders
  - a public health regulatory and legislative framework
- An IVM approach takes into account the available health infrastructure and resources and integrates all available and effective measures, whether chemical, biological or environmental. IVM encourages an integrated approach to disease control.
- The main purpose of indoor residual spraying is to reduce transmission by reducing the survival of malaria vectors entering houses or sleeping units.
- Insecticide-treated nets (ITNs) are a form of effective vector control when coverage rates are high and a large proportion of human-biting by local vectors takes place after people have gone to sleep. They can also be used for personal protection. Their use has repeatedly been shown to reduce severe disease and mortality due to malaria in endemic regions. In community-wide trials in several African settings, ITNs have been shown to reduce all-cause mortality by about 20 per cent or more.

REVIEW OF MALARIA LIFE CYCLE (STUDENT STATEMENTS)

Cut and distribute one statement per student. Encourage students to put the statements in order according to their collective knowledge of the malaria life cycle.

A malaria-infected female *Anopheles* mosquito takes a blood meal from a human.

Sex cells fuse in the mosquito gut and eventually develop into new malaria parasites (in the form of sporozoites).

Merozoites rapidly divide inside the red blood cells.

Plasmodium parasites in the form of sporozoites are injected into the human blood stream and travel to the liver (the site of blood cell production).

Sporozoites rapidly divide in the liver cells to form 30,000 to 40,000 merozoites.

Red blood cells burst and merozoites are released into the blood stream to invade other red blood cells.

A female *Anopheles* mosquito bites a malaria-infected human and ingests both male and female immature gametes (or sex cells) of the malaria parasite.

Some merozoites divide to form gametes (male and female sex cells for *Plasmodium* parasite)

Merozoites leave the liver and invade red blood cells.

Sporozoites migrate to the mosquito salivary glands.

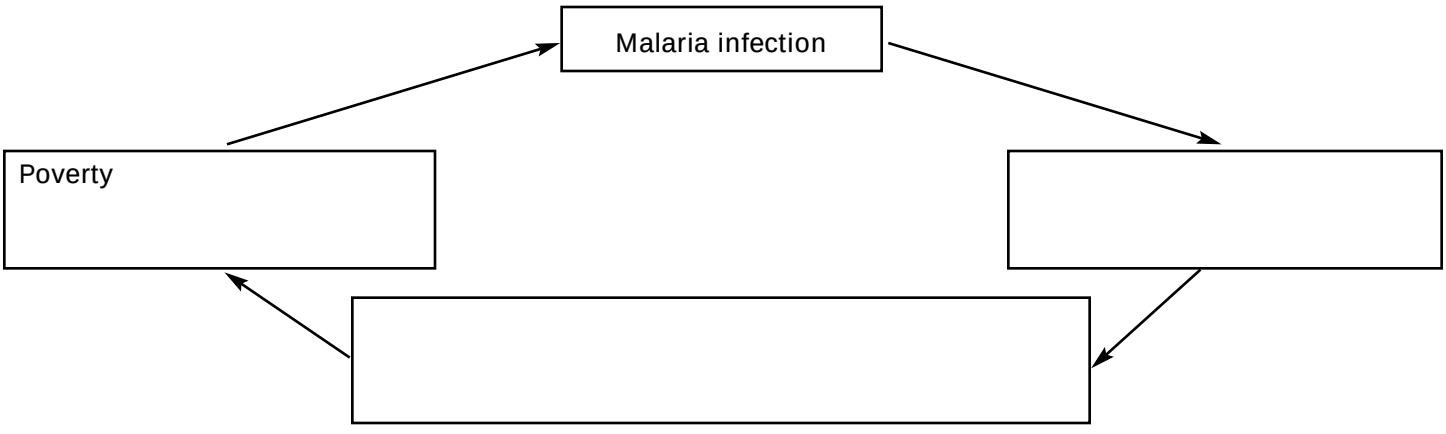
SUMMARY OF CASE STUDY FINDINGS

Case Study	Key Findings
1	
2	
3	
4	
5	
6	

1. I would like to learn more about:

2. Knowing what you do now, how do you think the world should respond to the current malaria crisis?

3. Using your knowledge from the case studies, complete the cycle below to outline how malaria contributes to poverty in the world.



SUMMARY OF CASE STUDY FINDINGS

(described in teacher notes for individual case studies)

1. I would like to learn more about:

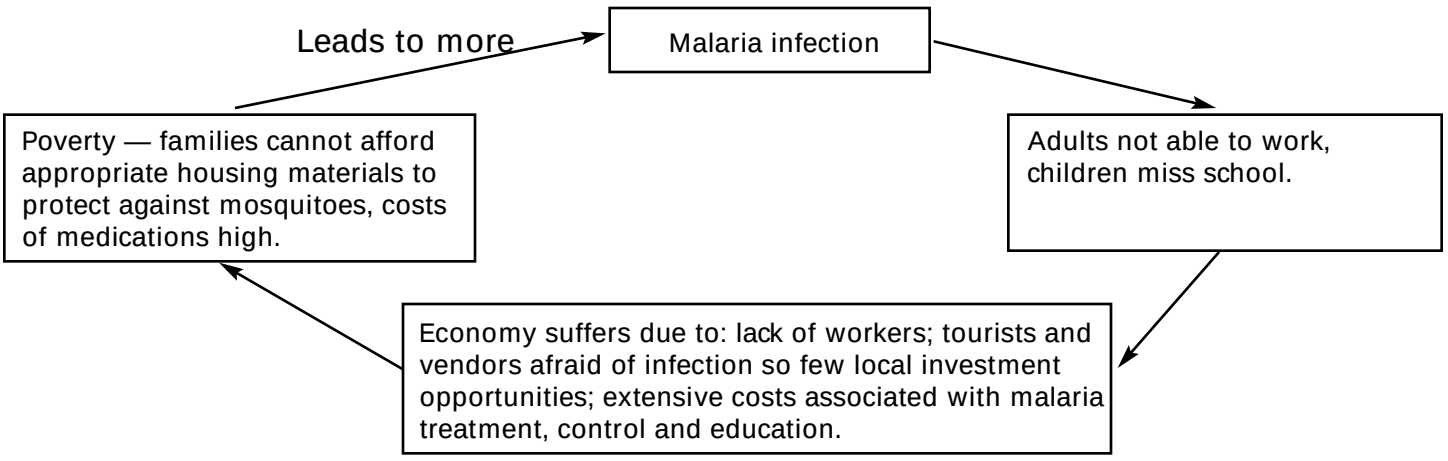
2. Knowing what you do now, how do you think the world should respond to the current malaria crisis? How should you respond?

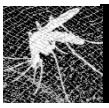
   Answers will vary but encourage discussions about empathy, haves vs. have-nots, international development and investment practices that encourage local development, ownership, sustainability, use of local expertise and capacity development

   Some ideas that might arise:
   - *make the provision of bed nets part of a holistic medical approach so that as many families as possible have access*
   - *negotiate lower costs for the new generation of malaria drugs so that they are more affordable for families and lower-resource countries*
   - *support building methods that allow for better overall vector protection*
   - *support overall strengthening of local health systems so that they can provide timely and appropriate care to more people as soon as possible*

   Possible individual calls to action:
   - *develop an awareness campaign for your class/school*
   - *volunteer with an organization raising funds for malaria programmes*
   - *write letters to local government officials asking them to honour their international development assistance pledges*
   - *organize a fundraiser at your school (staying under a bed net, raising funds for bed nets through UNICEF's Spread the Net campaign)*

3. Using your knowledge from the case studies, complete the cycle below to outline how malaria contributes to poverty in the world.





CULMINATING ACTIVITY: CALL TO ACTION

AWARENESS / ADVOCACY POSTERS

Description: For this activity, students will work in groups of four and select either a method of malarial control **OR** an awareness/advocacy issue related to malaria.

They will create a poster that will be used for a classroom presentation and for use in educating the rest of the school community about health and development issues associated with malaria. The posters should be created as if they are from a local organization requesting development funds or as if they are part of a larger education campaign to raise awareness about malaria-specific issues. An evaluation rubric has been included here.

Possible topics:

- insecticide treated bed nets (see Spread the Net campaign (www.spreadthenet.org)
- indoor residual spraying
- chloroquine resistance and advocating for access to affordable artemisinin-containing combination therapy (ACTs)
- the use of DDT to control malaria vector organisms
- the link between malaria and HIV/AIDS
- the socio-economic impact of malaria in Africa
- malaria and global warming
- impact of malaria on children and ways to protect them
- access to health care in developing countries
- malaria and poverty
- malaria and the Millennium Development Goals (MDGs)
- the need to provide financial support to organizations building sustainable malaria interventions
- use of malaria prophylaxis (preventative medications)

Prior Knowledge Required

- Students should have a basic understanding of the complex life cycle of the *Plasmodium* parasite.
- Students should understand the social and economic impacts of malaria.
- Students should be able to briefly explain the various methods of intervention in the fight against malaria.

Poster Requirements

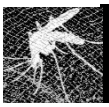
- Clearly identifies the issue and the author's position related to the issue with supporting data and graphics
- Shows a mature understanding of the issue presented with reference to the greater context of malaria as a development problem
- Includes appropriate graphics/tables/data (with relevant citations) to support issue
- Is eye-catching and colourful and makes a statement that impacts the audience
- Challenges audience to take action in response to the issue presented
- Gives the audience an opportunity to find out more information
- Includes a full reference list on the back of the poster (for both graphics and text information)

ASSESSMENT / EVALUATION RUBRIC – CALL TO ACTION POSTER / PRESENTATION

Categories/ Criteria	Level 1 (50-59 per cent)	Level 2 (60-69 per cent)	Level 3 (70-79 per cent)	Level 4 (80-89 per cent)
Clear articulation of issue	The issue is not clearly stated or presented.	The issue is vaguely communicated.	The issue is clearly presented and communicated through the text of the poster.	The issue is clearly stated and fully articulated using text and graphics.
Provides support or data for issue	There is limited support for issue presented.	An attempt has been made to present support/evidence for the issue but the link to the issue is weak. Support for the issue is clearly presented	and is linked to the issue with clear evidence.	Supporting data for the issues are both reasoned and persuasively presented.
Understanding of the issue	The issue is not well developed or understood.	The issue is understood in very simplistic terms.	The issue is well understood.	The issue is clearly understood and presented in a mature and thoughtful way with links to other major themes.
Graphics	Graphics do not relate to the topic OR several of the borrowed graphics are not referenced.	All graphics relate to the issue but one or two are not properly referenced.	All graphics are related to the issue and most of them enhance understand-ing of the issue. An attempt has been made to reference borrowed graphics.	All graphics are related to the issue and make it easier to understand. All borrowed graphics have a reference.
Poster suitability and visual appeal	The poster is very messy and poorly designed. It is too text-heavy and not appealing to the eye.	The poster is reasonably pleasing to the eye but contains some elements that detract from its effectiveness.	The poster has an attractive design and layout and is reasonably neat. The message is clear.	The poster is uniquely attractive and its design, layout and neatness emphasize the message being communicated.
Grammar	The poster contains many grammatical errors.	The poster contains several grammatical errors.	The poster contains one or two grammatical problems.	The poster is free of major grammatical problems.
Critically engages with available resources	Limited sensitivity to source of information; uses one or two references.	Moderate acknowledgement of source of information; uses limited references.	Effective engagement with source of information and makes attempt to access several sources.	Effective and critical engagement with many different sources of information.

RESOURCES

Canadian International Development Agency (CIDA) – malaria	http://www.acdi-cida.gc.ca/CIDAWEB/acdicida.nsf/En/FRA-101211511-KPS
Malaria No More	www.malarianomore.org/kids/educational-materials.php
Malaria/parasite games	http://nobelprize.org/educational_games/medicine/malaria/
Mosquito quiz	www.ucmrp.ucdavis.edu/pages/mosquitoquizanswers.html
Public Health Agency of Canada travel advice	http://www.phac-aspc.gc.ca/tmp-pmv/info/pal_mal_e.html
Roll Back Malaria Campaign	http://www.rbm.who.int/ or www.rollbackmalaria.org
Spread the Net Campaign	www.spreadthenet.org
UN Millennium Development Goals	http://www.un.org/millenniumgoals/
UNICEF (Canada)	http://www.unicef.ca/
UNICEF (international)	http://www.unicef.org/health/index_malaria.html
US Centre for Disease Control	http://www.cdc.gov/malaria/
World Health Organization	http://www.who.int/topics/malaria/en/



APPENDIX 1

Fact sheet N°94, May 2007

FACT SHEET: MALARIA

INFECTION AND TRANSMISSION

Malaria is a disease which can be transmitted to people of all ages. It is caused by parasites of the species *Plasmodium* that are spread from person to person through the bites of infected mosquitoes. The common first symptoms–fever, headache, chills, and vomiting–appear 10 to 15 days after a person is infected. If not treated promptly with effective medicines, malaria can cause severe illness that is often fatal.

There are four types of human malaria – *Plasmodium falciparum, P. vivax, P. malariae,* and *P. ovale. P. falciparum* and *P. vivax* are the most common. *P. falciparum* is by far the most deadly type of malaria infection.

Malaria transmission differs in intensity and regularity depending on local factors such as rainfall patterns, proximity of mosquito breeding sites and mosquito species. Some regions have a fairly constant number of cases throughout the year–these are *malaria endemic*–whereas in other areas there are "malaria" seasons, usually coinciding with the rainy season.

Large and devastating epidemics can occur in areas where people have had little contact with the malaria parasite, and therefore have little or no immunity. These epidemics can be triggered by weather conditions and further aggravated by complex emergencies or natural disasters.

GLOBAL AND REGIONAL RISK

Approximately, 40 per cent of the world's population, mostly those living in the world's poorest countries, are at risk of malaria. Every year, more than 500 million people become severely ill with malaria. Most cases and deaths are in sub-Saharan Africa. However, Asia, Latin America, the Middle East and parts of Europe are also affected. Travelers from malaria-free regions going to areas where there is malaria transmission are highly vulnerable – they have little or no immunity and are often exposed to delayed or wrong malaria diagnosis when returning to their home country.

TREATMENT

Early diagnosis and prompt treatment are the basic elements of malaria control. Early and effective treatment of malaria disease will shorten its duration and prevent the development of complications and the great majority of deaths from malaria. Access to disease management should be seen not only as a component of malaria control but a fundamental right of all populations at risk. Malaria control must be an essential part of health care

development. In contemporary control, treatment is provided to cure patients rather than to reduce parasite reservoirs.

Antimalarial treatment policies will vary between countries depending on the epidemiology of the disease, transmission, patterns of drug resistance and political and economic contexts.

DRUG RESISTANCE

The rapid spread of antimalarial drug resistance over the past few decades has required more intensive monitoring of drug resistance to ensure proper management of clinical cases and early detection of changing patterns of resistance so that national malaria treatment policies can be revised where necessary. Surveillance of therapeutic efficacy over time is an essential component of malaria control. Recent efforts to scale-up malaria control in endemic countries throughout the world including increased support for commodities and health systems, as well as the proposed price subsidy on artemisinin-based combination therapies (ACTs) is resulting in greater access to and a vastly increased use of antimalarial medicines, in particular ACTs. This is leading to a much higher degree of drug pressure on the parasite which will almost certainly increase the likelihood of selecting for resistant parasite genotypes. There are currently no effective alternatives to artemisinins for the treatment of *P. falciparum* malaria either on the market or towards the end of the development pipeline.

The parasite's resistance to medicines continues to undermine malaria control efforts. WHO has therefore called for continuous monitoring of the efficacy of recently implemented ACTs, and countries are being assisted in strengthening their drug resistance surveillance systems. In order to preserve the efficacy of artemisinins as an essential component of life-saving ACTs, WHO has called for a ban on the use of oral artemisinin monotherapies, at various levels, including manufacturers, international drug suppliers, national health authorities and international aid and funding agencies involved in the funding of essential antimalarial medicines.

PREVENTION: VECTOR CONTROL AND INTERMITTENT PREVENTIVE THERAPY IN PREGNANT WOMEN

The main objective of malaria vector control is to significantly reduce both the number and rate of parasite infection and clinical malaria by controlling the malaria-bearing mosquito and thereby reducing and/or interrupting transmission. There are two main operational interventions for malaria vector control currently available: Indoor Residual Spraying of long-acting insecticide (IRS) and Long-Lasting Insecticidal Nets (LLINs). These core interventions can be locally complemented by other methods (e.g. larval control or environmental management) in the context of Integrated Vector Management (IVM). Effective and sustained implementation of malaria vector control interventions (IRS or LLINs) requires clear political commitment and engagement from national authorities as well as long-term support from funding partners.

Pregnant women are at high risk of malaria. Non-immune pregnant women risk both acute and severe clinical disease, resulting in up to 60 per cent fetal loss and over 10 per cent maternal deaths, including 50 per cent mortality for severe disease. Semi-immune pregnant women with malaria infection risk severe anaemia and impaired fetal growth, even if they

show no signs of acute clinical disease. An estimated 10 000 of these women and 200 000 of their infants die annually as a result of malaria infection during pregnancy. HIV-infected pregnant women are at increased risk. WHO recommends that all endemic countries provide a package of interventions for prevention and management of malaria in pregnancy, consisting of (1) diagnosis and treatment for all episodes of clinical disease and anaemia and (2) insecticide-treated nets for night-time prevention of mosquito bites and infection. In highly endemic falciparum malaria areas, this should be complemented by (3) intermittent preventive treatment with sulfadoxine–pyrimethamine (IPT/SP) to clear the placenta periodically of parasites.

INSECTICIDE RESISTANCE

In spite of increased national and international efforts to scale up cost-effective malaria vector control interventions and maximize the protection of populations at risk, significant challenges continue to threaten these objectives and the sustainability of achievements. Challenges include increasing resistance of vector mosquitoes to insecticides, the behaviour and ecology of local malaria vectors – which often change as a result of vector control interventions — and the diminishing number of available insecticides that can be used against malaria vectors (adulticides).

There are currently no alternatives to DDT and pyrethroids and the development of new insecticides will be an expensive long-term endeavour. Therefore, immediate sound vector resistance management practices are required to assure the continued utility of the currently available insecticides. At present there is only limited evidence of the impact of various resistance mechanisms on the efficacy of vector control interventions, whether they are implemented singly or in combination.

Recent evidence from Africa indicates that pyrethroid and DDT resistance is more widespread than anticipated. It is believed that the same level of resistance will have a more detrimental impact on the efficacy of IRS than on that of LLINs, but evidence for this is very limited. Networks for vector resistance monitoring still need greater strengthening in order to make resistance detection a routine operational feature of national programmes, particularly in countries in Africa and the Eastern Mediterranean region. Regional level databases feeding into a global database accessible by governments, scientists and policy-makers would greatly assist in the rational use and deployment of vector control interventions.

SOCIOECONOMIC IMPACT

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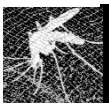

GLOSSARY

ACT Artemisinin-based Combination Therapy; the most effective treatment for malaria although cost remains a barrier for many in need.

Anopheles The genus of mosquito responsible for malaria infection in humans; acts as a host and vector for the malaria-causing *Plasmodium* organism.

Host The organism from which a parasite obtains its nutrition and/or shelter. A human acts as a host for the *Plasmodium* parasite causing malaria.

ITN Insecticide-Treated Nets; used while sleeping for mechanical and chemical protection against mosquito bites. A good picture and further information can be seen at http://www.rollbackmalaria.org/cmc_upload/0/000/015/368/RBMInfosheet_5.htm.

IVM Integrated Vector Management; an integrated locally-relevant approach used for the control of mosquitoes in malaria-prone areas. For more information: http://www.who.int/malaria/integratedvectormanagement.html.

Malaria An infectious disease caused by protozoan parasites of the genus *Plasmodium* that are transmitted through the bite of *Anopheles* mosquitoes.

MDG Millennium Development Goals; eight goals established by the United Nations in 2000 that form a blueprint for the reduction of global poverty by 2015. Goals include targets to improve maternal health, reduce HIV/AIDS and malaria rates, improve school enrolments, improve environmental health and improve gender imbalances. See http://www.un.org/millenniumgoals/.

Parasite An organism that lives on or in another organism (the host) and takes its nourishment from that other organism; parasites cannot live independently. With malaria, *Plasmodium sp*. is the parasite that requires a human or mosquito host to survive.

Plasmodium The genus of the organism responsible for the malaria infection; those species causing human malaria infection include *Plasmodium falciparum*, *Plasmodium vivax*, *Plasmodium malariae*, *Plasmodium ovale*.

RBM Roll Back Malaria Partnership; launched in 1998 by the World Health Organization (WHO), UNICEF, the United Nations Development Programme (UNDP), and the World Bank to provide a coordinated global approach in the fight against malaria. www.rollbackmalaria.org.

Symptom Any change in the body or its function that is attributable to a given disease or condition. For example, symptoms of the common cold include runny nose and watery eyes.

UNICEF United Nations Children's Fund; an organization of the United Nations committed to health, education, equality and protection of all children around the world www.unicef.org/www.unicef.ca.

Vector A carrier or "bearer"; with malaria, the mosquito serves as a vector, transmitting the *Plasmodium* organism to humans during successive bites.

WHO World Health Organization; the directing and coordinating body for health within the United Nations system. http://www.who.int/about/en/.