

Environmental Release of Genetically Engineered Mosquitoes

Is It Safe? A Role Playing Activity for STEM Education

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Introduction

There is agreement among educators that effective teaching helps students to think critically, communicate effectively, learn self-discipline, develop an understanding of oneself and others, and cultivate the perpetuation of self-education (Freiberg and Driscoll 2001; Cherif and Adams 1993). One effective technique that encourages such participation is role playing. Role playing provides an opportunity for “acting out” conflicts, collecting information about social issues, learning to take on the roles of others, and improving students’ social skills. As a teaching approach, role playing is an indispensable part of human development; it offers a unique way to resolve interpersonal and social dilemmas (Joyce et.al. 2009), and is helpful in achieving learning objectives (Cherif and Somerville 1995; Ross et al. 2008). Role playing also provides an opportunity for students to engage in active learning which involves the critical analysis of new ideas by linking them to already known concepts or principles; something that could lead to better understanding as well as long-term retention of

concepts (Houghton 2004). Additionally, it gives students the opportunity to tie together concepts from diverse fields such as molecular biology, medicine, public health, genetics, environmental protection/stewardship, and economics, promoting an interdisciplinary learning experience.

In this activity, groups of students assume the roles of representatives of the World Health Organization (WHO), Food and Drug Administration (FDA), Friends of the Earth (FOE) organization, the scientific community, a university research team, the biotechnology industry, and the media. The students work together to develop convincing arguments and debate whether or not to support the release of genetically engineered mosquitoes into the environment to provide a significant *immediate* benefit to society. In the process, the students learn and reinforce their understanding of the principles of DNA structure and replication, genetic mutations, genetic engineering, infectious diseases, insects and resistance to drugs and insecticides, public health, and environmental protection/stewardship. In addition, role playing activities such as this

one provide an engaging opportunity to discuss conflicting views on scientific issues, and also demonstrate how technological advances and social, political and economic issues change the direction and nature of science, while exploring the moral, ethical and social dimensions of our society.

Background

Mosquitoes are an important public health concern due to their ability to transmit diseases. In many parts of the world, especially the tropics and subtropics, the rainy season is associated with protecting oneself from the bites of insects, including over 3,500 different species of mosquitoes. Mosquitoes have four complex life cycle stages: egg, larva, pupa, and adult or imago. Each of the four stages goes through a very different interaction with their environment. The first three stages are aquatic in nature, and the fourth is the flying adult. To start the life-cycle, adult females lay their eggs in standing water in which they hatch into larva and then the pupae forms before emerging as flying adults within five to fourteen days. The adult mosquitoes often live for Four to eight weeks.

The mosquito is a member of the family *Culicidae*, with unique features including mouthparts that are specialized for piercing the skin of plants and animals. While males typically feed on plant nectar, in some species of mosquitoes, the females can only produce eggs once they have obtained protein-rich hemoglobin from a blood meal. Their mouthparts allow an infected mosquito to deliver the pathogenic organisms it is carrying directly into the bloodstream of the animal or human it bites (see [Appendix A](#)). Because of this, mosquitoes are vectors for a number of infectious diseases, including malaria, which affect millions of people each year.

Malaria is one of humankind's oldest recorded maladies. Signs of malaria have been discovered in Egyptian mummies, and the detailed documentation of the distinctive stages of illness was found in Hippocrates's medical journal in the fifth century. (Carmichael 2010a; Finkel 2007; Postlethwait and Hopson, 2003). The emergence of a treatment for malaria has an interesting historical origin:

In the mid-1600s, the natives of Lima, Peru, were already using bark from a tree in the Andean cloud forests to treat the disease. Spanish diplomats returned the bark to Europe, where it became known as quinine and remained the principal treatment until World War II, when researchers developed chloroquine and

other synthetic substitutes. Unfortunately, resistance to multiple malaria drugs has evolved in many populations of the deadly parasite *Plasmodium falciparum*. Their major hosts, *Anopheles* mosquitoes, also evolved resistances to DDT and other insecticides. As a result of this, the incidence of malaria began rising dramatically in the late 20th century. (Postlethwait and Hopson 2003, 295).

Malaria is transmitted by female mosquitoes of the *Anopheles* genus, the only insect capable of harboring the human malaria parasite *Plasmodium*. This single celled parasite is picked up by the female *Anopheles* mosquito from the blood of infected people and spread to uninfected people through a bite. (See [Appendix A](#) and [B](#).) There are four types of human malaria: *Plasmodium vivax*, *P. malariae*, *P. ovale* and *P. falciparum*. *Plasmodium vivax* and *P. falciparum* are the most common forms. Among all of them, Falciparum malaria is the most deadly type with highest rates of complications and mortality. It is also the most common in sub-Saharan Africa where more than 75 percent of all cases occur, and where it causes nearly a million deaths a year (WHO 2008, 11–12; WHO 2010). Worldwide, about 300–500 million people in 106 countries get malaria each year. In some parts of the world, malaria is responsible for as many as half of all childhood deaths (Finkel 2007). Common symptoms are extreme chills with shivering, sweating, and fever. Infected individuals alternate between chills and fever and have an enlarged spleen; in addition, rapid breathing and profuse sweating can occur as the fever decreases (Tortora et. al 2007; Bauman 2006). (See [Appendix B](#).) Malaria is not easily cleared by the human immune system. As stated by William (2010, 42), “malaria parasites invade human blood cells, they churn out a sticky protein that makes the blood cells clump together. This keeps the cells from reaching the spleen, where the immune system would destroy them, and gives the malaria parasite—*P. falciparum*—a safe haven inside the cells to replicate.” (William 2010, 42)

If not treated promptly with effective medicines, the red blood cells of infected people will be destroyed and their capillaries which carry blood to the brain or other vital organs can be clogged, leading to a painful death. For many years people all over the world have battled malaria by fighting its carrier, the stubborn mosquito. Today, WHO, other governmental and private health organizations, and many scientists and medical doctors have been working very hard to control mosquitoes and develop vaccines and anti-malaria drugs as well

as to improve the speed and rate of how the human immune system responds to the parasite. However, both mosquitoes and *Plasmodium* have evolved resistance to the insecticides and drugs that scientists have developed to combat them and prevent the occurrence of malaria among human population. (See Appendix C and D for prevention and for current treatment and drugs used to treat malaria.) Effective vaccines have yet to be developed against malaria, due to the parasite's ability to escape the host immune response. However, some hope is emerging in the vaccine research field. In "Halting the World's Most Lethal Parasite," Mary Carmichael (2010a, 69) writes:

Right now, somewhere in the world—in a petri dish in Baltimore, maybe, or in the salivary glands of a laboratory-bred mosquito in Seattle, or in the bloodstream of a villager in Ghana—resides a chemical compound that could help eradicate human history's biggest killer. Scientists have many promising malaria vaccine candidates in the works, and for the first time one have reached advanced human trials. If it or another candidate is even partly effective in people, it could save the lives of millions of children and pregnant women. It would be the only vaccine yet developed against a human parasite, an achievement of Nobel caliber.

If we could find an effective way to battle malaria, millions of lives could be saved each year. A group of scientists at the University of Arizona has turned to genetic engineering for a solution. In July 2010, the research team altered some of the genetic codes in female *Anopheles* mosquitoes, in hopes of developing a mosquito that is resistant to *Plasmodium*. It has been reported by Schneiderman (2010, 8):

They [scientists] performed the trick by altering the bug's DNA making it 100 percent resistant to the disease and shortening its life span enough to stymie the growth of malarial parasites. The next step would be to give this malaria-proof insect an evolutionary edge and release it into the wild, where it can conquer the world's existing mosquito species. It would take more than a decade before this idea is ready to be implemented. But the hand-wringing has already begun.

Scientists have never played God in such a way, replacing a natural species with one of their own creation. "We don't know the long-term effects," say Eric Hoffman, a campaigner at Friends of the Earth, which opposes genetically modified organisms. The World

Health Organization intends to devise rules for testing genetically modified mosquitoes to ensure, among other things, that the bug's altered DNA doesn't make it a better carrier of other diseases.

These developments may someday help fight insect-borne infectious diseases without the need for insecticide and significantly improve the quality of life for millions of people. Michael Riehle, an entomologist who led the University of Arizonian research, says, "Hopefully the benefits will outweigh the risks" (Schneiderman 2010, 8). But, using Mark Skinne's (2010) words in a different context, should science dictate policy or policy dictate science? This statement becomes the premise for this activity.

Learning Activity

The objective of this leaning activity is to help students understand the principles of DNA structure and replication, genetic mutations, genetic engineering, infectious diseases, insects, and drug and insecticide resistance through understanding and debating the role of genetic engineering in biological diversity, environmental protection/stewardship and sustainability, and the enhancing of life and living in human societies.

To begin, each group of students selects a committee to represent and design convincing arguments that either support or oppose genetic engineering of the DNA of the female mosquito. The genetic changes are meant to make mosquitoes resistant to infection by *Plasmodium*, thereby helping to prevent the occurrence of malaria among the world's populations. The long term effects of releasing genetically engineered mosquitoes into the environment are unknown.

To ensure that the students research the proper references and that the debate is conducted between very well informed groups, all the students are asked to read the following articles as the starting point of their own research:

- Carmichael 2010a;
- Dunavan 2010;
- Finkel 2007;
- Judson 2003;
- Koenig 2010.
- Marsa 2010;
- Perry 2010; and
- WHO report, current issue.

After the initial presentation of information by the instructor, the students are given time to work together and collect additional information necessary to design and develop a plan. They then “act out” that plan by successfully arguing in favor of or against genetically engineering the DNA of the female mosquitoes. This role-playing activity can last two hours to two weeks, including preparation and presentation time.

Through role-playing and classroom debates, students gain the following: They learn to make choices, organize their information, and take on roles; they improve their social skills and academic performance; and they learn and reinforce their understanding of the principles of DNA structure and replication, genetic mutations, genetic engineering, infectious diseases, insects and drug resistance, the roles of insects such as mosquitoes in the environment including biological diversity and environmental sustainability.

Procedures

Before presentations, implement the following procedures.

1. Form a debate committee that consists of the instructor of the class, another instructor from the school, and one or two academically respected students from the same class.
2. Divide the students into groups of two or three and randomly ask each group to select one of the communities to represent: World Health Organization, Food and Drug Administration, Friends of the Earth, the scientific community, a university research team, the biotechnology industry, or the media.
3. Allow the groups to inform each other of their selections, as well as to exchange selections if they wish. This will make the groups more committed to their selections.
4. Give the students two to three weeks (time can be shortened or lengthened) to prepare for the debate, and inform the groups to complete the following steps (a–e):
 - a. Read all the eight reading assignments before starting their own research. This will ensure that all the students at least are exposed to the same level and type of information before the debate.
 - b. Research and prepare a well-informed paper, based on their own group’s perspective, to support or oppose genetically engineering and releasing mosquitoes into the environment despite the fact that the long-term effects on its own species and on the surrounding environment are unknown.

- c. Be well prepared to engage in a meaningful debate to convince their classmates that their perspective is the one that should be adopted.
 - d. Have a well-researched handout to be distributed to the class before the presentation, as well as an illustrated poster, poems, songs, cartoons, etc. that can help convey the group’s message and support its argument and perspective.
 - e. Integrate the use of technology in their presentation, such as the use of PowerPoint, animations, interactive activities, as well as songs/poems, etc. to present their plan and strategy to show how and why their perspective should be adopted.
5. At every class meeting, make sure that students are working on their assignments. For example, give 15–30 minutes to the members of each group at the end of the class meeting to sit together and reflect on the progress they have made.
 6. Finally, remind each group of students that they must have a good grasp of their point of view, as well as an understanding of the opinions of the other communities: “Those who do not completely understand their adversary’s point of view do not fully understand their own” (Bender 1986, 9). In addition, also remind them that the objectives in this role-playing activity are to help them develop:
 - a. Team work and communication skills.
 - b. Critical thinking and problem-solving skills.
 - c. Breadth and depth of concepts and vocabulary of biotechnology and their application to life in our contemporary technological society.
 - d. An understanding of the social, economic and environmental implications and limitations of science, technology, and genetic engineering.
 - e. An awareness of their own attitudes, feelings and values and how they differ from others.
 - f. An awareness of the importance of biological diversity in environmental protection/stewardship, economy and sustainability.

During presentations, implement the following procedures

1. The groups take turns presenting their perspectives. The debate committee questions each group. In addition, the students in the class can ask up to three questions after a group finishes its presentation. The members of each group take note of all the questions that are asked.

2. When all the groups have presented, the members of the debate committee can ask more questions to all the groups. The students can also ask questions, which the members of the debate committee may consider in their final judgment and decision.
3. The members of the debate committee wait until the next class meeting before sharing their final decision with the groups. During this time, if there is room in the school, the posters, illustrations, and poems, etc. can be made available for all the students to view.
3. After all the groups present their final remarks; a representative of the debate committee reads and defends the committee's final decision.
4. The instructor of the class must reinforce the principles of DNA structure and replication, genetic mutations, genetic engineering, infectious diseases, insects, and resistance to drugs and insecticides. He or she must also discuss the role of insects in biological diversity and environmental sustainability as well as the public health importance of mosquitoes from nuisance to disease.

After presentations, implement the following procedures

1. In making their final decision, the members of the debate committee take into consideration the following (a–d).
 - a. The academic quality and integrity of the written paper, the oral presentation, the poster illustration, and/or any additional aids used by the students to convey their message.
 - b. Clear evidence that the members of a given group conducted research beyond the 8 articles assigned by the instructor for all the students as reading assignments.
 - c. The delivery of the presentation, the articulation of the perspective and arguments, the demonstration of the long term and short term effects, and the individual's personal involvement and engagement during the debate.
 - d. The type and quality of questions asked during the debate. In addition, the quality of the answers the group provided to questions directed at them. Teachers and instructors can refer to Cherif et al. (2009) for useful tools and techniques that can be used to monitor the level of cognitive involvement of the members of a given group during the activity as well as to record the types of questions being asked by the members of a group, the relevance of the questions to the subject matter and to the point being debated, and the number of questions asked by the members of each group. (See Tables 1, 2 and 3 on the following page.)
2. Each group is given 2–3 minutes to address the debate committee one more time before the members of the committee read the final decision. In this short final remark, the groups must have a written statement that can be read to support their case.

Appendix E provides additional discussion topics on the theme of mosquitoes and malaria.

Assessment

In assessing students' performance and understanding, as well as the effectiveness of these activities, we have been using McCormack and Yager's (1989) taxonomy for science education as a framework for student achievement. A summary of this taxonomy can be found in Cherif et al. (2009). In the same article, teachers and instructors can also find useful tools and techniques for monitoring the level of cognitive involvement of the members of a group during the activity and recording the types of questions being asked by the members of a group, the relevance of the questions to the subject matter and to the point being debated, and the number of questions being asked by the members of each group. See Tables 1–3.

Conclusion

In this learning activity, we have tried to create a strategy of role playing that enables students to become more actively involved in learning about genetically modified organisms and their role in human life. In doing so, they learn about DNA structure and replication, genetic engineering, infectious diseases, insects and drug and insecticide resistance. Choosing a stance, either for or against releasing genetically engineered female mosquitoes into the environment, and debating that opinion among classmates improves student's communication, collaboration, and critical-thinking skills, and it enables them to have fun and enjoy learning.

The activity can be conducted before or after the topic is covered in class. In both cases, the wrap-up or ending discussion is important because it drives home the importance that

TABLE 1. Individual Group Questions Analysis and Account*

Type of Question or Conditional Statement	Extremely Relevant	Relevant	Less Relevant	Not Relevant	Total Number of Questions
1 Why					
2 How					
3 What do you think if . . . ?					
4 Which					
5 What					
6 When					
7 Where					
8 Is/Are					
Total number of questions and/or wondering statements					

* From Cherif et.al., 2009, 350.

TABLE 2. Tracking the Number of Question Asked by Each Group of Other Groups*

	WHO	FDA	Scientific Community	UA Research Team	Friends of the Earth	Biotech Community	Media
WHO	X						
FDA		X					
Scientific Community			X				
UA Research Team				X			
Friends of the Earth					X		
Biotech community						X	
Media							X
Total of Questions							

*From Cherif et.al, 2009, 351.

NOTE: WHO = World Health Organization; FDA = Food and Drug Administration; UA = University of Arizona

TABLE 3. Type of Questions or Conditional Statements and Their Values for Assessment Purposes

Type of Question	Extremely Relevant			Relevant			Less Relevant			Not Relevant			TOTAL
	Number	Value Per	Total Values	Number	Value Per	Total Values	Number	Value Per	Total Values	Number	Value Per	Total Values	
1 Why, How		5		4			3			1			
2 What do you think if . . . ?		4		3			2			1			
3 Which		3		2			1			0.5			
4 What, When, Where		2		1			0.5			0			
5 Is, Are		1		0.5			0			0			
Total													

DNA and genetic engineering have in our lives. In our case, this role-playing activity has benefited some of our students by motivating them to engage in deep learning that results in a meaningful understanding of material and content as well as long-term retention of learned concepts.

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APPENDIX A: IT BEGINS WITH A PAINLESS BITE

The female *Anopheles* mosquito is the only insect capable of harboring the human malaria parasite *Plasmodium*. The mosquito's proboscis is made of highly specialized separate tools including cutting blades and a feeding tube powered by two tiny pumps.

She [anopheles female] drills through the epidermis, then through a thin layer of fat, then into the network of blood-filled micro-capillaries. She starts to drink. To inhibit the blood from coagulation, the mosquito oils the bit area with a spray of saliva. This is when it happens. Carried in the mosquito's salivary glands—and entering the body with the lubricating squirt—are minute, worm-like creatures. These are the one-celled malaria parasites, known as plasmodia. Fifty thousand of them could swim in a pool the size of the period at the end of this sentence.

Typically a couple of dozen slip into the bloodstream. But it takes just one. A single plasmodium is enough to kill a person. The parasites remain in the bloodstream for only a few minutes. They ride the flume of the circulatory system to the liver. There they stop. Each plasmodium burrows into a different liver cell. Almost certainly, the person who has been bitten hardly stirs from sleep. And for the next week or two, there's no overt sign that something in the body has just gone horribly wrong. (Finkel 2007, 40–41)

APPENDIX B: MOSQUITO BITES

Mosquitoes are most active at dawn or at dusk and that is the time when most people who are outdoors or in unprotected areas often get bitten by the hungry mosquitoes. Mosquitoes are attracted to the odor of human's skin and the carbon dioxide in human breath. If it is not for the protein-rich hemoglobin in our blood and the special odor of our skin, female mosquitoes might not even bother by biting us.

Mosquito bites are not only annoying, but they also have a high potential for transmitting serious diseases, such as West Nile virus, malaria and dengue fever. People may not feel or see any sign of being bitten by female mosquitoes simply because the signs and the symptoms of the bites may not show up for a few days depends on how sensitive a given person is to mosquito bites. The redness, swelling, and itching commonly noticed after a bite are actually caused by an allergic reaction. If such symptoms followed with fever, severe headache, body aches, nausea, vomiting, rash, sensitivity to light, and or neurological changes, etc., then, an individual must seek medical attention immediately.

While female mosquitoes are sucking blood, they deposit some of their saliva into the patients' skin. This type of saliva contains proteins called that remain in the victim's skin. In people who react to mosquito bites, special immune cells known as mast cells release histamine, a protein that causes itching and swelling. Although they itch, you should avoid scratching mosquito bites. According to Dr. Hema Sundaram, a dermatologist from Washington, D.C., when you scratch a mosquito bite, it stimulates your body to produce more histamine, causing even more itching (Deardorff, 2010, ¶. 2) Furthermore, scratching the mosquito bites causes skin injuries that often compromise the skin defense barrier. This could provide a golden opportunity for secondary bacterial infection to be caused with those bacteria that are naturally live on our skin and or in the environment.

APPENDIX C: PREVENTION OF MALARIA

While there is no way of preventing malaria that is 100 percent effective, prevention as well as protection techniques, tools, and treatments for malaria are evolving. Travel agencies, embassies, and medical agencies all provide up to date information about the best malaria protection for travelers and their citizens. According to the Health Central Network (2010) prevention should be based on:

- Evaluating the risk of exposure to infection;
- Preventing mosquito bites by using DEET mosquito repellent, bed nets, and clothing that covers most of the body; and
- Chemoprophylaxis (preventive medications).

The Health Central Network (2010) also lists questions to ask your doctor about malaria:

- Are preventive measures necessary for the region of the world I'll be visiting?
- Is this a high-risk area for malaria?
- What drugs can be taken as a preventive measure?
- What is the correct dosage?
- When should the drug be started and stopped?
- What other precautions should I take; repellents, clothes, nets?
- What symptoms should I look for?

APPENDIX D: CURRENT DRUGS USED TO TREAT MALARIA PATIENTS

Because malaria is a serious disease, a doctor should be consulted if patients are experiencing malaria symptoms such as a severe and pounding headache inside the skull, a high fever and chills. Malaria may be confirmed through a blood test and will likely be able to be confirmed through a noninvasive saliva test in the future (Wilson, Adjei, Anderson, Baidoo, and Stiles, 2008, 733). If the test is positive, medical personnel will determine the treatment plan most appropriate for infected individuals. Treatment is decided based on several factors including the geographical region in which the infected individual lives, the species of the parasite, different stages of the parasite's life cycle, the condition in which the infected person in, and sometimes, the age of the individuals.

Historically speaking, especially in sub-Saharan Africa, the classical treatment was quinine, which is really "nasty, bitter stuff that makes you urinate and makes your ears ring" (Postlethwait and Hopson, 2003, 277). Quinine remained the principle treatment worldwide until World War II, when researchers developed chloroquine and other synthetic substitutes. According to the Health Central Network (2010), today, the most prescribed drugs for treatment malaria patients include, "chloroquine, mefloquine, primaquine, quinine, pyrimethamine-sulfadoxine (Fansidar), doxycycline", artemisinin, to name a few. Unfortunately however, the deadly *Plasmodium falciparum* has already developed resistance to chloroquine (which is one of the most commonly used to treat it), and even it has started to develop resistance to the newer drug, artemisinin (Carmichael 2010b). People should be aware that there is no prophylactic regimen that gives complete protection against the disease. *Plasmodium* are constantly developing resistance to medications and additionally, they may produce more than one variation of the sticky protein at a time which makes infected red blood cells even stickier thus clumping together faster and tighter. This "keeps the cells from reaching the spleen, where the immune system would destroy, and gives the malaria parasite—*Plasmodium falciparum*—a safe haven inside the cells to replicate." (William 2010, 42)

APPENDIX E: STUDENT ACTIVITIES

This appendix contains other student activities on the theme of mosquitoes and malaria.

Activity: Malaria and HIV: Should We Really Be Concerned?

With malaria threatening half the world's population, and with *Plasmodium* developing resistance to almost every drug that was created

to fight it, Michael Finkel (2010, 41) seems to be right by claiming that “we live on a malarious planet.” Furthermore, in his book *A Short History of Nearly Everything*, Bill Bryson (2003, 312) writes:

[M]any grade-A diseases—malaria, yellow fever, dengue fever, encephalitis, and a hundred or so other less celebrated but often rapacious maladies—begin with a mosquito bite. It is a fortunate fluke for us that HIV, the AIDS agent, isn’t among them—at least not yet. Any HIV the mosquito sucks up on its travels is dissolved by the mosquito’s own metabolism. When the day comes that the virus mutates its way around this, we may be in real trouble.

Conduct an Internet research to find out why Bill Bryson is very concerned about the possibility of the HIV virus mutating its way around the mosquito’s own metabolism. Is there a relationship between what Bryson is talking about and what Finkel claims?

Activity: Sickle Cell Anemia, Thalassaemia, and Malaria

Conduct a literature search on sickle cell anemia and thalassaemia to find out:

1. What type of diseases are these?
2. How are they similar and how do they differ?
3. Why do these diseases occur in some places and not others?
4. Where are these two diseases most common?
5. What is (are) the common treatment(s) for both of them?
6. What is the relationship between these two diseases and malaria?

Activity: Planned Eradication of Species to Prevent Diseases

Out of 3,500 known species of mosquitoes worldwide, only about 30 species cause serious diseases to humans. These diseases include malaria, which is spread by *Anopheles* mosquitoes and dengue fever, yellow fever, and elephantiasis which are spread by *Aedes* mosquitoes. Recently, a number of scientists have been advocating the idea of eradicating mosquitoes that cause serious diseases to human would not lead to serious consequences in any ecosystem. Indeed, not only it would save the lives of millions of people, but also, for example, more than \$12 billion in lost growth every year in African countries and hundreds of millions of dollars spent every year on mosquito control in the United States. Because of this, those scientists are supporting planned extinction of those species that have causing serious diseases. Indeed, this type of thought and techniques are not a new.

Humans have aggressively worked toward the extinction of many species of viruses and bacteria in the cause of disease eradication. For example, the smallpox virus is now extinct in the wild—although samples are retained in laboratory settings, and the polio virus is now confined to small parts of the world as a result of human efforts to prevent the disease it causes (Wikipedia 2010)

In her article, “A Bug’s Death”, Olivia Judson has advocated the idea of “specicide,” the planned extinction of an entire species that causes serious diseases. Even though it has never been tried before, Judson’s idea is a simple and straightforward concept.

Specicide . . . could be engineered by exploiting the biology of selfish genetic elements . . . which contribute nothing to the well-being of their hosts, but simply proliferate themselves. . . . As a

result, a selfish genetic element can spread through a population extremely fast—far faster than a regular gene—even if it is harmful to its host. . . . [Therefore] to engineer extinction, devise an extinction gene—a selfish genetic element that has a strongly detrimental effect. The element could, for example, be designed to put itself into the middle of an essential gene and thereby render it useless, creating what geneticists call a “knockout.” If the knockout is recessive (with one copy of it you’re alive and well, but with two you’re dead), it could spread through, and then extinguish, a species in fewer than twenty generations. (Judson 2003, 2-3)

Given the fact that species become extinct “all the time” and anti-malarial and mosquito control programs all over the world offer little realistic hope to the 300 million people in developing nations who will be infected with acute illnesses every year, this does not seem to be a bad idea. While Judson couldn’t predict the possible risks including ecological collapse and genetic escape, she believes that the proposed extinction technology “could eradicate the malaria mosquito, and malaria with it, within 10 years of the time mosquitoes modified to carry an extinction gene are released into the wild” (Judson 2003, 6). She adds, “Ideally, malaria would be defeated in other ways. Uganda has recently reported a 50 percent drop in death rates as a result of handing out free malaria medicines; if the program can be emulated and the trend sustained, perhaps by the time the technology is ready, it will no longer be needed. But if, by then, the situation is not much improved, we should consider the ultimate swatting.” (Judson 2003, 13)

1. After reading Judson’s article, compare the ecological collapse and the genetic escape as possible risks for planned extinction of misquotes that cause deadly illness to humans.
2. Do you agree with the idea of planned extinction of a species to prevent serious diseases?
3. If you were to write a letter to Olivia Judson what would you write and why?
4. Compare and contrast genetic modification (engineering) as a tool of creation and as a tool of extinction.
5. If you have to select one over the other in supporting biological diversity, environmental sustainability, and better life and living for human societies, which one of the two mechanisms in question 3 would you select? Explain.

Activity: Controlling the Mosquitoes:

Conduct research on mosquito’s control to find out answers to the following questions.

1. What are some common strategies for controlling mosquitoes?
2. What compounds or chemicals are commonly used for controlling mosquitoes?
3. How effective are they and what are some concerns about them?
4. What research is being conducted in mosquito control in terms of pesticides and application methods?

Discussion Questions

1. Why do scientists still have a hard time developing an effective vaccine against malaria?

2. Although all four species of *Plasmodium* can be deadly, why is *P. falciparum* particularly dangerous and more likely to be fatal than the others?
3. During which of these phases of the life cycle of *Plasmodium* (exoerythrocytic, erythrocyte, and sporogonic) can malaria be diagnosed from a human blood sample?
4. In your research, did you encounter other methods for diagnosing the presence of the parasite *Plasmodium* in human and or mosquitoes?
5. During mosquito seasons, many people get bitten and develop red bumps on their skin. Conduct literature research to find out and then come to class ready to discuss:
 - a. Why do some people develop red bumps from mosquito bites and some others don't?
 - b. Why do doctors advise us not to scratch mosquito bites?
 - c. What will happen when you scratch the red bumps from mosquito bites? What are the consequences of this?
 - d. What is the best way to avoid scratching your red bumps from mosquito bites?
 - e. What do mosquito bites make the body skin cells do to produce the red bumps on the skin?
 - f. What chemical(s) is(are) used in heart conditions that is similar to mosquito secretions?
6. What may happen if the bacteria that naturally occur on various areas of our body such as the skin or intestines gain entry into another area of the body? For example, what can happen if bacteria that normally live on the skin gain entrance to the bloodstream through a cut?
7. Since 1994 the Bill & Melinda Gates Foundation has been working to find ways to prevent and treat malaria. What techniques are they using in their fight to eradicate this disease?
8. What are the three most promising vaccine strategies to fight malaria? Explain how they work.
9. Given the fact that million people die every year from malaria worldwide, can you envision ways to speed up the distribution of an effective vaccine once one is found?
10. Discuss the public health importance of mosquitoes from nuisance to disease.
11. Discuss how geography and poverty are influence factors in the distribution of malaria.

Homework Assignment

To reinforce the learning objectives of the activity, ask students to answer the following questions, either individually or in groups (give them a time limit, such as 10 minutes or until the next class meeting).

1. Reflect on the final decision made by the members of the debate committee. Do you agree with it? Why or why not?
2. What have you learned from the activity, academically and personally?
3. If you had to do this all over again, what would you change, discard, or add? Why?
4. What advice would you give to public officials after your role playing experiences? (Freiberg and Driscoll, 2001, 347)
5. Evaluate the strengths of each presentation including your own group's and comment on the effect the arguments of others had on your consideration of the issue.

6. Did you initially agree or disagree with the point you were arguing for or against? Did your perspective change over the course of the activity?

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