# Problem-Based Learning: A Patient Returning from Africa

**Resource Type:** Curriculum: Classroom

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## Authors

*Jan Jacobs*
Department of Medical Microbiology
University Hospital Maastricht
The Netherlands
Email: jja@lmib.azm.nl

*Astrid Visschers-Pleijers*
Department of Educational Development and Research
Maastricht University
The Netherlands
Email: A.pleijers@educ.unimass.nl

## Abstract

Students explore the story of a peer student who developed malaria after returning from Africa. The case contains a number of hints with regard to the transmission of the parasite, the identity and behavior of the vector, the implications of the disease for the local population, and the clinical history in the nonimmune host.

## Activity

**Invitation for User Feedback.** If you have used the activity and would like to provide feedback, please send an e-mail to MicrobeLibrary@asmusa.org. Feedback can include ideas which complement the activity and new approaches for implementing the activity. Your comments will be added to the activity under a separate section labeled "Feedback." Comments may be edited.

**INTRODUCTION**

**Learning Objectives.**

I. After study of this case, students will

- be able to demonstrate knowledge and understanding of the malaria parasite's sexual and asexual cycles and its transmission.
- have a basic knowledge of the endemic areas of malaria.
- know and explain the effects of malaria on childhood mortality and partial immunity.
- be able to demonstrate and explain how to prevent malaria transmission (not details on drug names used for prevention).

II. Generic skills. The process of problem-based learning will allow students

- to gain and train attitudes such as teamwork, chairing a group, critical evaluation of literature, self-directed learning, and use of resources and presentation skills.

III. If applied to medical students, these students will

- know and explain the symptoms and signs of malaria in the nonimmune host.
- know how to establish the diagnosis of malaria and recognize the alarming laboratory values.

**PROCEDURE**

**Materials.**
Digital projector (for video display of case presentation)
Flip chart or whiteboard for taking notes during the group meetings

**Student Version.**
You will now start to work on a microbiology case in a small group. You will use a systematic procedure to handle this case. This procedure consists of seven steps in which you formulate the problem, analyze it, formulate learning goals for individual study, report findings, and synthesize them in order to acquire a deep understanding of the phenomena described in the case.

**I. First meeting: Analysis, Steps 1 to 5.**
During your first meeting, one of you should be appointed as the chairperson. S/he will (i) structure the content and logical sequence of events in the group meeting, (ii) ensure that you proceed well through the seven-step approach described below, and (iii) ensure proper interaction and cooperation between group members. Another colleague will be appointed as the secretary to record the different points made by the group.

**Step 1.** Read the following text. Clarify with your present knowledge as much as possible all terms that are unfamiliar to you. Also have a look at Fig. 1 and 2.

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Kangu (Mayumbe, Bas-Congo, République du Congo), October 4th
Dear Barbara,

Sorry for writing you so late.

I am staying in Kangu (Congo, West Africa) for 3 weeks. It is a small missionary town founded in 1892. The place was once known as the "white

man's grave," not only because of its crocodiles and snakes, but also because of lethal malaria.

To prevent malaria, I was told to take some pills. Due to my exams (which I've passed well), I forgot to take them before departure. "No problem," said Jack (the medical student upstairs, you know); he told me the incubation period of malaria extends for more than a week, so time enough to start taking my pills upon arrival.

I spent some marvelous days in Kinshasa. To save money, I left the Hotel California and moved to a room in the suburban area. The owner and his wife were friendly people. They had seven children, two of them had died "because of fever" at the age of 2. They cultivated protein-rich fish in a pond in their garden. My room was nice and clean, with a large bed covered by an impregnated mosquito net. In vain, I tried to sleep under this suffocating bed net for 2 days. The third night I loosened the edges that were tucked in under the mattress, and the next day, I decided to remove it! Of course, I was clever enough first to confirm the absence of mosquitoes. I did not see any of them on the walls of my little room, and I slept peacefully without being disturbed by any buzzing of mosquitoes.

I visited small markets and shops and tasted local sauces and beverages. I know I shouldn't have done that, because I was punished by a 5-day diarrhea which confined me to my bed....After that, I spent the nights outside with some friendly people and a bottle of Skoll (local beer) discussing politics and football, with Makeba's music coming out of the local cafe. At first, I consistently wore those outdoor clothes with long pants and sleeves as dad had advised me to. But later I felt too much colonially dressed and I decided to change into a more African-style boxer short. Anyway, I bought some incense coils to repel mosquitoes. Again, don't be afraid of malaria, Barbara, as none of my local friends suffered from malaria those weeks.

I'll soon come back home. Don't be shocked when you see me: I have grown a beard. Someone has stolen my dressing-case (with my shaver, my spare spectacles, and my DEET stick in it). Never mind, this beard is looking good on me, and as far as the stick is concerned, I don't care; it smelled awful....

Love,
Bob Robberts

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Maastricht (The Netherlands), November 20th
**Scanned for malicious contents. Get your free e-mail at www.Anopheles.org**
Wednesday morning, 4 a.m.

Dear Barbara,
Thanks for your e-mail.
Back in Maastricht now.
Arrived on Friday 4 p.m.
Lost my box of pills. Never mind, Africa is over now.
I'm not feeling so well.
Tired, slight headache. Nauseous, feel like vomiting.
Bad climate here.
I have been working like a dog.
How I wish you were here!

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Maastricht, November 22nd, 5 a.m.
Mobile phone SMS message

BARB
SPENT ALL NIGHT WITH FEVER. HEADACHE +++. FEEL SLEEPY. THINK I NEED A DOCTOR.

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Maastricht, November 22nd, 8 a.m.
University Hospital Maastricht, Department of Medical Microbiology

patient R.B., age 20 years.
Microscopic view of Giemsa-stained thick smear (Fig. 1) and thin smear (Fig. 2).

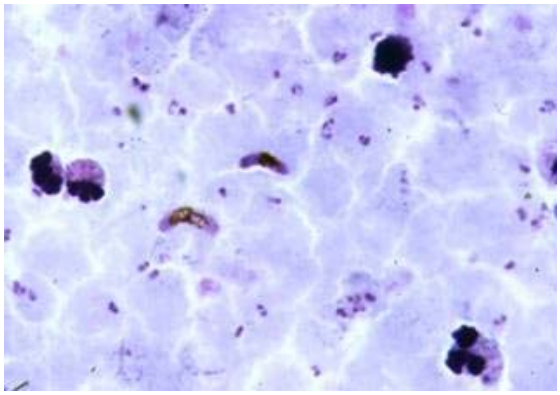

FIG. 1. Microscopic view of Giemsa-stained thick smear.

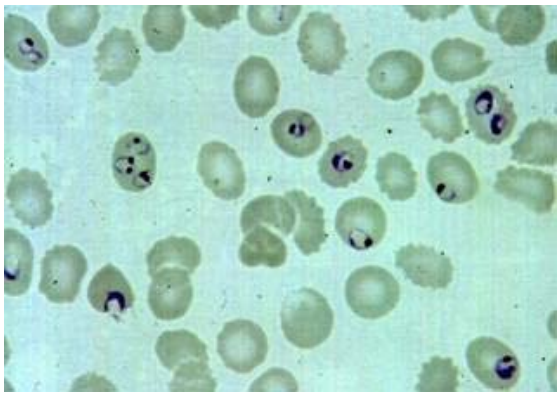

FIG. 2. Microscopic view of Giemsa-stained thin smear.

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**Step 2.** List all problems and questions you encountered in this text.
The secretary writes down these problems and questions and numbers them. Next, cluster all related problems and rank them in a logical order which allows you to discuss them one by one.

**Step 3.** Brainstorming: generate explanations.
Discuss one by one the clustered problems. Put together all your present knowledge and possible explanations to clarify the problems. Write these brief explanations down.

**Step 4.** Arrange the proposed explanations.
Classify the explanations, look for relations between them. Determine the "gaps in knowledge": any knowledge you are lacking or anything that remained unclear to explain the problems extracted from the case.

**Step 5.** Formulate "Learning Goals": define what you are going to look up and study the next days, based on the gaps in knowledge (Step 4). Formulate these learning goals in clear, well-defined, and concrete terms. A useful learning goal contains a keyword that demarcates the content of a certain topic, is formulated concisely, and is unambiguous for all group members (Van den Hurk et al., 1998). For example, "Describe the life cycle of the malaria parasite: state all stages in a human and mosquito, as well as the different durations."

**II. Self-study: Study of learning goals**
**Step 6.** Make a schedule for study, select sources of information on the basis of the learning objectives formulated during the group's first meeting. Ask yourself whether what has been studied is clear, make notes and diagrams, and prepare yourself well for the reporting group meeting. Translate unclear information into concrete questions for your group members and determine whether you are able to report your studied material clearly and briefly.

**III. Second meeting: Synthesis by reporting, Step 7.**
**Step 7.** Present what you have studied to the group briefly and clearly, create links with learning objectives. Quote sources and support your presentation with examples and/or diagrams. Ask questions about unclear information. Test the new knowledge critically and check whether the new knowledge is understood and apply new knowledge to the problem. Finally, evaluate the process of knowledge acquisition (preparation, use of learning materials, depth of discussion...), and the group process (collaboration, interactions, contributions of individual members...). Eventually, give suggestions for improvement of the case to the tutor.

**Instructor Version.**
**I. Problem-based learning and your role as instructor (tutor).**
In problem-based learning, a group of students defines their own learning goals which cover the "gaps in knowledge" they defined after analysing a problem case during their first meeting. The problem case contains "triggers" to stimulate students in activation of their present knowledge and to guide them in formulating learning objectives. After independent and self-directed study, the students return for a second meeting during which they report their private findings, discuss the remaining problem, and refine their acquired knowledge. The different steps of the "seven jump" are described in the student's version. Apart from a high retention rate of knowledge, problem-based learning stimulates a number of generic skills and attitudes such as teamwork, self-directed learning, and critical use of study resources.

Your role as tutor (instructor) is to be a facilitator, who scaffolds student learning through modelling and coaching, primarily by using questioning strategies. You can intervene when you notice that the students do not work on the task with sufficient depth. A list of questions for brainstorming is provided, so that you can check whether all relevant aspects of the problem are addressed by the students (see step 3 of the seven-step approach in the student version). You should also intervene if the group discussion stagnates or if the group does not function properly. Encourage students to check their understanding of the material by asking open-ended questions, by stimulating students to explain the items in their own words and report from memory rather than scanning through their notes. By asking questions, you can help the students to discover and clarify any misconceptions on their own. You can also give brief explanations or examples, but not before students have tried by themselves. Help the chairman to maintain group dynamics, move the group through the task, and ensure that the group achieves the appropriate learning objectives. When you evaluate the group sessions, provide feedback to the students about the group process you observed and about the individual contributions and the product of the discussion.

As your main task is to promote both the students' learning process and their mutual cooperation, you are the role model of an expert learner rather than a content expert. Nevertheless, you should acquire sufficient biomedical knowledge to understand the learning task and the discussion of the students. The content instructions can guide you. In addition, we advise that you have a content expert available who can be consulted by the students after the group sessions with any questions that remain.

**II. The problem's content: malaria**
Obviously, Bob Robberts suffers from serious malaria.

Malaria is a disease caused by a parasite, *Plasmodium*. Four species are recognized in humans: *P. falciparum* (causes tropical malaria, malignant tertian malaria), *P. vivax* and *P. ovale* (benign tertian malaria), and *P. malariae* (quartan malaria). The most prevalent *Plasmodium* species in Central Africa is *P. falciparum*; *P. ovale* and *P. malariae* are also found. *P. falciparum* is also prevalent in Southeast Asia and South America. The fourth species, *P. vivax*, occurs primarily on the Indian subcontinent, Southeast Asia, and Central and South America. *P. malariae* has a world-wide distribution in malaria-endemic areas.

*Plasmodium* parasites are transmitted by the bite of a female mosquito of the genus *Anopheles*. While feeding on a human host, the mosquito can ingest malaria parasites (gametocytes). The parasites develop in the insect over approximately 14 days (sexual cycle) until the infectious phase of the parasite (sporozoite) migrates to the salivary glands of the mosquito. At the next blood meal, the sporozoites are injected into the

human host where they accomplish their asexual cycle. The sporozoites invade the liver and develop into tissue schizonts which produce several thousand merozoites. In *P. vivax* and *P. ovale*, the sporozoites may develop into hypnozoites, which may remain dormant for several months before eventually maturing to tissue schizonts. After this liver phase (or, "extra-erythrocytic" phase), the resulting merozoites enter the red blood cells, where they develop as trophozoites which mature to schizonts ultimately producing 8 to 24 new merozoites which are released as the infected red blood cells lyse, thereby initiating another cycle of red blood cell infection ("red cell cycle", "erythrocytic phase"). Some parasites within red blood cells differentiate into male and female gametocytes (sexual forms). Malaria originating from hypnozoites (*P. vivax, P. ovale*) is called relapse, *P. malariae* may persist asymptomatically in the blood at undetectable levels for up to 52 years and is the species most frequently implicated in transfusion-related malaria. Development of a clinical *P. malariae* infection (after splenectomy or during immunosuppression) is called recrudescence.

The terms "tertian" and "quartan" refer to the periodicity of fever in the case of malaria: this pattern is related to the duration of the red cell cycle. The malarial paroxysm of fever includes a "cold and chilling stage" and then a "hot stage" coincident with red cell lysis and the release of merozoites, and finally a "sweating" phase with resolution of fever and marked fatigue. This paroxysm occurs each third ("tertian") or fourth ("quartan") day (periodicity of 48 and 72 hours, respectively). In the case of *P. falciparum* however, the red blood cell parasites are not synchronized, which means that typical tertian fever patterns are unusual and their absence does not exclude malaria.

*P. falciparum* is the most lethal malaria parasite. Its incubation period approximates 14 days (depending on the parasite load, related to the number of mosquito bites), and part of its lethality is due to cerebral involvement (reason why Bob feels sleepy is coma!). Other complications of *P. falciparum* malaria include anemia (due to hemolysis), acute renal failure, hypoglycemia, and, rarely, pulmonary edema, disseminated intravascular coagulation, and liver function impairment (these are not learning goals for the moment).

*P. falciparum* is prevalent in tropical countries, and as a result of continuous contact with the parasite, the local population has gained partial immunity against malaria (none of Bob's local friends suffered from malaria those weeks), at the cost of a high mortality rate in their children younger than 5 years old (two out of seven children of the guest family died of malaria). This partial immunity however fades away after leaving the malaria-endemic region. Immunologically naive people such as the "white men" in the early 20th century (and Bob Robberts) should avoid contact with mosquitos by wearing long pants and long sleeves, sleeping under bed nets impregnated with insecticides, using diethyltoluamide (DEET), and taking prophylactic drugs. Ideally, these drugs should be started before arrival, to check for side-effects and to ensure adequate blood levels upon exposure. Diarrhea may interfere with the absorption of preventive drugs for malaria. Depending on the kind of drug and its mechanisms, drugs should be continued for a certain period after return from the endemic area. Up-to-date recommendations on prophylaxis can be obtained from various centers such as the World Health Organization and the Centers for Disease Control and Prevention (see references).

The mosquito hides itself during the day (reason why Bob did not see any mosquitos in his room) and bites between dusk and dawn. Unlike the *Culex* mosquito, *Anopheles* does not buzz (reason why Bob slept peacefully). It was obviously a mistake to loosen the edges of the mosquito net, but under tightly fitted cotton nets the temperature is higher than outside. Ponds for fish cultivation may be a reservoir for mosquitos, especially in shallow areas. Insect coils are not very effective. Insecticide-treated bed nets are effective in protecting the population in endemic areas.

The diagnosis of malaria can be made by examination of a stained smear of peripheral blood. A thin smear is one cell layer thick and allows the examination of the parasitized red blood cells in sufficient detail to determine *Plasmodium* species involvement. In addition, the number of red blood cells parasitized can be counted; they are expressed as a percentage, which is important in guiding therapy. A thick smear (thick film), which is many cells thick, can detect a low parasitemia that may be undetectable in the thin smear. If initial films are negative but malaria remains a possible diagnosis, then repeat films should be taken. Parasitemias are limited in *P. vivax* and *P. ovale* (maximal ~4%) because these species only infect young red blood cells, and in *P. malariae* (~1%) because the species only infects old red blood cells. In *P. falciparum* malaria, parasitemia exceeding 5% as well as the presence of schizonts are alarming signs. Gametocytes may persist during therapy, their presence does not indicate therapy failure.

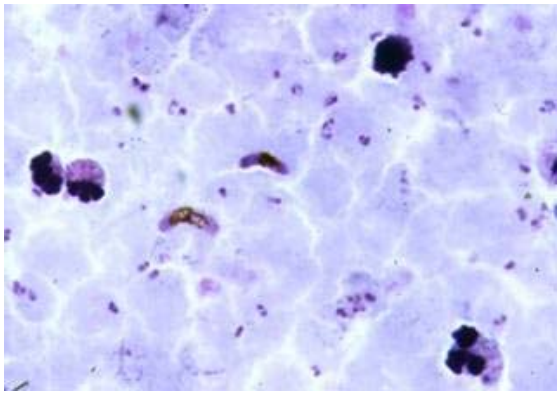

FIG. 1. Giemsa-stained thick smear, oil immersion field. Four leukocytes can be seen, as well as two gametocytes (banana-shaped organisms) and numerous trophozoites (ring forms). The gametocytes have the typical *P. falciparum* shape.

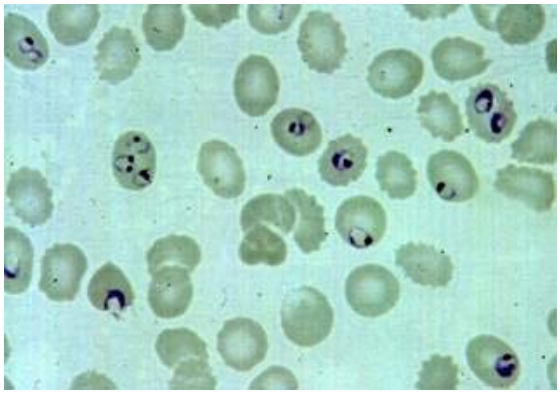

FIG. 2. Giemsa-stained thin smear, oil immersion field. Numerous red blood cells are parasitized with trophozoites (ring forms), with the occurrence of two and three trophozoites in a single red blood cell, typical of *P. falciparum*. Approximately 25% of the red blood cells are parasitized, or the parasitemia is 25%. The high parasitemia and the absence of mature forms of the parasite point to *P. falciparum* as the

involved species.

It may advisable to read through the case after the students have reported their findings to ensure that all details have been covered. References suitable as background for instructors and/or supplemental material for students may include standard textbooks on infectious diseases. In addition, we selected some additional references, of which the articles by Wyler (8) (although old) and Suh and coworkers (7) are very accessible and appropriate to meet the present learning goals. The reference *Malaria on the World Wide Web* (5) may guide students through the epidemiology and prophylactic measures (see Possible Modifications). Preferably, these references are handed out after the second meeting, to allow students to consult different sources, which favors discussion.

To help you, we have provided the Questions for Brainstorming and the Learning Goals (see I).

**Questions for Brainstorming**

- What is the incubation period of malaria? Did Jack mention the correct period?
- Why did the malaria pills (prophylaxis) have to be started before a visit to malaria-endemic regions?
- What is meant by an impregnated bed net?
- What does the pond have to do with the situation?
- Why did Bob sleep well after removing his bed net?
- Does diarrhea have something to do with malaria?
- Why should you wear long pants and sleeves during a tropical night?
- How effective are incense coils as an insect repellent?
- Why did none of Bob's local friends suffer from malaria?
- How does the DEET stick work, if it works at all?
- Is it wise not to continue the mefloquine prophylaxis?
- What is happening on November 20th?
- Why does Bob feel sleepy?
- Describe what you see on the microscopic slides. What is a thick prep? a thin prep?
- Do you know the Anopheles site? Is it a company?

**Learning Goals**
I. After study of this case, students will

- be able to demonstrate knowledge and understanding of the malaria parasite's sexual and asexual cycles and its transmission.
- have a basic knowledge of the endemic areas of malaria.
- know and explain the effects of malaria on childhood mortality and partial immunity.
- be able to demonstrate and explain how to prevent malaria transmission (not details on drug names used for prevention).

II. Generic skills. The process of problem-based learning will allow students

- to gain and train attitudes such as teamwork, chairing a group, critical evaluation of literature, self-directed learning, and use of resources and presentation skills.

III. If applied to medical students, these students will

- know and explain the symptoms and signs of malaria in the nonimmune host.
- know how to establish the diagnosis of malaria and recognize the alarming laboratory values.

**Safety Issues.** Not applicable.

**ASSESSMENT and OUTCOMES**

**Suggestions for Assessment.**
Multiple-choice questions on the subject

1. A thick smear and a thin smear are both used for the microscopic diagnosis of malaria.
   One of the following statements is correct:
   a. Gametocytes of *P. falciparum* can only be identified in thick smears, not in thin smears.
   b. The sensitivity of a thick smear is higher than that of a thin smear.
   c. A thick smear is more suitable to identify a species than a thin smear.

2. A 48-year-old, previously healthy agricultural engineer worked in Central Africa for 2 months. She has not been to any tropical country for 3 years. She presents with symptoms of a malaria paroxysm. One of the following species is the most likely cause:
   a. *Plasmodium falciparum*
   b. *Plasmodium ovale*
   c. *Plasmodium vivax*

3. A 38-year-old, previously healthy tourist returned from India 3 weeks ago. He presents with complaints of attacks of headache and fever. The attacks started last week. The patient has no fever at the moment. Blood test is negative for malaria. Based on this result, the correct strategy is to:
   a. advise the patient to come back to repeat the blood test when the fever peaks again.
   b. start antimalarial therapy now, because of suspected malaria.
   c. tell the patient to come back in 8 hours to repeat the blood test.

4. A 75-year-old missionary worked in Central Africa (Congo) for 40 years. He is retired and has been living in The Netherlands (Europe) for 10 years and did not return to the malaria-endemic regions during this period. He presents with complaints of attacks of headache and fever. The diagnosis of malaria is made. One of the following species is the most likely cause:
   a. *Plasmodium falciparum*
   b. *Plasmodium vivax*
   c. *Plasmodium malariae*

5. A 40-year-old patient comes for a follow-up consultation 1 week after antimalarial therapy for *Plasmodium falciparum* infection was stopped. The results of the blood test include: *Plasmodium falciparum* and gametocytes. Which decision is now correct?
   a. continue antimalarial therapy
   b. start treatment of the liver-stage parasites (hypnozoites)
   c. no change of policy

6. A student originating from Burundi (Central Africa) has been studying for 16 months in The Netherlands (Europe). He now returns to his country to visit his family and friends. With regard to malaria, one of the following statements is correct:
   a. malaria prophylaxis is needed
   b. no malaria prophylaxis is needed because of his innate immunity
   c. no malaria prophylaxis is needed because of acquired immunity

**Evidence of Field Testing.**

**Student Data.**
The case was run during the years 2002-2003 and 2003-2004 in the second year of Medicine, Maastricht University, The Netherlands, during the 6-week block "Puberty and Adolescence." Students were asked to rate the case. Ratings provided by 299 students were as follows: insufficient (1.5%), sufficient (51.5%), and good (47.0%). Overall, all six multiple-choice questions were answered correctly by 65% of students.

**SUPPLEMENTARY MATERIALS**

**Possible Modifications.**
A home-based task complementary to this case: write out the malaria preventive measures for a tourist (aid worker, pregnant women, child...) who will make a 4-week visit to Rwanda (or any other country). Each student will consider a different country. Students will access the World Wide Web for information and discuss their findings.

Something extra: a bar of chocolate may be awarded to the student who discovers the hints to famous songs or authors (*Hotel California* by the Eagles, *Wednesday Morning 4 a.m.* by Simon and Garfunkel , Myriam Makeba, *I've Been Working like a Dog* by the Beatles, *How I Wish You Were Here* by Pink Floyd)

**References.**

I. Further reading about problem-based learning


1. **Barrows, H. S., and R. M. Tamblyn.** 1980. Problem-based learning: an approach to medical education. Springer Publishing Company, New York, N.Y.
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3. **Davis, M. H., and R. M. Harden.** 1999. AMEE medical education guide no.15. Problem-based learning: a practical guide. Med. Teacher **21:**130-140.
4. **Van den Hurk, M. M., D. Dolmans, et al.** 1998. Essential characteristics of student-generated learning issues in a problem-based curriculum. Med. Teacher **20**(4): 307-309.
5. **Wood, D.** 2003. ABC of learning and teaching in medicine. Problem based learning. Br. Med. J. **326:**328-330.


II. Malaria


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2. **Newman R. D., M. E. Parise, A. M. Barber, and R. W. Steketee.** 2004. Malaria-related deaths among U.S. travelers, 1963-2001. Ann. Intern. Med. **141:**547-555.
3. **Suh K. N., K. C. Kain, and J. S. Keystone.** 2004. Malaria. Canadian Med. Assoc. J. **170:**1693-1702.
4. **Wyler D. J.** 1993. Malaria: overview and update. Clin. Infect. Dis. **16:**449-458.


Links to internet sites
The B. J. Angus article gives an extensive overview of websites, among them:
Centers for Disease Control and Prevention, http://www.cdc.gov/travel/
World Health Organization, http://www.who.int/tdr/diseases/malaria/default.htm
A link to the malaria cycle can be found at http://www.malaria.org/lifecycle.html

**Appendices and Answer Keys.**
Correct answers to the cases:
1. b
2. b
3. c
4. c
5. c
6. a