Global Health has No Borders: Case Investigations in Biology and Global Health

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The International Union of Biological Sciences has a long history of addressing difficult biological problems and tackling complex global issues. A recent challenge issued by the United Nations in its Millennium Report (2000) identified its eight highest goals (see left image) that it hoped could be achieved by 2015. As this deadline approaches, it is frightening how much still needs to be accomplished. Thus, we commissioned a group of educators who have been addressing many of the Millennium Goals such as reducing child mortality, improving maternal health, combating infectious diseases such as AIDS and malaria, and eradicating hunger. The authors of this issue of Biology International, “Global Health has No Borders,” share their set of interactive, quantitative, and exploratory activities that educators can adopt, adapt, and implement in order to engage their students in these crucial issues. Biology International is an open-access, Creative Commons journal; in other words, all of these educational materials are globally available for repurposing for local use with simple attribution. We hope that readers find them useful in addressing these crucial issues.

Global Health Issues, Lorna Holtman, University of the Western Cape, S. Africa 3
Introduction, Spencer Benson, University of Maryland 5

Marion Field Fass, Julie A. Seiter, Ethel D. Stanley, Margaret A. Waterman

<table>
<thead>
<tr>
<th>Topic</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Global Health: No Easy Answers</td>
<td>7</td>
</tr>
<tr>
<td>Global Health is Local Health: Looking at the Big Picture</td>
<td>9</td>
</tr>
<tr>
<td>Healthy Mothers and Healthy Babies in the New Millennium: the Basis of Global Health</td>
<td>17</td>
</tr>
<tr>
<td>Nutrition, Good Health and Global Health</td>
<td>27</td>
</tr>
<tr>
<td>Controlling Infectious Diseases: Learning from Failures, Building Success</td>
<td>44</td>
</tr>
<tr>
<td>The Challenges of Mosquitoes and Disease: Making Sense of Complexity</td>
<td>59</td>
</tr>
<tr>
<td>HIV/AIDS: Barriers and Opportunities for Control</td>
<td>73</td>
</tr>
<tr>
<td>HIV/AIDS: Biology and Treatment</td>
<td>86</td>
</tr>
<tr>
<td>Author Biographies</td>
<td>97</td>
</tr>
</tbody>
</table>

Peroration, Susan Assinder, Liverpool School of Tropical Medicine, UK 99
Global Health Issues
Lorna Holtman, University of the Western Cape, South Africa

Introduction:

In this issue of Biology International, a big picture of global health is presented. Articles discuss topical issues related to maternal health, motherhood, and infectious diseases such as AIDS and cholera. They are presented as case studies.

Global health issues are important for teachers worldwide because, apart from providing an overview of global health trends, they stress the common health problems affecting the human race, whilst also highlighting geographically significant localized problems. Case studies also help to identify environmental and life style related solutions to global health issues. Students will therefore gain better understanding of the interrelatedness of human health needs, with environmental and life style issues.

Case studies that provide online quantitative data also facilitate quantitative reasoning. Online data analysis helps students to appreciate global trends in areas that would otherwise be difficult to access or predict. For example, climate change makes sense when observed over a period of time and over great geographical distances: South Africa’s changing climate can best be understood for example in terms of the changing variations in the ocean currents, water (and therefore air temperatures), and the temporal period of these changes. South Africans can also learn from climate change experiences in other parts of the world, namely Southeast Asia, the Artic, and South America.

Sharing global stories help to instill in our youth, the interrelatedness of the earth’s ecosystems, the need to partake in global conservation efforts, and also the oneness of the human race. Through global case studies, our students learn to appreciate the challenges that societies are facing in sharing the planet we call our home. Most importantly, the students learn to appreciate the fact that our actions in one part of the world can affect the livelihood and health of others several thousand kilometres away. Students begin to appreciate and understand our collective responsibility to “think globally, but act locally” to solve the problems and challenges currently facing our shared planet.

The cases on infectious diseases demonstrate that some diseases can be controlled but not eliminated while others can only be controlled. These case studies expose how political, social and religious issues can impact on disease control and eradication. When students look at the “Global Health is Local Health” case study, they can compare their community with the whole of the United States of America and realise it is not only community resources and local environment that have an impact on local health, but that individual behaviour is also very important. Students must be aware of disease control principles. Much of disease control rests on the education of the population about disease transmission. The provision of clean drinking water and proper sanitation form the other crucial components of disease control.
The “Healthy Mothers and Healthy Babies in the New Millennium” case study puts local pregnancy practices and their impact on maternal and infant health into perspective. Students are required to give simple ways of preventing complications in childbirth.

In the case study “Nutrition, Good Health and Global Health” students are faced with how food choices affect health and made aware of how abundance of food and food insecurity can exist in the same city. Nutrition problems in the Developed World and in the Developing World are addressed.

Sharing global stories shows us that many of the problems we face are faced in other parts of the world and stories may also offer some solutions to the problems. We need to know that our actions could affect people we do not even know in completely different parts of the world.

Lorna Holtman is a South African who lives in Cape Town, South Africa. She is currently the Director of Postgraduate Studies at the University of the Western Cape South Africa. She completed her PhD at Louisiana State University, Baton Rouge, LA in 2000. Her PhD thesis examined the importance of the biology laboratory in facilitating conceptual change. Lorna is the current chairperson of the South African National Committee chairperson of the International Union of Biological Sciences (IUBS), an Executive Member of IUBS, Vice President of the Commission on Biology Education (CBE) and Africa representative. She is also the Associate Editor of Biology International.
As educators we are always in search of resources that we can adopt, adapt and build upon to meet educational needs within our courses and institutions. This special International Union of Biological Sciences (IUBS) issue “Global Health has No Borders” provides a valuable resource for faculty everywhere. It provides a wealth of resources, pedagogies, ideas and stories that faculty can immediately use to enhance student understanding of basic principles in biology, application of mathematics, and the development of essential life long learning skills that can be applied to many subjects. The seven global health articles provide a robust set of learning activities that can be used to foster learning in microbiology, health, geography, population, disease, epidemiology, etc.; every citizen should know this basic information. The pedagogies challenge students to learn by doing and, in doing so, develop an appreciation of scale (how big is a billion, when does an epidemic become a pandemic, how much food is needed to feed a population), and to think about health problems through both local and global lenses. The importance of students broadening their perspectives and thinking beyond their local environment, as they begin their journey to become aware informed global citizens, is paramount for their success in the world in which they will work, develop, and grow old. Today’s students have always existed in a world connected by rapid travel, near instantaneous news and communication, quick access to vast libraries of information, and powerful technologies that enable them to see, hear and capture the world around them. They access information and seek answers to questions by a few clicks on powerful personal electronic devices. These articles capitalize on such resources to help students develop and answer questions.

Both in the US and elsewhere, higher education is increasingly demanding that curricula engage global issues either through general education and/or the major. In today’s world, global issues and events that involve energy, food security, and health and that occur half a world away often affect local economies, health, and access to resources. Global health issues provide a fertile and robust environment in which students can learn essential content, construct new knowledge, and develop observational, analytical, quantitative, and communication skills. We truly live in a world where unseen microbes move rapidly and irreversibly across borders into new populations. Understanding the relationship between microbes and health is important for personal as well as societal health. As teachers we have a moral obligation to provide students with educational content and experiences that are relevant, engaging, foster life-long learning, go beyond the traditional dissemination of content, and can be easily accessed via modern technologies. These global health articles provide numerous student engagement activities that can be adapted to a wide variety of courses for both majors and non-majors and address the need for students to develop global health awareness and competence. Biology has emerged as the science of the 21st century and increasingly quantitative approaches are required to understand and solve important biological problems.
Numerous US science committee reports on educational needs in the sciences stress the need to integrate mathematics and quantitative reasoning throughout the biological sciences. Global health by its very nature deals with numbers, probabilities, quantitative relationships, elements of scale and the applications of modeling and mathematics are needed to describe, analyze and predict many aspects of human health consequences. This issue of Biology International provides many examples and exercises that can be used to build student understanding of the roles of mathematics in the biological sciences and help students develop an appreciation of the central place mathematics plays in biological sciences. Through the use of free interactive programs such as WorldMapper and GapMinder, students are encouraged to explore relationships, pose problems, make predictions, and develop a working sense of scale that can be transformational in their learning processes. In addition, the articles provide an abundance of engaging student activities that will help students learn how to access, evaluate, and present complex information on local, regional and global health issues.

There are many different approaches by which individuals teach and learn. Narratives/stories are the oldest forms of teaching through which the learner obtains and builds new knowledge. The sharing of stories is the first step in building relationships and community. Stories and cases help facilitate awareness of global health issues. For students who have never traveled beyond their town, state or country, stories provide a context for imagining and seeing the new areas of the world and can have the transformational effect of awakening a desire to experience foreign lands. A central theme among the seven articles is the use of stories to convey information, pose problems, and contextualize learning activities. These articles provide adaptable scaffolding that teachers can use to help students broaden their horizons beyond simple memorization of content.

I encourage you to read the articles, find things that you can use in your courses, and be creative. The articles provide many activities that can be used as they are or adapted to the needs of your courses.

Dr. Spencer Benson is the director of the Center for Teaching Excellence, an associate professor in the Department of Cell Biology and Molecular Genetics, and an affiliate professor in the Department of Curriculum and Instruction at the University of Maryland. In 2008-2009 he was a Fulbright Fellow in Hong Kong working on General Education implementation for the eight public Hong Kong Universities.
This issue of Biology International, “Global Health has No Borders”, is designed as an online textbook of student educational materials. These active learning experiences can complement courses in introductory biology or can structure courses in global health. There are not easy answers to most of the activities presented here; they use real-life data to address complex contemporary problems. As we worked together on this project, we learned to embrace the complexity and search for the data, reports, and online graphing and mapping tools that professionals use as they plan projects to improve health. We moved from teaching about global health to teaching about how to navigate the resources available, how to think critically about the problems and their solutions, and how to present information and ideas clearly and persuasively.

Courses on Global Health are becoming more common in undergraduate education in the United States in order to address global awareness, critical thinking and problem solving. The Association of American Colleges and Universities (AAC&U) in collaboration with the Association for Prevention Teaching and Research (APTR), the Council of Colleges of Arts and Sciences (CCAS), and the Association of Schools of Public Health, have promoted the Educated Citizen and Public Health initiative <http://www.aacu.org/public_health/index.cfm>. A course in Global Health is one of the three courses suggested as part of the education of all undergraduates.

“Global Health has No Borders” builds upon two important innovative projects in science education, the BioQUEST Curriculum Consortium and SENCER, Science Education for New Civic Engagements and Responsibilities. Both the BioQUEST Curriculum Consortium <http://bioquest.org> and the SENCER project <http://www.sencer.net> advocate for the need to involve students actively in their learning, through work with real world problems and authentic data. By focusing on the big questions in global health, we have created the connections that draw students in as scientists and as engaged citizens. The activities in these chapters use the data, interactive maps and graphing tools that professionals in the field use to define the problems of interest. The questions we explore are real questions that do not yet have answers. We have incorporated ideas and activities from participants at the BioQUEST Summer Workshop in 2009, and from collaborators at the SENCER Summer Institutes, from 2001 through 2009.

We hope that readers will adapt these materials to fit their needs, as part of traditional biology classes to engage students in the pressing issues of biology and health, or as the backbone of a course in global health. Please modify them to fit local situations and emerging problems. These are exciting topics for students, because they enable them to see the relevance of their studies to the big issues of our times.

We’ve struggled to find great resources, and to update them. Global data are revised, new reports released, and new diseases eradicated. As we went to press in spring 2011,
we learned of the eradication of rinderpest, a viral disease that affects cattle. We changed the chapter on disease control to reflect this. The US Department of Agriculture introduced the Food Plate to replace the Food Pyramid. We added that too. We’re certain the more changes will follow, and we hope that the users of these materials will take advantages of the changes to create learning opportunities in discussing how scientific knowledge changes and how scientists and policy makers communicate about these changes. Teaching about global health is a moving target, and that makes it fun to teach.

The activities in the articles in “Global Health has No Borders” have all been used in undergraduate classrooms, in introductory biology, microbiology and general education classes in global health. In fall 2010 Professors Julie Seiter and Marion Fass both taught Global Health courses, and together refined many of the activities in these chapters. Our teaching environments are different; Professor Seiter teaches at a 2-year, open enrollment community college, while Professor Fass teaches at a small, selective liberal arts college. Although our students were different, our concerns were similar.

As we taught our courses in Global Health, we learned from our students that they valued the activities in these chapters. One student commented, “As a non-science person it was a great course to spark interest in science/health issues and to learn skills like using maps, charts, etc. I had never gotten before, and was relatable to practically all majors.” We hope that your students will appreciate these opportunities.

We have many people to thank for their help on this project. Thanks first to Editor John R. Jungck who believed in this project and facilitated its production as an issue of Biology International. David Burns, Principal Investigator of SENCER, encouraged this project with his commitment to science education that engages, and his deep connection to issues of global health. Professor Spencer Benson’s enthusiasm for the activities on quantitative reasoning prodded us to finish when barriers seemed too great. Many students contributed to this, through their experiences and their comments. Shanna Dell, then a student at Beloit College, edited a first draft of these chapters and checked the many references. Emily Seiter, a graduate student in public health, kept us thinking about social justice when we became too biological. Sue Risseeuw, Managing Editor of Biology International, did the challenging job of laying out these chapters, and Jourdan Posner completed the final check of weblinks.
Global Health is Local Health: Looking at the Big Picture

Marion Fass, Julie Seiter, Ethel Stanley, and Margaret Waterman

Learning objectives:
- Define global health.
- Identify influence of social determinants of health on health outcomes.
- Use online data sources to pose problems and test hypotheses.
- Map a local health environment.
- Compare and contrast local and national health outcomes.
- Compare and contrast factors that contribute to health and health outcomes in countries in different regions of the world.

Introduction

What is good health? What are the factors that make an individual healthy or sick? How many of these are individual factors, and how many are shaped by the environment? What is a healthy community, a healthy country?

We can think of health as a characteristic of individuals, or we can think of health as a characteristic of communities. We are accustomed to thinking about the health of individuals, and we often hear about the things we should do to “be healthy” - from eating five servings of fruits and vegetables each day, to exercising, getting enough sleep, and not smoking.

While the same things are important determinants of the health of communities, other environmental and social factors contribute significantly to healthy communities. Much has been written recently about health as a human right, and although each individual cannot be guaranteed good health, societies can be held responsible for providing individuals with access to the resources for good health (Mann, 1999). These resources include factors related to food availability, access to clean water, gender equity, sanitation, and the education of children.

Recently a group of global health experts offered a definition that frames the scope of this issue of Biology International:

“Global health is an area for study, research, and practice that places a priority on improving health and achieving equity in health for all people worldwide. Global health emphasizes transnational health issues, determinants, and solutions; involves many disciplines within and beyond the health sciences and promotes interdisciplinary collaboration; and is a synthesis of population-based prevention with individual-level clinical care” (Koplan, et al., 2009).

We are approaching the study of global health with stories, statistics, science, systems, service and civic engagement, and synthesis and reflection. Stories explore problems as they affect individuals. Statistics, the basic tool of public health,
enable us to see patterns in the occurrence or disease. Science validates the connections between the stories and the statistics. We ask if there are biological mechanisms that underlie our findings or if there are treatments that work. We explore systems such as ecosystems, political systems, financial systems and biological systems that connect across many levels of analysis.

Public health and global health are activist disciplines that put a priority on improving health. College students have the potential to contribute to improving community health in their own communities by volunteering, collecting and communicating data, and, in larger communities, by advocating for policy changes, identifying areas where improvement is possible, and even raising funds for non-governmental organizations.

Synthesis and reflection are the greatest challenges. We live in an increasingly connected world where the problems are complex and multidisciplinary. Most of the biological conditions are exacerbated by poverty, by social disparities, and by policies and practices that discriminate against one group of people. By exploring the nature of these issues- the biology, the culture and the policy- we learn more about the world and about ourselves.

Many of the tools that we will use in this special issue are available on the internet. The internet has had a profound impact on the practice of global health. The ability to communicate about outbreaks of infectious diseases has improved dramatically since the 1994 founding of the Program for Monitoring Infectious Diseases (International Society for Infectious Diseases, 2009). It is now possible to coordinate information about outbreaks in every part of the world, to follow the spread of an epidemic, and to institute in-time prevention. The ability to easily communicate globally has led to increased efforts to share scientific and public health research. The World Health Organization (WHO) and all of the affiliated United Nations (UN) organizations provide data and policy reports online (WHO, 2008).

Global health initiatives in the past decade have focused attention on social disparities in health. This work explores the health gap between rich countries and poor countries, and between rich and poor individuals in any one country. It looks at who is marginalized and/or unable to access information and services as needed. The Bill and Melinda Gates Foundation, the UN Millennium Development Goals, and the WHO Report on the Social Determinants of Health, “Closing the Gap in a Generation,” among other initiatives, have identified the need to achieve equity and protect health through a focus on poverty alleviation, gender equity, and human rights. We have attempted to include these issues as we explore some of the health problems of importance in the world today. We recognize that each chapter in this special issue of Biology International could be a book in itself; thus, we have worked to find investigative questions that lead to further questions as you use the reports and data sets provided by the global health community.

Figure 1. Contrast between the Germ Theory and Epidemiological Models of Disease
**The Models of Health and Disease**

The scientific understanding of health and disease has expanded from the 19th century germ-theory of disease to a more complex epidemiological model (Figure 1). More recently, public health studies have embraced a comprehensive ecosystem perspective.

Epidemiology is the study of the distribution of diseases in populations. An epidemiological model investigates disease distribution by studying the characteristics of the agent of disease, the host that it affects, and the environment in which this happens. For example, if we think about the disease malaria, caused by the agent, *Plasmodium falciparum*, it is a more dangerous disease for a young child or pregnant woman than for other human hosts. The environment is critical, too, because malaria only occurs where there are *Anopheles* mosquitoes, and, therefore, temperature, rainfall, and mosquito control strategies determine whether someone will be exposed to the mosquitoes that carry the *Plasmodium* parasite.

Lung cancer due to smoking provides another example of the effects of the environment, because the agent, the cigarette, causes disease in both the host who smokes it and the host who is exposed to second hand smoke. Exposure to smoke is more likely to happen where policies that limit smoking in public places do not exist or are not enforced, and where there is advertising that promotes smoking for teenagers.

This epidemiological model of disease begins to address the importance of environment, while an ecosystem perspective on health and disease recognizes the interdependence of humans and the environment, and acknowledges the important impact that ecosystem services (Figure 2) have on health. It provides a linkage between ecosystem services and many of the factors that are essential for achieving the human right to health. It shifts responsibility for disease from the agent of disease to actions that change the environment in which the agent is just another resident. Environmental policies directly affect human health and how the human right to health is achieved.

### Health and disease cannot be separated from the environments in which we live.

The ecosystem model begins to highlight the reasons why people in poor countries are more vulnerable to disease than those in rich ones. When ecosystem services fail, thereby making food, water or fuel unavailable, it is the people with the fewest resources who experience the greatest health impacts. Whether natural disasters such as drought or flooding due to climate change, earthquakes, fires, blizzards, tsunamis, hurricanes, tornados, or other natural disasters are the cause, families without financial resources cannot easily relocate and cannot access health services they need.

![Figure 2. Ecosystem Services](image-url)
Investigation 1: Building a model for global health
The WHO Commission on Social Determinants of Health report, *Closing the gap in a generation* (2008), focuses broadly on the issues that create a healthy living environment, access to care, and assessment tools to monitor progress. They use “success stories” to support their argument for programs that address poverty and inequality and help build the foundation for good health. The programs aren’t always what we consider medical strategies, but rather focus on conditions important for prevention of poor health.

Questions for Investigation 1:
Read the case stories in *Closing the gap in a generation* (2008). These stories from around the world give examples of positive actions that can be taken.

1. Generate a list of 4-5 different strategies that are used in these stories to improve health by improving housing, awareness, workers’ rights, early education or other approaches. For each, identify the desired health outcome.

Resources for this investigation:

Health at the Local Level
Good health begins by understanding our own community. Public health officials gather data about life expectancy, about the number of babies who die before their first birthday (infant mortality), and children who die before the age of five (child mortality). They work to assure environmental health standards by inspecting restaurants and groceries, by measuring the risks of lead poisoning, and by testing water quality. At a community level, characteristics of the built environment shape health. A healthy community has safe streets, sidewalks, and places that adults and children can exercise.

The community health approach, in contrast to the biomedical approach, asks if communities have the resources for a healthy lifestyle, as well as the medical services to treat those who are sick. Poor health is the result of community resources and environment as well as individual behavior, genetics, and bad luck.

To understand what determines health, we need to integrate information from many levels: from the molecular and genetic level, to the physiological level, and to the community and the ecosystem level.

Investigation 2: How do we measure the health of community?
Environment matters to health. In the US, people who live in rich communities are less likely to have heart attacks than people who live in poor communities. Even rich people who live in poor communities have greater risks than if they lived in a more well-to-do community (Diez-Roux, 2001).

Why is this? How can our environment impact our health? Perhaps it is availability of resources, like good food and places to exercise. Or it could be the experience of stress. The documentary series, *Unnatural Causes: Is Inequality Making Us Sick?* (2008) identifies some environmental factors that influence health. A video clip from *Unnatural Causes, Living in Disadvantaged Neighborhoods is Bad for Your Health*, provides an overview of the relationship between neighborhood and health (California Newsreel, 2007).

Explore your state, province, or other regional department of health website to see
what local health data is available. Some regions of the world have good data available to the public, but others may not. If data are not available for your local area, you can consult data on health in Wisconsin (University of Wisconsin Population Health Institute, n.d.), Georgia (Georgia Department of Community Health, n.d.), or California (California Department of Public Health, 2007).

The US Department of Agriculture has also assembled data in a map format in the Food Environment Atlas. These provide comparative data at <http://maps.ers.usda.gov/FoodAtlas/>.

**Questions for Investigation 2:**
1. Fill out Table I below to compare how where you live compares with other areas of your local region.

<table>
<thead>
<tr>
<th>Table I. Health indicators as a function of geographic/political region.</th>
</tr>
</thead>
<tbody>
<tr>
<td>My city/county/region</td>
</tr>
<tr>
<td>-----------------------</td>
</tr>
<tr>
<td>Infant Mortality Rates</td>
</tr>
<tr>
<td>Teen Pregnancy rates</td>
</tr>
<tr>
<td>Obesity rates</td>
</tr>
<tr>
<td>Disability rates</td>
</tr>
<tr>
<td>Life expectancy</td>
</tr>
<tr>
<td>% without health insurance</td>
</tr>
<tr>
<td>% who didn’t visit a dentist</td>
</tr>
<tr>
<td>% children with positive tests for lead poisoning</td>
</tr>
<tr>
<td>Other</td>
</tr>
</tbody>
</table>

2. How does your city/county compare with regional or national data?

3. What questions could you ask to learn more about the differences between where you live and other locales?

**Resources for this investigation:**


**Investigation 3: Communities differ in terms of access to good food, to places to exercise, or to good air to breathe.**

**Questions for Investigation 3:**
1. Take a public health trip through your community. Using Google Maps <http://maps.google.com/maps?hl=en&tab=w>, or a paper map, make a health resources map that notes some of these factors:
   - Elementary schools
   - Fast food restaurants
   - Liquor stores
   - Major traffic routes
   - Factories that may pollute air or water
   - Pedestrian access- are there sidewalks, is there public transportation?
   - Parks and gyms for exercise
2. Compare neighborhoods in your city, or, if you are in a small city, contrast different small cities. What makes a healthy place to live? How does your map help you see community resources for health?

**Investigation 4: Developing country level perspectives**

The United Nations, the World Health Organization, and other organizations collect extensive data about indicators of health and development. Table II lists some of the many data sets available from the United Nations Children’s Fund (UNICEF) and USAID Measure DHS project. These are easily accessible to anyone with a computer. Throughout this book we will use these statistics to provide a framework for analyzing global health problems (Table II).

**Questions for Investigation 4:**

1. Different measures give you different perspectives on health and safety in a country or region. Consider infant mortality rates, less than 5 years of age mortality rates, and life expectancy. While all measure similar things, they differ in some important aspects. Of these three, choose one measure and discuss what information it gives you about the country/region’s level of health.

2. Use the data on 195 countries collected by UNICEF to build your own data tables at the UNICEF statistics site or at <www.measuredhs.com>. Choose 10 countries from around the world and pick three health parameters to compare. Study your table and describe the similarities and differences that you see between countries.

3. You can also use the Gapminder program <http://www.gapminder.org/>, to look at health-related variables. Gapminder permits you to choose variables for the x and y axes. The data point for each country is sized to represent the population size of the country. You can run your mouse over the point and see the country’s name. The countries are color-coded by continent. In addition, there is an animation feature that allows you to see how the data has changed over a period of years. This is helpful to gauge the impact of development. Watch the tutorial to learn how to use this software.

| Table II. Factors to consider in developing indicators of health for an individual country. |
|----------------------------------|----------------------------------|
| Infant mortality                | Adult literacy rate; females as a % of males |
| Children under 5 mortality      | Contraceptive prevalence         |
| Life expectancy at birth        | % population with safe water      |
| Life expectancy; females as a % of males | % population with improved sanitation |
| % children breastfed            | % population fully immunized     |
| % children under 5 years of age | Gross National Product, GNP      |
| Primary school enrollment       |                                  |

Global Health is Local Health
Use Gapminder to develop three graphs that illustrate the relationship between the health outcome that you have chosen and a measure of population such as GNP, literacy rate, availability of safe water, etc. Sometimes measures correlate in a way that you expect, but sometimes they do not.

Write a short essay that describes each graph that you have created, explain what you infer from your data curves about the parameters that you chose. Explore the reasons why the results for some countries surprised you.

**Resources for this investigation:**


**Extended Activities**

**Investigation E-1 Semester long investigation: becoming an expert**
From your analyses using Gapminder or UNICEF data, choose one country that you want to learn more about. It may be a country that fits with all of your hypotheses about the determinants of health, or it may be one that never is where it “should” be, because of HIV, or conflict or disaster, or some other reason. This will be the country that you follow throughout the activities of this semester learning about Human Biology and Global Health.

As a class, make sure that your choices represent a variety of countries from many parts of the world.

Data are available on the internet from UNICEF, FAO, WHO, the US CIA and many other sources that enable us to probe deeper, to ask more complex questions and to explore associations. NGOs document their work in many areas.

Keep a journal throughout the semester, noting where your country stands, how it compares to others, and the particular problems it faces and successes it has achieved.

**References:**


Healthy Mothers and Healthy Babies in the New Millennium:  
the Basis of Global Health

Marion Fass, Julie Seiter, Ethel Stanley, and Margaret Waterman

Learning objectives:
Identify recommendations for healthy pregnancy in the U.S.
Explain risks for adverse outcomes of pregnancy.
Analyze demographic trends, using Gapminder, for factors that correlate with falling infant mortality rates.
Compare and contrast rates of infant mortality and maternal mortality in different regions of the world.
Evaluate the role of a human rights approach in improving maternal and child health.

Introduction
Human birth is a biological event, but takes place in a social context. The family, the community, and even the state and its policies all influence the health of mothers and babies. In this chapter we will look at some of the biological challenges of pregnancy and childbirth, compare and contrast the experiences of women in different cultures, and review challenges in reducing maternal mortality, the complications of childbirth and infant mortality. Our explorations will take us from individual physiology to international statistics. The international context for our investigations will come from the UNICEF publication, *The State of the World’s Children*, (2009) <http://www.unicef.org/sowc09/index.php>, which focuses on Maternal and Newborn Health.

Investigation 1: Contrasting pregnancy practices
Several years ago an undergraduate student studying abroad in Tanzania interviewed a group of Maasai women who lived in a village that was an 8-hour walk from a small hospital. (Neils, 2008) The student, who planned to become a doctor, was interested in what these women did during pregnancy to stay healthy and to deliver their babies safely. She was astonished when they told her that they reduced their food intake during the last three months of their pregnancies. She hypothesized that this cultural practice led to smaller, more easily delivered babies (Neils, 2008). For more information about Maasai culture go to the reference listed below.

Questions for Investigation 1: Contrasting pregnancy practices
1. How does this practice compare to the recommendations for weight gain for pregnant women in the United States. The Mayo Clinic and other medical centers provide good resources for pregnant women and their partners.

2. While this student research revealed the practices of these women during pregnancy, it didn’t provide information on the health of the mothers or babies after birth. We don’t know the birth
weight of the babies or the health of the mothers in between pregnancies. What risks might there be to the practice of these Maasai women? What are the rates of infant mortality and maternal mortality in Tanzania? How do they compare to those in the US?

3. What are the common causes of maternal mortality? Of infant mortality? The US Agency for International Development, USAID, is one source for information to answer these questions.

**Resources for these activities:**


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**Investigation 2: Injuries while giving birth**

Stories of the injuries suffered during childbirth by women in regions of the world where there is little access to medical and emergency care during delivery shock those of us in countries where complications of childbirth are rare. Researchers report that for each woman who dies in childbirth in areas that lack trained birth attendants and emergency care, 30 suffer disabling injuries.

Three types of injury happen to women: (1) who have very long labors, (2) who are delivering babies in breech position or (3) who are carrying babies that are too big to pass through their pelvises. Holes, called fistula, may develop between their rectum or bladder and their vagina. Because of these holes, they constantly leak urine and/or feces. Most pictures and diagrams don't show the impact of pregnancy on surrounding organs. Look at Figure 1 to review female reproductive anatomy.
**Questions for Investigation 2: Injuries while giving birth**

1. Search for images of obstetric fistulas and label Figure 1 to show where they can occur.

2. Stories of women from rural Uganda who have suffered obstetrical fistulas were recorded at a workshop coordinated by Engender Health. Listen to the stories from three Ugandan women on this website.
   a. What do they have in common?
   b. What kinds of steps could be made available to prevent the complications they have experienced?

**Resources for investigation:**

**Investigation 3: When do infant mortality rates fall?**

The risk of death for both mothers and for newborn infants has declined dramatically in the last 200 years in many parts of the world, including the United States. Women in some countries have not fully benefitted from advances in public health and medicine that reduce these rates; however, maternal mortality and infant mortality remain common. In some areas of the United States women and infants still face unacceptably high risks.

The **infant mortality rate** is calculated as the number of deaths in the first year of life for every 1000 live births. The **maternal mortality rate** is calculated as the number of deaths of women from pregnancy-related causes per 100,000 live births.

The differences in infant mortality around the world highlight the challenges of global health. While infant mortality in the United States is just 6.26 per 1000 live births, the rate in Kenya is 54.7 deaths per 1000 live births and the rate in Pakistan is 65.14 per 1000 live births. Fifteen countries have less than 4 infant deaths per 1000 live births. Within a single country infant mortality can vary widely depending on the health of the mother, the environment and access to health care (CIA, 2009.)

In the developing world, the death of women in childbirth is still a major problem. The major causes of maternal death are extreme blood loss, infection, unsafe abortion, eclampsia (seizures in pregnant women) and obstructed labor. All of these are avoidable when trained birth attendants are available, and when emergency services are accessible for the women.

We can compare how these rates have changed in different countries using data and analysis tools available at the [Gapminder website](http://www.gapminder.org), Gapminder focuses on helping people understand information about social, economic and environmental development at local, national and global levels. The site contains video-lectures showing how data can be analyzed and has interactive maps which individuals can use to explore data. Infant mortality data from the 1950s until the present are available at Gapminder and can be used to look at some of the contributing factors such as income, fertility rate and literacy.

Go to the videos in Gapminder and view “Reducing Childhood Mortality “Maternal Mortality” and “Poor Beat Race in MDG Race” to provide a background for your investigations. Then go to Gapminder World and review the video tutorial.

**Questions for Investigation 3: When do infant mortality rates fall?**

1. Open Gapminder World. Choose the variable “infant mortality rate” from
the Health menu for the y axis of your graph. Use per capita income as the x axis. Use the “play” button to watch the changes for infant mortality rate vs. per capita income from 1950 to present. What time periods represent the greatest increase in life expectancy?

2. Choose 5 countries from 5 different continents to follow. Click on the “Trails” button near the x axis to graph changes over time. What questions can you pose from the changes in infant mortality over time? Do these countries experience decreases in infant mortality at the same times? What hypotheses do you have about the differences you observe?

3. Repeat questions 1 and 2 using Children per woman (Fertility) as your independent variable (on the horizontal axis). Does this change what you observe? What do you think is the relationship between fertility and infant mortality? Think both about the impact on the health of the mother and the health of the child.

Resource for investigation:

Investigation 4: Exploring global disparities in infant and maternal mortality
Worldmapper is another tool for looking at the geographic distribution of global data. The site contains a rich set of data on categories including health, economic, environmental and demographics. The data is presented both in a map format and as an Excel data sheet. The map in Figure 3 for Maternal Mortality shows the way the countries are re-sized in Worldmapper to show the impact of the subject of interest.

Figure 3. Maternal mortality per country as shown in Worldmapper

In the year 2000, more than 513 thousand women died due to pregnancy-related causes. The map shows that most of these maternal deaths were in Southern Asian and African territories. The fewest maternal deaths were in Western Europe and Japan.

The highest rate of maternal deaths was in Sierra Leone, where 2 mothers die per 100 births. At the other extreme, Malta and Iceland reported no maternal deaths in 2000. The world average is 386 maternal deaths for every 100,000 births.

“Terry size shows the proportion of deaths of women worldwide while pregnant or within 6 weeks of pregnancy and partly due to it, that occur there.
Questions for investigation 4: Understanding the burden of mortality

1. Go to Worldmapper and using the list of categories, find the map for maternal mortality. Open up the PDF poster for the map and look at the data. Repeat this process for infant mortality. Note that the data for infant mortality is given as deaths per 1000 live births and the data for maternal mortality is given as deaths per 100,000 births. Look critically at the maps in Worldmapper. What do the sizes of countries represent? Use the data on the Excel spread sheet linked with each map to help understand what you see.

2. Write a two paragraph description of what you observe in each map. Share these with a classmate and develop a joint description.
   a. Where are the rates of infant and mortality greatest?
   b. Where are the numbers greatest?
   c. What are the advantages and disadvantages of using these maps to understand the challenges in improving infant and maternal mortality?

Investigation 5: Using statistics to identify factors that affect infant mortality

In many urban areas in the US, the statistics for infant mortality are alarming. Although the infant mortality rates for babies born to white mothers are about the same as US rates, the infant mortality rate for babies born to African American mothers is 14.5 deaths per 1000 live births which is similar to rates in Bulgaria (17.9), Thailand (17.6) and Sri Lanka (18.6). Many factors contribute to these differences, including access to prenatal care, nutrition, stress and racism, and high rates of babies born early or small.

The data kept by the Centers for Disease Control confirm that in the U.S. there are differences in the rates of prematurity and infant death in babies born to White mothers and African American mothers. (Lyasu, Tomashek, 2002) These problems aren’t always visible to the doctors who see the mothers and babies because they treat one patient at a time. Carefully kept statistics can often reveal problems that our experiences hide from us.

Questions for Investigation 5: Using statistics to identify factors that affect infant mortality

1. The state of Wisconsin keeps careful records about births in the state. Use the Wisconsin report from 2007 (Table I) to fill out the following table.

Resource for these investigations:
Table I. All births | White babies | African American babies
--- | --- | ---
Total number born | 72,757 | 54,567 | 7276
Number of low birth weight babies (includes Very low birth weight) | 5092 | 3383 | 982
Number of very low birth weight babies | 873 | 546 | 211
Number of babies who die in first year (Infant mortality) | 465 | 138 | 105
Infant mortality rate | 6.4/1000 | 5.5/1000 | 14.5/1000
Infant mortality rate among births with low birth rate | 57/1000

Table II. Wisconsin Births and Infant Deaths Report, (Bureau of Health Information and Policy, 2008)
2. One of the major contributors to infant mortality is low birth weight, which can be caused by premature birth or babies being born small-for-gestational age, but full term. Read about the causes of low birth rate in the March of Dimes site listed below. Other causes of infant mortality are discussed in the Global Health Council site. What are some additional causes of low birth weight?

3. Using the Wisconsin data set in Table II, what factors are associated with infant mortality in Wisconsin?

4. What could contribute the differences in infant mortality rates between different ethnic groups in Wisconsin, based on your readings at the two resource sites? What are some strategies that might improve the rate of low birth weight babies born to African American mothers?

5. Is this finding particular to Wisconsin, or does it occur around the US?

**Resources for investigation:**


**Investigation 6: Synthesis: Is Medicine Enough?**

At the United Nations Millennium Summit in 2000 189 world leaders signed the Millennium Declaration and agreed to meet the Millennium Development Goals (MDGs) by 2015. The MDGs are an eight-point road map for improving the lives of the poorest world citizens and working toward the end of poverty. The MDGs are detailed on the UN website along with factsheets and progress reports. The goals focus on basic needs and human rights which in the long term will improve the health of the whole community.

Non-governmental organizations like CARE that are interested in improving women’s health have also taken a “human rights” approach to analyzing healthcare problems and developing interventions with community members. A human rights approach does not guarantee that everyone will have good health, but rather works with governments and other agencies to establish a “level playing field” on which all people have equal access to the services and conditions that enable them to achieve good health.

**Questions for Investigation 6: Is Medicine Enough?**

Use resources in this chapter and elsewhere to develop a paper, poster, PowerPoint, discussion points or other format specified by your instructor to address one or more of the following:
1. Listen to the stories at Engender health or other stories on the internet that focus on mothers and babies. Try to include stories of women from urban areas and rural areas. This time, as you listen, think about these basic human rights: the right to education, right to make decisions about own future, right to clean water, safe food and basic housing, access to basic medical services, and equal rights for women. Access to basic medical care may be complicated by a woman’s need to obtain permission from her husband or father to be transported to a hospital. Pick four stories representing urban and rural women and summarize their compare and contrast their experiences.

2. Investigate the UN Millennium Development Goals (MDGs) and look at the fact sheets. Think about how attaining several MDGs will contribute to better maternal health and/or lower infant mortality. With another student, develop a poster to share progress on the achievement of MDGs 4 and 5 in a country of your choice. Make sure to include a graph, a map and a chart to highlight important contrasts in your presentation.

References


Resources for investigation:


United States Agency for International Development. (2009, June 02).


UNICEF, ChildInfo: Monitoring the Situation of Children and Women, Maternal Mortality Rate,
Nutrition, Good Health and Global Health

Marion Fass, Julie Seiter, Ethel Stanley, and Margaret Waterman

Learning objectives:
Define hunger in terms of its impact on child health.
Contrast hunger and food insecurity.
Graph and analyze the relationship between food consumption and child growth.
Test hypotheses about nutrition and child health using data from different regions of the world.
Gather data and analyze costs of food, locally and regionally, and relate to food insecurity and health outcomes.
Test hypotheses using graphs generated from online data sources.

Introduction
As we examine food and nutrition worldwide, we begin to grasp the complex nature of global health issues. In this chapter we will first explore how changes in the Japanese diet endanger ecosystem health, second consider the food landscape of a US city, and, third review recommendations for a healthy diet and compare it to the diets of people who suffer from chronic hunger. Fourth, we will investigate strategies to improve conditions of poverty and hunger undertaken by non-governmental organizations (NGOs) around the world.

At the most basic level, we require food to fuel metabolism and to make new cells. We need calories, a measure of the energy stored in food, but also other nutrients such as carbohydrates, fat, protein and an array of micronutrients, often referred to as vitamins and minerals.

At the community level, food is an essential component of the rituals of social life, the fabric of families, and the relationships between individuals. We eat together to connect, to celebrate, and to establish family traditions. What we eat is determined by where we live, what our families eat, and by the availability of food and the means to purchase it. Poverty and hunger are inextricably linked.

In the 21st century it is hard to understand the realities of food and nutrition, because both hunger and obesity exist simultaneously. In the 1970s development experts asked, “Can we feed the world?” The “Green Revolution” which followed introduced high-yielding crop varieties, widespread use of pesticides, and new crop management techniques that increased yields in many areas of the world. That capacity exists now to produce enough calories to “feed the world,” but the issues are complicated. Feeding the world means more than providing sufficient calories. To grow, harvest, and distribute food, it takes inputs of energy, labor, and water. To move food to consumers also requires technology, energy, political stability and trade offs with ecosystem health.

Changing food habits both here and abroad challenge our ability to feed the world. People with more cash to spend on food
often choose to increase meat and fish consumption. But the production of animals for food is very energy demanding and requires large amounts of water. Also, large animal production facilities contribute non-sustainable amounts of waste products to the environment. Increased demand for seafood has caused overfishing of the oceans and requires new management techniques to repair the damage to the ocean food webs. We can feed the world on plant foods, but the goal of giving everyone a steak for dinner, a questionable goal for good health, is much harder to achieve.

Investigation 1: Buying Food in a Global Market
Today Japan, with a population of 127 million people, imports 60% of its food supply. When the population was smaller and people ate a traditional diet, Japan was able to produce its own food. The Japanese diet once consisted mainly of rice, fish and vegetables, but now it has shifted to more meat and fat. This change in diet has driven changes in health, agriculture, and the environment. Watch the video from the Japanese Ministry of Agriculture, Forestry, and Fisheries, Ensuring the Future of Food, under Resources and answer the questions below.

Questions for Investigation 1:
1. List at least five changes that have occurred in Japan because of the modifications in the typical Japanese diet. Pick one and describe the consequences of this change.

2. Describe three actions that could be taken to reduce Japan’s dependence on food imports. Choose one action that you think would be difficult for Japan and explain why.

Resources for this investigation:

Investigation 2: Hunger in the land of plenty
Purchasing power and food availability vary widely between and within nations. Average annual incomes in countries around the world range from <$500 US in parts of sub-Saharan Africa to a high of $84,890 in Luxemburg (World Bank). Even within higher average income countries, there are pockets of poverty.

The quality of a diet, measured by the calories and micronutrients, is important for all income levels. For very poor families, the question is what to eat when there is not enough money to buy food and/or variety of food to buy. In other situations the family can afford enough calories, but the food choices lead to a nutritionally unbalanced diet. Rising expendable income in both developed and developing countries have led to increased consumption of packaged foods high in sugar or fat. (There are few places in the world where you cannot buy a cold soft drink.) The combination of low income and poor food choices severely limits the nutritive value of the diet for many families in the world.

The food landscape of Chicago, Illinois, also serves as an example of the complexity of issues around food and nutrition. Tourists know the Magnificent Mile, complete with food of every tradition, from Cajun to Greek, and food of every cost, from fast food to high-end gourmet. Fat-laden Chicago-style hotdogs and deep dish pizza stand out as part of the city’s culinary tradition.
Throughout the summer and fall, local small farmers bring fresh produce to the city’s farmer’s markets, but most of the farms within 100 miles of Chicago grow only corn and soy.

Many Chicago residents enjoy abundant food, but others are food insecure. Food insecurity is the condition in which people lack economic or socially acceptable access to safe, nutritious food. The USDA estimates that 11% of US households are food insecure and that about 1/3rd of those experience hunger (FRAC, 2009). In Chicago, a city of 3 million people, more than 500,000 people each year use emergency food services such as food banks or meals provided by 600 different programs. More than 1/3rd of these are children (Greater Chicago Food Depository, 2009).

Walk down the streets in Chicago, and you may notice that many people are overweight or obese. The Centers for Disease Control reports that 26.4% of Illinois adults were obese in 2008 (CDC, Obesity, 2009). This is less than in Alabama where 32.4% of adults are obese, but more than in Colorado where only 18.5% obese. Obesity in adults is defined as having a BMI, body mass index, of over 30. (For more information on BMI, see resources.) A 2003 study of obesity among Chicago children aged 2-12 found that rates varied by neighborhood, income level, and ethnicity from 18.6% of children characterized as obese in one area to 56.4% of children characterized as obese in a more low income neighborhood (Margellos-Anast, 2008).

Questions for Investigation 2:
Think about the situation in Chicago described above and the situation in your home country or current location. Use the tools from the USDA Food Environment Atlas <http://www.ers.usda.gov/foodatlas/> and other online sources of data to contrast food availability, price, and health outcomes in Cook County, IL (Chicago), or your country, and with counties in the US.

1. What patterns do you observe in poverty rates, obesity rates and access to fresh foods?
2. Are these related to health outcomes like diabetes rates?
3. What other factors could contribute to the patterns that you observe?
4. What services are there to address food availability, hunger and obesity in your hometown? How many people use them?
Chicago and many other cities have Internet pages that provide information on food banks, soup kitchens, and other services for people who are food insecure. Do these exist in your community?

5. Look at your own community. Are there farmers’ markets, food co-ops or international grocers that contribute to the dietary choices of your community? Describe at least two benefits that these resources could have for the health of the local population. What are some barriers to their use?

Resources for this investigation:


Nutrition, Good Health and Global Health


Investigation 3: The basics of good nutrition

In the United States, there is much public discussion about nutrition and what food choices are best for health. With the increasing rate of obesity among Americans, new diet books constantly suggest strategies for losing weight. Recently, the US First Lady Michelle Obama has become involved in advocating for good nutrition and obesity prevention and has planted a vegetable garden on the White House grounds.

The US Department of Agriculture (USDA) and the Department of Health and Human Services (DHHS) are charged by Congress to provide consumers with information about good nutrition through Dietary Guidelines for Americans. Prior to the 1970s, public health recommendations about diet were directed toward reducing dietary deficiencies, but by the 1970s safety net programs like Food Stamps, Women, Infants and Children, and the School Lunch program began to reduce deficiencies. Also, new epidemiological research highlighted the relationships between diet and chronic disease.

Public health nutrition in the US began to focus on positive aspects of nutrition such as the need to reduce weight and improve health. The first formal Dietary Guidelines were issued in 1980 (Post, 2008). My Pyramid <http://mypyramid.gov> was released in 2005. The familiar striped pyramid from the USDA provides generic guidelines and consumers are referred to the My Pyramid website for personally tailored information. The newest guidelines, ChooseMyPlate.gov, were released in 2011. ChooseMyPlate replaces the food pyramid with a clear new emphasis on increasing consumption of fruits and vegetables. ChooseMyPlate remains silent, however, on many aspects of the American diet including salty foods, fried foods, candy and sweets, and refined vs. whole grains (Figure 1).

Nutritionists at the Harvard School of Public Health have put together the Healthy Eating Pyramid in response to the USDA Pyramid (Figure 2). They believe that the recommendations of the Healthy Eating pyramid better reflect current research findings about nutrition and provide clearer guidelines for good health. Their pyramid is grounded in physical activity and weight control; it highlights the need that many Americans have to reduce weight.
Questions for Investigation 3: Recommendations for a healthy diet

In order to do this activity, you will need to document what you eat and your physical activity for 1-3 days. Keep a written food diary of all food, drink and exercise, or make a photo record of all the food that you eat. Try to estimate portion sizes, or use a measuring cup and a ruler for more accuracy. After completing the food diary, complete the questions below.

Figure 2. Healthy Eating Pyramid, Harvard Nutrition Source, <http://www.hsph.harvard.edu/nutritionsource/what-should-you-eat/pyramid/>

1. Review the Harvard Healthy Eating Pyramid and read the sections under “What you should eat.”
   a. How did the foods you consumed compare with the foods recommended?
   b. What questions do you have?

2. How does your physical activity compare to the recommended activity in the Healthy Eating Pyramid?

3. Share your food diary with a classmate. Together review what you each ate and how it fits with the Harvard Healthy Eating Pyramid. Make three recommendations for improvement. Use the Harvard Nutrition Source to document why these are important recommendations.

**Resources for this investigation:**


Investigation 4: Food - Quality and quantity

Nutrition is always important, but the nutritional experience of infants and small children literally shapes how they will grow up. Children in many parts of the world face chronic hunger as they lack safety net programs available in the US. The first of the Millennium Development Goals is to reduce extreme poverty and hunger. As we’ve seen in the food pyramids, scientists have defined basic nutritional needs. Despite this knowledge, large proportions of the world’s population are either not getting enough food or getting too much of the wrong foods. Carbohydrates, proteins and fats, needed in larger amounts, are called macronutrients while vitamins and minerals are called micronutrients since they are needed in very small amounts.

Essential macronutrients and their functions are shown in Table I. Humans need enough calories to provide energy for body functions and growth, protein to serve as building blocks for new proteins, and fats for cell membranes and other functions. Vitamins and minerals are required for their essential roles in enzymes, in DNA and other cellular functions. Without vitamins and minerals, children’s bodies are unable to carry out essential tasks. Without enough
calories, children can’t fully develop, physically nor mentally. If severe undernutrition persists through early childhood, the child will not catch up. The quality of food is as important as the quantity of food, especially for children. Adults and children who are chronically undernourished are more susceptible to infectious diseases.

Many people consider water an important nutrient as well. Lack of access to clean water for drinking, cooking and cleaning exacerbates many of the health risks of undernutrition. In many developing countries, in both urban and rural areas, women and girls spend hours each day acquiring the family’s water from wells and streams. This hard sought after water is often contaminated.

The Progress Report on the Millennium Development Goals finds that the number of people in the world who are undernourished has increased since 2005, due to rising food prices, the changing global economy, wars, drought, the use of food to produce ethanol, and the policies of food subsidies from developed countries (MDG Report, 2008).

The FAO estimates that in 2011, almost 1 billion of the 7 billion people in the world were chronically hungry (FAO, Hunger Map, 2011). India, due to its large population size, has the largest number of chronically hungry people. The countries of Sub-Saharan Africa have the largest percentage of undernourished. Chronic hunger in Sub-Saharan Africa has increased after decades of decrease, due to global economic conditions, rising food prices and the effect of weather. Recent economic growth in China has resulted in significant progress in reducing the number of undernourished.

<table>
<thead>
<tr>
<th>Macronutrient</th>
<th>Role in human health</th>
<th>Health Issues with Under-consumption</th>
<th>Health Issues with Over-consumption</th>
</tr>
</thead>
<tbody>
<tr>
<td>Protein- found in meat, eggs, beans</td>
<td>Provides amino acids used in building cellular structures and serve as enzymes in cell reactions</td>
<td>Growth retardation and stunting in children, lack of brain development, anemia. Stunting in girls makes them more likely to have complications when they deliver babies.</td>
<td>Obesity, calcium excretion and bone loss, loss of excess amino acids in urine</td>
</tr>
<tr>
<td>Carbohydrates- sugars and starches from plant sources</td>
<td>Their metabolism is coupled to ATP production</td>
<td>Weight loss, tissue loss as muscle is broken down to supply energy, bone loss from metabolic acidosis</td>
<td>Obesity, storage of excess energy as glycogen, increased risk of diabetes</td>
</tr>
<tr>
<td>Fats and oils- Found in foods of plant and animal origins; adds palatability and concentrated calories</td>
<td>Lipids are major components of cell structures, carriers of fat soluble vitamins, and coupled to ATP production</td>
<td>Weight loss, poor growth, problems regulating temperature, poor immunity to disease, deficiencies in fat soluble vitamins.</td>
<td>Obesity, storage of excess energy in fat, metabolic changes in insulin receptors, increased development of cardiovascular disease and diabetes</td>
</tr>
</tbody>
</table>
Although some people in rural areas are able to grow all the food that they need for a healthy diet, that number is shrinking. The reasons are varied. Water shortages limit how much food people can grow. People leave rural, farming areas to move to cities for work and they become dependent on food available for purchase in stores in their neighborhoods. If they have enough money, they have enough food. If they have less money, or if food costs are up, they may sacrifice vegetables, eggs and meat to fill up on staple foods like bread and rice. In order to enter a cash economy, many people abandon home gardens to raise cash crops such as roses, corn, soy, coffee and chocolate. Still others are unable to farm because the land is too poor, the seeds too expensive, the rains unpredictable, or the political situation too unstable. These are the people at greatest risk of chronic hunger.

**Questions for Investigation 4: The effects of hunger**

Poverty and hunger go hand in hand. Young children are most affected. Undernutrition affects growth and leaves children with long-term deficits not only in size and weight, but also in mental capacity.

Hunger is devastating. It is heartbreaking to see photos of parents holding starving babies. UNICEF workers assist local doctors and health workers in providing emergency food and medical care. They are active in Guatemala where poverty and hunger in rural areas coexist despite improving conditions in urban areas. In Kenya and Ethiopia drought has made it harder for families to grow the food that they need. In India, gender inequities create special challenges for the health of little girls.
Watch the videos about Hunger from UNICEF, <http://www.unicef.org>, using the resources below. Answer the following questions:

1. What are the main sources of calories in the diets of these families? Are they adequate?

2. What are the sources of protein in these families’ diet?

3. What are the impacts of undernutrition on child growth and development?

4. What strategies could or are being used by UNICEF or other NSO’s to improve the nutrition of these families.

**Resources for this investigation:**


**Investigation 5: The big picture: food, hunger and child health**

The relationship between total calories, food sources and the nutritional status of children is complex. Table II shows the average daily energy intake of people in eight countries in South and Central America. The average calories consumed range from 1840 daily in Haiti to 3270 in Mexico. The rate of stunting in children under age 5 ranges from 49% in Guatemala to 1% in Chile.

In this table, cereals refer to products made with grains, such as bread, rice or tortillas, and animal products include meat, milk and eggs, but not fat. Roots and tubers refer to potatoes, cassava and other staple root crops. The “other” category includes vegetables, nuts, sweeteners, fruits and vegetables and pulses such as dried beans and lentils.

The measure of underweight is a short-term consequence of not getting enough food. Stunting is the irreversible consequence of chronic insufficient nutrient intake. It includes short stature, delayed development of motor skills, and cognitive deficits that will result in poor school performance.

<table>
<thead>
<tr>
<th>Country</th>
<th>Cereals</th>
<th>Animal Products</th>
<th>Roots and Tubers</th>
<th>Fats and Oils</th>
<th>Other</th>
<th>Total calories</th>
<th>% children underweight</th>
<th>% children stunted</th>
</tr>
</thead>
<tbody>
<tr>
<td>Haiti</td>
<td>920</td>
<td>134</td>
<td>147</td>
<td>120</td>
<td>519</td>
<td>1840</td>
<td>22</td>
<td>24</td>
</tr>
<tr>
<td>Nicaragua</td>
<td>1246</td>
<td>235</td>
<td>24</td>
<td>216</td>
<td>629</td>
<td>2350</td>
<td>10</td>
<td>20</td>
</tr>
<tr>
<td>Dominican Republic</td>
<td>667</td>
<td>322</td>
<td>69</td>
<td>414</td>
<td>828</td>
<td>2300</td>
<td>5</td>
<td>7</td>
</tr>
<tr>
<td>Uruguay</td>
<td>1226</td>
<td>671</td>
<td>116</td>
<td>250</td>
<td>657</td>
<td>2920</td>
<td>5</td>
<td>11</td>
</tr>
<tr>
<td>Mexico</td>
<td>1439</td>
<td>556</td>
<td>32</td>
<td>327</td>
<td>916</td>
<td>3270</td>
<td>5</td>
<td>13</td>
</tr>
<tr>
<td>Chile</td>
<td>1163</td>
<td>596</td>
<td>89</td>
<td>387</td>
<td>746</td>
<td>2980</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Costa Rica</td>
<td>949</td>
<td>474</td>
<td>56</td>
<td>391</td>
<td>920</td>
<td>2790</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>Guatemala</td>
<td>1170</td>
<td>181</td>
<td>23</td>
<td>200</td>
<td>696</td>
<td>2270</td>
<td>23</td>
<td>49</td>
</tr>
</tbody>
</table>

Questions for Investigation 5: Food energy, food nutrients and the consequences

1. Graphs can often visualize relationships that a table of numbers cannot. Enter the data in Table II in an Excel Spreadsheet and use the Charts menu to make graphs that represent data from these countries in a way that helps you understand the relationship between calories and the kinds of food that people eat. You do not have to use all the countries at one time. Sometimes the use of fewer data sets makes the graph easier to interpret. Experiment with different graphing formats and choose 3 presentations that you think are useful. Label the x and y axis of the graphs you make.

2. For each graph, write a short paragraph describing what you infer from the graph. Compare differences on food consumption to the % underweight children and % stunted children for the countries that you used.

3. From your 3 graphs, choose the one that you think best represents the comparison of diet components between countries. Why does this graph show this relationship better?

4. What questions from the patterns that you observe in your data and graphs, would you like to investigate further?

5. By using information from additional countries you can test the validity of your observations. Use data from Table III below to test your hypothesis about calories, food groups, and child health.

   How does the food consumption differ between the two sets of countries?

   How do these differences relate to child health?

   Do the same relationships persist when you test them with additional countries?

<table>
<thead>
<tr>
<th>Country</th>
<th>Cereals</th>
<th>Animal Products</th>
<th>Roots and Tubers</th>
<th>Fats and Oils</th>
<th>Other</th>
<th>Total calories</th>
<th>% children underweight</th>
<th>% children stunted</th>
</tr>
</thead>
<tbody>
<tr>
<td>Botswana</td>
<td>990</td>
<td>264</td>
<td>154</td>
<td>220</td>
<td>572</td>
<td>2200</td>
<td>13</td>
<td>23</td>
</tr>
<tr>
<td>Kenya</td>
<td>1020</td>
<td>244</td>
<td>122</td>
<td>163</td>
<td>491</td>
<td>2040</td>
<td>20</td>
<td>30</td>
</tr>
<tr>
<td>Tanzania</td>
<td>1060</td>
<td>120</td>
<td>371</td>
<td>141</td>
<td>318</td>
<td>2010</td>
<td>44</td>
<td>50</td>
</tr>
</tbody>
</table>

You can find information about other countries at the FAO site: State of Food Insecurity, <http://www.fao.org>. The Technical Annex at the end of the report has data from countries around the world.

**Resources for this investigation:**


**Investigation 6: Micronutrients and Health**  
The goals of the Millennium Development Project for alleviating hunger include protecting children from micronutrient deficiencies, especially Iron, Vitamin A, Zinc, and Iodine, which contribute to growth and immune protection, and reduce mortality. The goals also identify the need to provide good nutrition for girls growing up, because, as we have seen in the last chapter, small girls grow up to be small women who have problems delivering babies. The value of good nutrition for girls throughout their lifespan- is realized when they have easier and safer births.

**Questions for Investigation 6: Understanding micronutrients and global health**

1. Although micronutrients are only needed in small amounts in the diet, they are critically important to good health. Fill out Table IV below to identify how essential micronutrients impact health.
Table IV. Role of micronutrients in human health.

<table>
<thead>
<tr>
<th>Micronutrient</th>
<th>What foods is it found in?</th>
<th>What does it do? List at least 2 functions?</th>
<th>Who doesn’t get enough? Why?</th>
<th>What is the impact of deficiency?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vitamin A</td>
<td>Dark Green and dark orange fruits and vegetables, like carrots and spinach, whole eggs, milk and liver</td>
<td>Needed to activate T lymphocytes. In older adults, prevents development of macular degeneration</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Zinc</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Iodine</td>
<td></td>
<td>People who don’t eat saltwater fish, or iodized salt- high in Russia, Sudan, others</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Iron</td>
<td></td>
<td>Anemia, devastating where malaria is common- Weak, tired, slow cognitive growth</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

These micronutrient deficiencies are highest in places where people do not have access to an adequate varied diet of high quality food.

The reduction of poverty and the improvement of food availability is one strategy to reduce deficiencies, but other specific strategies such as fortification of foods and distribution of supplements have been suggested.

2. For two micronutrients above, identify strategies that have been used to improve consumption of these micronutrients in two countries. What are the barriers to effective implementation? What have been the successes?

*Resources for this investigation:*
Investigation 7: The paradox of obesity and undernutrition

The Food and Agriculture Organization of the United Nations warns that “A growing number of developing countries must shoulder a "double burden" of malnutrition: the persistence of undernutrition, especially among children, along with a rapid rise in overweight, obesity and diet-related chronic diseases...” (State of Food Security in the World 2006, 2006).

Obesity exists alongside hunger in many countries. For example, the poorest 20% of the population may have barely enough food to eat, and are food insecure. In contrast, the richest 20% of the population may consume more than 2800 calories which is enough for weight gain for a moderately active adult. With money available to purchase sweets and soft drinks, children and adults gain weight, thereby leading to an increase in obesity that has been noted in Egypt, China, India, Mexico and South Africa (Rosen and Shapouri, 2008). These countries also have rising rates of diabetes.

We see similar increases in obesity in the United States, with higher rates of child overweight and obesity found in less affluent neighborhoods (Margellos-Anast, et al, 2008). Fast foods and soft drinks are easily available, effectively reduce feelings of hunger, and provide an energy boost but they do not provide a full complement of nutrients.

One key to this paradox of hunger and obesity comes from the grocery store. It could be a grocery store in the US, or a small market in any country. If you have a limited amount of money to spend, how can you get the most food and the most calories for your family? Remember, as you shop, that you want to make your family members happy, not just full. In 2009, one Midwest gas station, that was competing with nearby fast food restaurants, advertised 32 ounces of soda and a jumbo hotdog for $1.00. That’s about 620 calories for a dollar- a real calorie bargain!

It is possible to analyze foods at the store or at a fast food restaurant by looking at “calories per dollar” and “nutrients per dollar.” Comparing calories per dollar and nutrients per dollar, the bargains are different.

Questions for Investigation 7: How much does it cost to buy 100 calories?
Most moderately active adults need...
about 2000-2500 calories per day to maintain body weight. How much does that cost? Are foods that are high in nutrients more costly than those that are lower in nutrients? What is the tradeoff between fresh and cheap?

1. Review the Harvard healthy eating pyramid and identify 10 recommended foods for further study. Go to a local grocery and find the prices of these foods, so that you can calculate the cost per 100 calories, the price per pound and the calories per pound. Continue shopping to find 10 other foods that have a lower cost per 100 calories- find 5 nutritional bargains that have high levels of good nutrients and 5 nutritional bad deals, that have lots of calories in sugar, carbohydrates and fat but which are available at a low cost.
   a. Display your findings in a table.
   b. Make a graph to compare cost/100 calories with calories per pound. Identify different food groups with different symbols or colors.

2. After you have completed Activity 1, work with a classmate to pose your own question. You might ask; “how much does a day’s worth of food cost at the grocery or at fast food restaurants,” or any other related question you choose (have your question approved by your instructor). Develop a strategy for gathering data, carry out your investigation, and communicate your findings in a poster for sharing with the class.

3. Researcher Adam Drewnowski of the University of Washington, in an address to the panel members who were updating the US Nutrition Guidelines for 2010, stressed the need to identify nutrient-dense, affordable and appealing foods in order to help Americans of all income levels to choose foods for good health (Drewnowski, 2009). From your research and the research done by your classmates, what 3 foods would you contribute to this list and why? Compile a class list of the best foods to eat.

4. Use the Food Environment Atlas to contrast the costs of foods in different regions of the US, <http://www.ers.usda.gov/foodatlas/>. How do other regions of the country compare with your state/ region? How do food prices and food availability compare to rates of obesity? Demonstrate your reasoning with at least 4 maps that are logically related to your answer.

**Resources for this investigation:**


**Investigation 8: Working together to reduce hunger**
Many non-governmental organizations (NGOs) and civil society organizations (CSOs) are collaborating with WHO and UNICEF to work on the goals of reducing hunger globally. These groups
have taken a variety of approaches. While some organizations provide food directly, others work on building the capacity of people to earn money, grow food and feed their families. There are some projects that work in the US to reduce the burden of hunger and food insecurity, while others work in every other part of the world.

What are the best ways to reduce hunger? What is essential to good nutrition?

Some essential factors are a stable source of income, an educated mother, and access to food and fuel for cooking. Sometimes just providing emergency food is not enough.

**Question for Investigation 8: “Give a man a fishing pole.”**

A Chinese proverb says, “Give a man a fish and you feed him for a day. Teach a man to fish and you feed him for a lifetime.” This project will investigate different strategies for mitigating hunger.

Work with a group of three other students on this project.

For this activity, you and your group will serve as the administrators of a small charity that would like to donate $25,000 to a larger organization that is fighting world hunger. In order to spend your money wisely, you will need to review the work of at least three NGOs to identify the strategies that they are taking to reduce poverty and hunger. From these organizations, choose the one that you would fund.

Your product should be a short paper that includes a table that contrasts the three programs on their goals, target populations, and outcome measures. Identify the NGO that you recommend for funding. Justify your choice by focusing on the value of the intervention to its target population and the potential for sustainability, as well as your perspective on the philosophy that drives the organization. You may choose a large program like CARE that focuses on many places or a small program that is limited geographically.

Some of the NGOs to look at include:

* CARE
* Heifer International
* Hunger Free World
* Carter Center
* Catholic Relief Services (CRS)
* Save the Children (US)
* World Vision International
* German Agro Action
* Danish Refugee Council (DRC)
* Norwegian Refugee Council (NRC)
* Food for the Hungry - International
* Adventist Dev & Relief Agency
* Action contre la Faim network
* Caritas Internationalis
* Movimondo - Molisv
* Lutheran World Federation (LWF)
* OxFam
* Others (Your choice)

**Extension activity:** Use your research to develop a real fund raising program at your university or in your community for the NGO that you’ve chosen.
References:


Controlling Infectious Diseases: 
Learning from Failures, Building Success

Julie Seiter, Marion Fass, Ethel Stanley, and Margaret Waterman

**Learning objectives:**
Students will be able to identify reasons why some diseases can be eradicated while others can only be controlled.
Students will be able to describe the impact improvements in sanitation and clean water have in the control of waterborne diseases.
Students will evaluate the role of herd immunity.
Students will identify biological and social barriers to disease control and eradication.
Students will evaluate the potential for disease eradication for specific diseases.

**Introduction**
The vision of a disease free world has driven medical researchers and public health practitioners to develop vaccines, medicines, safe-water campaigns, and educational programs to reduce the burden of infectious and chronic diseases. Efforts to control or eradicate diseases remind us that the development of disease is affected not only by the biology of the disease-causing agent, but also by environmental and social conditions.

**What is disease eradication vs. disease elimination and disease control?**
Disease eradication refers to the reduction to zero of the incidence of a disease caused by a specific agent. This reduction is worldwide and permanent, and is achieved through deliberate efforts and campaigns. When zero incidence is achieved, no new cases occur; intervention measures are no longer needed. Smallpox was declared eradicated in 1979 after several years of intense, international cooperation (Fig. 1). Rinderpest, a disease of cattle, was eradicated in 2011. A global effort to eradicate polio is underway led by the Bill and Melinda Gates Foundation and Rotary International. Several other eradication campaigns have been attempted without success: yaws, yellow fever, and malaria.

*Figure 1. Cover of World Health Magazine, May 1980, announcing the end of Smallpox. [http://www.cdc.gov/Features/SmallpoxEradication/]*

**Disease elimination** describes diseases that have been reduced to zero incidence in defined geographical areas as a result of deliberate efforts. Since only a region or
regions are free of disease, maintaining zero incidence requires continued efforts to prevent re-establishment of the disease by introduction from other areas. This achievement has been accomplished for measles in North and South America. Occasionally there are still small, localized outbreaks of measles in the Americas when someone who has acquired measles in another country enters a disease-free country and spreads the disease to unvaccinated individuals. Public health actions are immediately taken. With some diseases, the strategy of disease elimination is to prevent a specific outcome of the disease in a region if it is impractical to eliminate the disease itself. Examples include preventing blindness from trachoma infections and keeping leprosy incidence below one case per 10,000 people.

Finally, disease control consists of reducing disease incidence, prevalence, morbidity or mortality to a locally acceptable level through deliberate efforts. Continued measures are required to maintain the reduction in incidence. Controlling an outbreak of Norovirus on cruise ships or in college dormitories are examples of disease control. Prevention of Norovirus outbreaks depends on maintaining hand-washing, surface sanitizing, and scrutiny of food handling. Disease control principles are also applied to prevent outbreaks of influenza.

Control of Diseases: Focus on Water-Borne Diseases
Although we often think about using vaccines and antibiotics to prevent and treat diseases, strategies such as improved sanitation and community education can also be effective tools. Water-borne diseases can be controlled by improving sanitation and hygiene, providing safe drinking water, and offering community health education.

When an individual is ill with most waterborne diseases, he/she excretes the disease-causing organism in their feces. If drinking water becomes contaminated with sewage, other individuals can become infected from using the water. This route of disease transmission is called the fecal-oral route because disease organisms excreted in feces are then ingested from drinking water. The most effective approach for controlling water-borne disease has been to: provide clean, safe drinking water; educate about hand washing and hygiene; and, improve sanitary latrines and toilets that help break the fecal-oral pattern of transmission. The 7th UN Millennium Development Goal (MDG) recognizes the disease burden of water-borne diseases and sets a goal of reducing by half the number of people without access to safe drinking water and adequate sanitation.

Investigation 1: Controlling Water-borne Disease
Water-borne diseases such as acute watery diarrhea, typhoid fever, cholera, amoebic dysentery, polio and rotavirus are spread by the fecal-oral route and cause diarrhea. Another serious water-borne disease is Guinea worm disease, which affects the skin and other body tissues.

Globally 5 million people die each year due to diseases arising from unsafe drinking water and lack of basic sanitation. Unfortunately, one billion people do not have access to safe water and 2.6 billion people (i.e., 2 of every 5 people in the world) do not have improved sanitation. Improved sanitation maintains separation of human urine and feces from human contact in order to prevent the spread of disease. Composting toilets, improved pit latrines with slab covers, and flush or pour-flush toilets that drain into septic tanks are examples of improved sanitation.
The United Nations declared 2005-2015 the “Water for Life” decade, and 2008 was the International Year of Sanitation. During this period, governments and non-governmental organizations (NGOs) engaged in major efforts to improve sanitation. Figures 2 and 3 show the percentage of people that do not have access to improved sanitation and improved drinking water, respectively.

Diarrheal diseases are the third leading cause of death in low-income countries thereby accounting for 6.9% of total deaths (WHO 2004). To illustrate this, if we assume that for every 1000 deaths in the world that 447 occur in low-income countries, then 31 of the 447 deaths would be due to infectious diarrheal diseases. The toll is greater in young children. Seventeen percent of childhood deaths are caused by diarrheal diseases. This works out to about 5000 deaths per day for children under five (IYS 2008).

Water-borne diseases are spread by a combination of factors such as poor quality drinking water, lack of treatment for human waste, lack of water availability, and personal hygiene practices. A single intervention, such as providing safe drinking water, is not sufficient to lower the disease burden. In fact, in a community with a high incidence of fecal-oral pathogens, there are usually several routes for the spread of disease and it is difficult to link a disease outbreak to any one pathway. Figure 4 presents possible transmission pathways for fecal-oral pathogens. Because there is a web of interactions, the health community and policy-makers need to consider a cluster of interventions to break the cycle of disease.

Figure 2. Regional distribution of the 2.6 billion people that do not have improved sanitation facilities in 2008, population (million). WHO/UNICEF: Progress in Drinking-water and sanitation: special focus on sanitation. <http://documents.wssinfo.org>

Figure 3. Regional distribution of the 884 million people that do not have improved drinking-water sources in 2008, population (million). WHO/UNICEF: Progress in Drinking-water and sanitation: special focus on sanitation. <http://documents.wssinfo.org>
Questions for Investigation 1: Controlling Water Borne Disease

1. In every region of the world there are countries that have been successful in providing safe water and improved sanitation for their residents – the first two steps in breaking the water-borne disease transmission cycle. Success toward achieving the MDG’s is presented in a visual display using Gapminder software (Gapminder). These data are located on a UN site and not on Gapminder so use the link below. Explore the 7th MDG in a special Gapminder presentation that focuses on the UN goals. (See MDG “Trendalyzer”) Make a graph using the following data bases. On the x-axis choose “Goal Number 4, Reducing Child Mortality” and choose “Children under five mortality rate” from the drop down menu. On the y-axis use the drop down menu to choose Goal Number 7 and then explore the “Proportion of the population using improved…” drinking water and sanitation in rural, urban and the whole country.

   a) From the data on the graph, pick China and India as well as four additional countries from different continents, and compare their progress toward achieving improved drinking water and improved sanitation. Fill in Table I.

   b) Look at the data in your Gapminder graph and Table I. Has more progress been made for improved drinking water or improved sanitation? Using references from the resources explain why this happened from cultural, political and economic perspectives.

   c) Compare the progress toward achieving improved drinking water and sanitation in rural areas versus the urban areas. Write a paragraph or two describing the differences in progress between the rural and the urban areas. What are some of the challenges in providing improved drinking water and sanitation in these two different areas?
d) Describe the relationship between improved water and sanitation and the mortality rate for children under five using information from the graph that you have made.

Table I. Country’s progress toward achieving improved drinking water and sanitation expressed as a percentage and by the population affected.

<table>
<thead>
<tr>
<th>Country</th>
<th>Percent Population with Improved Drinking Water</th>
<th>Percent Population with Improved Sanitation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total</td>
<td>Urban</td>
</tr>
<tr>
<td>India</td>
<td>86</td>
<td>95</td>
</tr>
<tr>
<td>China</td>
<td>2.</td>
<td>3.</td>
</tr>
</tbody>
</table>

2. Improved hygiene is a third way of breaking the transmission cycle of water-borne diseases. Convincing people to change their hygiene habits means explaining the beneficial outcomes for making changes for both the individual and for the community. Read about the connection between disease transmission and hygiene in the Resources and read some of the case studies in the UNICEF link, 10 Sanitation Stories. Describe the hygiene habits that contribute to disease transmission. Describe some hurdles that may need to be overcome before the community makes changes.

3. Use Figure 4 as a guide to develop three health intervention scenarios that could break the spread of fecal-oral pathogens. Each scenario should contain a combination of intervention strategies including modifications to the transmission route and environmental and behavioral approaches. Explain the rationale for each scenario.

**Resources for this investigation:**


**Investigation 2: Elimination of Diseases: Trachoma**

Eliminating a disease takes different measures depending on the nature of the disease. In some cases, disease transmission is completely eliminated in a region by combining environmental strategies and immunization programs, as has been seen with polio and measles in many parts of the world. Disease elimination can also mean keeping the incidence below a certain level which is the goal with leprosy. In other cases, the cause of the disease cannot be eliminated, but the damaging outcomes of the disease can be prevented.

Trachoma, caused by the bacterium *Chlamydia trachomatis*, is the leading cause of preventable blindness and has caused 7 million cases of blindness worldwide. Trachoma is spread by flies that pick up the bacteria from human feces and then land on or near the eyes of children and adults. In some regions of the world, people experience continuous or repeated infections. Scar tissue produced in response
to the infection causes the upper eyelid to turn under and the eyelashes scratch and scar the cornea leading to blindness. Trachoma is easily spread by person-to-person contact, towels and clothing, and by flies that breed in human excreta as shown in Figure 5.

The program to eliminate trachoma has two goals. The first is to prevent blindness in infected individuals and the second is to break the chain of transmission through improved sanitation. As sanitation improves in a country, the disease will be eventually eliminated. Watch the video about trachoma control on the Carter Center website listed in the resources.

Questions for Investigation 2: Elimination of Diseases: Trachoma

The Carter Foundation has an active program in Africa to reduce the incidence of trachoma and prevent blindness. Their program uses the SAFE strategy developed by the WHO to control trachoma. SAFE stands for Surgery, Antibiotics, Facial cleanliness, and Environmental improvement.

1. Explore the Carter Center program on trachoma by looking at the maps, diagrams, and slide shows on their web site. Read about the SAFE strategy and its applications. Choose one piece of the SAFE strategy and write 2 paragraphs describing the challenges of implementing the strategy.

2. Read Chapter 3, “Generating Momentum for Changing Health-Related
Behavior”, in the document, *Implementing the SAFE strategy for Trachoma Control*. Write two paragraphs discussing the process of health behavior change and how this process applies to trachoma control.

**Resources for this investigation:**


**Investigation 3: Disease Eradication: What does it take?**
In 1993, the International Task Force for Disease Eradication evaluated over 80 infectious diseases to determine which ones would be candidates for an eradication program. Today there are seven candidates for eradication on the list; however, this number could change as vaccines and medications are developed.

The process of disease eradication requires social and political commitment to be successful. Disease eradication is expensive and labor-intensive and can only be achieved with well-coordinated, multinational efforts. In addition to the necessary biological characteristics of the disease needed for eradication, three other conditions are important for a successful disease eradication campaign: (1) There must be consensus on the public health threat of the target disease and on the priority of tackling the disease compared to other diseases; (2) Political commitment must be at the highest governmental and NGO levels; and, (3) The eradication should benefit all levels of society (CDC, 1999).

The source of financial support for recent disease eradication campaigns has been a blend of donations from: the governments of developed countries; private organizations such as the Bill and Melinda Gates Foundation and the Carter Center; and, international organizations including WHO and UNICEF. Implementing a disease eradication program involves not only analysis of the biological and epidemiological aspects of the disease, but also the examination of the political and social commitment to taking on the program.

**Questions for Investigation 3: Disease Eradication: What does it take?**
1. In addition to social, political and economic concerns, there are three biological conditions necessary before a disease can be a candidate for eradication. Visit the MMWR site in the resources and explore the key factors that affect a disease eradication program. Describe the three biological conditions necessary before a disease can be eradicated. Include some specific concerns for each condition.

2. The International Task Force for Disease Eradication has compiled a list of diseases, sanctioned by The World Health Organization, which can be eradicated with today’s tools. Additional diseases, selected by the International Task Force for Disease Eradication are organized into groups: diseases that are targeted for eradication, diseases/conditions of which some aspects could be eliminated, diseases that are not eradicable now, and diseases that are not eradicable. Pick a disease that is “not eradicable now” or one which has some “aspects [that] could be eradicated” now and...
describe the limitations for eradicating the disease based on biological conditions. Discuss specific developments that could change this disease to one that is potentially eradicable. How feasible are these developments?

**Resources for this investigation:**


**Investigation 4: Guinea worm eradication in progress**
Currently WHO has sanctioned the eradication of two human diseases, guinea worm disease (dracunculiasis) and polio, although other diseases could potentially be eradicated. Over the last two decades dramatic progress has been achieved toward eradicating guinea worm disease. When the Carter Center began leading the eradication program in 1986 there were about 3.5 million cases in twenty countries in Africa and Asia. In 2008, there were fewer than 4,000 cases found in only six African countries; by March 2009, disease transmission was restricted to four countries: Sudan, Ghana, Mali and Ethiopia. The amazing aspect of the guinea worm eradication story is that this eradication program has been carried out without using drugs or vaccines. In fact, drugs and vaccines are not available for guinea worm treatment so the eradication program has focused on community education, surveillance, and breaking the transmission cycle of the parasite (Figure 6). Guinea worm disease is poised to be the second human disease successfully eradicated from the world.

![The Life Cycle of Guinea Worm](http://www.cartercenter.org/news/features/h/guinea_worm/financial_times.html)
Questions for Investigation 4: Guinea worm eradication in progress
The Carter Center and the WHO are excellent sources of information on Guinea worm disease, treatment, prevention, epidemiology, and eradication. Explore the resources for this investigation, including the videos, to learn more about Guinea worm.

1. Explain why Guinea worm could be eradicated without the use of antibiotics and vaccines. Write at least two paragraphs describing the two stages in the Guinea worm life cycle where interventions are effective to stop transmission to humans and discuss the actions that are being taken to prevent transmission of the disease. Are the effects of these actions seen immediately?

2. What is the impact of the Guinea worm infection? Answer these questions.
   a. When the Guinea worm begins to emerge from a person’s body, what is the treatment and what effect does it have on the individual’s health and activities?
   b. When adults in a family are infected, what effect does the emerging worm have on the family? What is the impact of Guinea worm infections on the community?

Resources for the investigation:


Investigation 5: Herd Immunity and the Control of Diseases
The concept of herd immunity holds that the higher the percentage of people that have been immunized for a disease, the fewer susceptible individuals remain in the population. Herd immunity is achieved with different levels of immunization for different diseases, because some diseases are more contagious than others. For many diseases, it is essential to achieve and maintain herd immunity to sustain disease control, disease elimination, or disease eradication. Table II gives some examples.

Herd immunity thresholds can be calculated using data collected from the community. The threshold is dependent on factors that vary between communities, so herd immunity threshold values can vary from region to region. The calculated threshold value can be used to design immunization programs. Simulations, such as the SIR model used in the article on influenza, have been designed to address five quantifiable variables: (1) the number of susceptible individuals ($S$); (2) the number of infected individuals ($I$); (3) the percentage of individuals who have recovered from infection and thereby become immune to re-infection ($R$); (4) the initial transmission rate; and, (5) the nature of interventions such as vaccines and recovery rate. The numerical value of these variables can be changed (in the simulation) to reflect the specific situation. However, there are some variables such as the overall level of sanitation in the community, level of nutrition and general health of the population that cannot easily be simulated, but which have a significant effect on the spread of disease. Table II lists the herd immunity threshold and school-age vaccination rates for several vaccine-preventable diseases.
Table II. Estimated herd immunity thresholds and school-age coverage for vaccine preventable diseases in the United States, 2007-2008

<table>
<thead>
<tr>
<th>Disease</th>
<th>Transmission</th>
<th>$R_0^1$</th>
<th>Herd immunity threshold, %$^2$</th>
<th>Children vaccinated when entering school, %$^3$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diphtheria</td>
<td>Saliva</td>
<td>6-7</td>
<td>85</td>
<td>95.45</td>
</tr>
<tr>
<td>Measles</td>
<td>Airborne</td>
<td>12-18</td>
<td>94.87</td>
<td></td>
</tr>
<tr>
<td>Mumps</td>
<td>Airborne droplet</td>
<td>4-7</td>
<td>75-86</td>
<td>95.55</td>
</tr>
<tr>
<td>Pertussis</td>
<td>Airborne droplet</td>
<td>12-17</td>
<td>92-94</td>
<td>95.77</td>
</tr>
<tr>
<td>Polio</td>
<td>Water-food</td>
<td>5-7</td>
<td>95.87</td>
<td></td>
</tr>
<tr>
<td>Rubella</td>
<td>Airborne droplet</td>
<td>5-7</td>
<td>80-85</td>
<td>95.56</td>
</tr>
<tr>
<td>Smallpox</td>
<td>Contact face-to-face or with contaminated belongings</td>
<td>6-7</td>
<td>NA</td>
<td></td>
</tr>
</tbody>
</table>

1. $R_0$ is the basic reproduction number, or the average number of secondary cases that are produced by a single index case in a completely sustainable population.

2. History and Epidemiology of Global Smallpox Eradication. From the training course titled "Smallpox: Disease, Prevention, and Intervention". The CDC and the World Health Organization. Slide 16-17.


**Questions for Investigation 5: Herd immunity and the control of diseases**

1. By using the “Herd Immunity Simulation Tool” listed in Resources, calculate the herd immunity threshold for measles, polio and smallpox. Several assumptions were made when this simulation was simplified:
   - You can only change the virulence rate, duration of infection, rate of transmission, and herd immunity threshold in this simulation.
   - Virulence is the fraction of infected people that will die.
   - Duration of infection includes the total infectious period including days before the disease is diagnosed, but the person is still infectious.
   - Rate of infection is the number of secondary cases produced by a single case. This is based on the assumption that a person will have 100 contacts per day.
   - An epidemic is defined as 10% or more of the population having the disease.
   - No interventions or their effects are included.
Table III. Calculated values for the herd immunity threshold for three diseases.

<table>
<thead>
<tr>
<th>Disease</th>
<th>Virulence</th>
<th>Duration of Infection</th>
<th>Rate of Transmission</th>
<th>Herd Immunity Threshold</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small pox</td>
<td>high (0.25)</td>
<td>14 days</td>
<td>high (2.5)</td>
<td></td>
</tr>
<tr>
<td>Polio</td>
<td>low (0.01)</td>
<td>18 days</td>
<td>average (1)</td>
<td></td>
</tr>
<tr>
<td>Measles</td>
<td>low (0.01)</td>
<td>8 days</td>
<td>very high (10)</td>
<td></td>
</tr>
</tbody>
</table>

2. Which disease is more likely to remain at a low level in a population, assuming no interventions, one with a high or low virulence factor? Explain your answer.

3. What effect does a long infectious period have on the spread of disease? Explain your answer.

4. What is the effect of a high rate of transmission? Explain your answer.

5. How does high herd immunity threshold prevent epidemics or outbreaks from occurring?

Resources for this investigation:
National Health Service (Great Britain) Immunization site. Accessed May 2011, from: <http://www.immunisation.nhs.uk/About_Immunisation/Science/What_is_a_vaccine>


Investigation 6: A Tale of Disease Eradication
In 1988 members of WHO voted to launch a campaign to eradicate polio by the year 2000. At that time, wild type poliovirus was endemic in 125 countries and caused 350,000 cases globally. Although the goal of eradication by 2000 was not met, today wild type poliovirus is endemic in only four countries, Nigeria, Afghanistan, India and Pakistan, and occurs as imported cases in a number of neighboring countries causing 1651 cases in 2008. The campaign to completely eradicate polio, now named the Global Polio Eradication Initiative, is spearheaded by national governments, WHO, Rotary International, CDC, UNICEF and more recently the Bill and Melinda Gates Foundation. The polio eradication campaign is the largest internationally-coordinated public health project to date.
Figure 7. Global polio eradication initiative financing from 1985-2013. <http://www.polioeradication.org/strategies.asp>

Polio virus meets the biological criteria for disease eradication since there is a cost-effective vaccine, humans are the only host, and a diagnostic test is available to use for surveillance. Disease eradication depends on the social, cultural and political conditions within countries as well as on the biological and medical criteria. In the social upheaval of war in Afghanistan and fighting in Pakistan, there is not enough political stability to systematically get people vaccinated. Children in security-compromised areas are especially difficult to vaccinate and monitor and may end up moving to internally-displaced population camps. The vaccine that is being used in India has not produced a strong enough immune response to stop the transmission of wild poliovirus. The transmission rates in India may reflect the dense living conditions and level of sanitation which create a need for a higher level of herd immunity (WHO, 2009). Different vaccines are being tested in a trial.

The story of polio eradication in Nigeria demonstrates the complexity of both political and cultural issues surrounding public health campaigns. In 2003, leaders of several states in northern Nigeria called
upon parents to avoid vaccinating their children for polio. Muslim religious leaders claimed that Internet sources confirmed that the vaccine was contaminated with anti-fertility drugs and viruses known to cause AIDS. Since northern Nigeria is predominantly Muslim, rumors began circulating that the polio vaccine was a part of a plot to sterilize Muslim girls and spread HIV in Nigeria (Nature Immunology, 2009; Yahya, 2007). This led to a suspension for over a year of the polio vaccination program. WHO worked to secure support from various religious and political leaders. One compromise that was reached was procuring vaccines from drug companies in Muslim parts of Asia rather than Europe or the US. Once convinced that the vaccine was safe, vaccination resumed, but not before the incidence of polio increased in Nigeria and spread from Nigeria to 18 other countries, some of whom are still trying to regain polio-free status.

Community health workers identified several cultural issues that also deterred parents from getting their children vaccinated. Many Nigerians use traditional healers for medical care or see both Western and traditional healers depending on accessibility and need. In some traditional Nigerian cultures, polio is thought to be a powerful spirit that consumes the limbs of individuals and that traditional healers can interact with the spirit world to help the patient. This belief is in sharp contrast to the Western view that polio can be prevented by oral vaccines and it is difficult to know how much traditional views affect immunization rates (Yahya, 2007). Another issue that became apparent revolved around the house-to-house immunization programs. Some people indicated that they had more confidence in a vaccine given in a clinic by a professional than one given by a field worker.

Questions for Investigation 6: A Tale of Disease Eradication
Internationally-coordinated disease eradication campaigns typically start with discussions at international venues such as at WHO, UNICEF, the European Union, and the Pan American Health Organization. The guidelines for the health programs are developed at the international level and then commitments for support and participation are sought from target countries. Implementation in countries relies on cooperation between the country’s health department, NGO participants, and local community health workers. Ideally the goals and specifics of the eradication program should be communicated to local citizens in a culturally sensitive manner. Citizens are more likely to embrace and support a program if it is compatible with their worldview.

1. Explore the resources for a disease eradication program and write two paragraphs about its essential aspects of communication and community education. This analysis should be based on agency recommendations, not on opinion.

2. As this issue of Biology International goes to press, the eradication of polio is in sight. Investigate reports from the Centers for Disease Control, Morbidity and the Mortality Weekly Report <www.cdc.gov/mmwr>, and the Bill and Melinda Gates Foundation. What is the status of polio eradication now?

Resources for this investigation:


References:


Message of UN Secretary-General Kofi Annan on World Water Day

Access to safe water is a fundamental human need and, therefore, a basic human right. Contaminated water jeopardizes both the physical and social health of all people. It is an affront to human dignity.
The Challenges of Mosquitoes and Disease: 
Making Sense of Complexity

Marion Fass, Julie Seiter, Ethel Stanley, and Margaret Waterman

Learning objectives:
Define vector borne disease.
Evaluate risks of acquiring a mosquito disease in a specific geographic area using online resources.
Evaluate potential benefit of medical and public health strategies for reducing malaria.
Work collaboratively to explain strategies for malaria control to adults and children.
Present scientific information in a poster format.
Predict future spread of dengue virus and its vector using data and maps available from governmental resources, PAHO, WHO.

Introduction
In the United States, the bite of a mosquito is usually just an annoyance. In most parts of the world, however, and sometimes even in the US, the bite of a mosquito transmits painful and potentially life-threatening diseases. Mosquitoes serve as vectors, or disease carriers, for a range of diseases. The control of vector borne diseases is complex because it involves considerations of the physiology, behavior, and ecology of at least three species of organisms - the host, the biological agent of disease, and the mosquito or other vector. West Nile virus fever, which appeared suddenly in the United States in 1999, caused widespread fear and almost 10,000 confirmed infections in 2003 alone, and reminded Americans that they were not immune to mosquito borne diseases.

The risk for mosquito borne infections is far greater in tropical and sub-tropical areas where the chances of being bitten is more likely throughout the more extensive mosquito breeding seasons. Risk is influenced by the species of mosquitoes present, whether these mosquitoes are carrying pathogens, and the behavioral preferences of the mosquito in terms of seeking human hosts. Local weather conditions and housing conditions also affect disease transmission.

Some mosquito borne diseases such as malaria and yellow fever are endemic in large parts of the world, while others, such as chikungunya fever, emerge only sporadically. An endemic disease is one that is established within a population and occurs regularly. This status is subject to change as is the case for West Nile virus, which is currently considered endemic in the US.

Globally, the two most common mosquito borne diseases are malaria and dengue fever. Malaria, caused by protozoan parasites of the genus
*Plasmodium*, affects 300 to 500 million people each year. Dengue fever, also known as “break-bone fever” because of its painful symptoms, is so widespread that 2.5 billion people are at risk of being bitten by a mosquito carrying the dengue virus each year. Currently the US does not have to cope with global risks as malaria and dengue, but global climate change may modify this in the next fifty years as temperatures rise, low lying areas flood, and rain patterns shift.

The US has been involved in historically significant mosquito eradication efforts in the Americas. The use of DDT in the 20th century had far reaching impacts on the development of environmental control policies. Strategies for controlling mosquito breeding still includes spraying mosquito toxins such as Bt proteins, but additional efforts such as the release of sterile male mosquitoes, recommended personal use of mosquito repellants, and draining swimming pools in the backyards of foreclosed houses are in use by public health administrations.

**Investigation 1: Determining the cause of infection**

Jose, a 20 year-old student at your university, was born in the Dominican Republic and remembers having a bad illness, with high fevers and lots of pain, in the year before he moved, at age 5, to central Florida. He remembers the mosquito bites that covered him. Jose always figured that he had malaria and had recovered.

In his class on Global Health, Jose began to wonder if malaria was really what had made him sick. Every year or two, mostly in the summer, he returns with his parents to visit relatives in the city of Santo Domingo. For the first time, he began to worry about his future trips to his family home and what he should do to protect himself.

In class, Jose learned about lots of mosquito borne diseases including:
- Malaria
- West Nile Virus Fever
- Chikungunya Fever
- Dengue and Dengue Hemorrhagic Fever
- Eastern Equine Encephalitis

He wonders which of these illnesses he was most likely to have had as a child, and which would cause him the most problems if he were re-infected.

**Questions for Investigation 1: Using epidemiology to identify possible mosquito diseases**

1. The epidemiology of disease and the kind of mosquito vectors present in the area that carry the disease agent can help you narrow the choices in identifying the cause of someone’s illness. A **vector** is an organism that enhances disease spread by carrying the agent from host to host. For each of these diseases, identify if the agent of disease is a bacterium, virus or protozoan and the genus of mosquito that serves as the vector. Confirm whether or not the mosquitoes that serve as the vector are present in the Dominican Republic, if the disease itself is present in the Dominican Republic, and how many cases occur each year (if the information is available). Investigate the symptoms and tests that a doctor uses to diagnose each disease and distinguish it from the others in Table I. In the resources, there are links to maps of the distribution of mosquitoes and diseases that will help you.
Table I. Comparison of insect borne diseases.

<table>
<thead>
<tr>
<th>Disease</th>
<th>Agent</th>
<th>Mosquito species</th>
<th>Mosquito in DR?</th>
<th>Disease cases in DR?</th>
<th>Symptoms and tests for diagnosis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Malaria</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>West Nile Virus</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dengue</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chikungunya Fever</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Eastern Equine Encephalitis</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1. What do you think Jose had? Why?

2. People with malaria and with dengue experience high fevers, but these two diseases are very different. What signs and symptoms could you use to differentiate between malaria and dengue?

**Resources for this investigation:**


Malaria Atlas Project. Accessed May 2011, from: <http://www.map.ox.ac.uk/>

Walter Reed Biosystematics Unit, Vector Identification Resources (2010). <http://wrbu.si.edu/>

**Investigation 2: Malaria and its control: Ecological, physiological and behavioral complexity**

Malaria infects 300 to 500 million people each year and is the cause of at least 1 million deaths annually (WHO, 2009). The disease is caused by the protozoan parasites of the genus *Plasmodium*. The most common of the four species that cause human disease is *Plasmodium falciparum*. The *Plasmodium* parasites must gain entry to the host bloodstream in order to reproduce. They do it with the help of female mosquitoes of the genus *Anopheles*.

These parasites have co-evolved with the mosquitoes that carry them; that part of the life cycle of the *Plasmodium* occurs within the body of the mosquito seemingly without harming the mosquito. The parasites migrate to the salivary glands of the mosquito where they are transmitted to the next human that the mosquito bites.

Within the human host, malaria parasites go through yet another series of life stages. Depending on the species of *Plasmodium*, these stages take from one to four weeks. Parasites enter liver cells where they reproduce. Next they return to the bloodstream thereby causing inflammation and potentially blockages. The flood of new parasites invades many more red blood cells, and the destruction can cause severe anemia, particularly in small children. Some parasites are ingested by mosquitoes when they bite and the spread of malaria continues.

During the time of active infection, people develop fevers and chills, extreme fatigue and headaches. Some may go on to coma and death. In areas
where malaria is endemic, people are continuously re-infected with *Plasmodium* parasites and most people therein develop some immunity to the infection. Children are most vulnerable to serious complications and death because they have not yet developed an immune response to the *Plasmodium* parasites. Malaria is responsible for the heavy burdens of child mortality and lost productivity by adults in these countries. The multiple stages of the *Plasmodium* life cycle, complete with different life forms, create many of the challenges of malaria control. Familiarize yourself with the *Plasmodium* life cycle shown in Figure 1 and through the videos and websites found in the resources.

**Questions for Investigation 2:**
One of the goals of the Bill and Melinda Gates Foundation is the eradication of malaria. They state that malaria is “preventable and treatable.” (Gates Foundation, 2009). Watch the two short videos on malaria on the Gates Foundation website, “Can We Really Eradicate Malaria? Fighting the Disease on Many Fronts” and “Why I Work to Stop Malaria.” Watch Bill Gates’ TED talk on “mosquitoes, malaria and education,” or other video productions about “malaria eradication” available on the internet.

Figure 1. Life cycle of *Plasmodium*. 
Describe why the following five strategies that are being developed or implemented to stop and treat malaria infections are effective.

a. Better access to medical care
b. New drugs for resistant malaria
c. Vaccine
d. Insecticide treated Bed nets
e. Indoor spraying for mosquitoes.

Resources for this investigation:


Investigation 3: Controlling malaria
Malaria researchers and physicians are optimistic that new drug therapies, combined with public health measures and the control of mosquito populations, can effectively reduce the incidence of malaria in the next decade.

Historians have found references to the use of extracts from the Qing Hao plant,
also known as Chinese wormwood, to treat malaria in China as early as the 2nd century BCE (CDC, 2004). Quinine and other medicines have been used to control malaria since the 18th century, but malarial parasites have evolved resistance to these drugs, thereby rendering them less effective. Drugs called artemisinins made from that Qing Hao plant, currently hold promise for the control of malaria in the 21st century, almost 2000 years after they were first used (Campbell, 2008).

Artemisinins work by rapidly killing the asexual stages of the parasite in the blood of the human host (White, 2008). Researchers believe that they are effective because they kill ring stage parasites as they circulate in the blood, and thus reduce the number of mature parasites that are produced.

WHO recommends that artemisinins be used in combination with other anti-malaria drugs in order to reduce the risk of the development of resistant strains of plasmodium. While artemisinin therapies are making the goal of malaria control seem within reach, many barriers still exist. Effective control strategies must focus not only on curing infected individuals, but also on preventing infection by blocking contact between humans and infected mosquitoes, or by administering a vaccine. It is also important to reduce the concentration of parasites in the blood of infected humans so that mosquitoes that do bite get a parasite-free meal. This investigation explores some strategies for prevention and control.

The complex life cycles and changing interactions of the Plasmodium parasites, the Anopheles mosquitoes, and their human hosts have made the control of malaria an elusive goal. The malaria parasites have become resistant to the drugs used to treat the disease. The mosquitoes also have evolved resistance to insecticides. At the same time, human populations have increased and moved to urban areas, including crowded slums, where conditions such as the lack of screens on windows provide new breeding grounds for mosquitoes.

The UN Millennium Development Goal #6 is to “combat HIV/AIDS, malaria and other diseases.” The Task Force on Malaria has set a goal to reduce malaria morbidity and mortality by 75% from 2005 levels by 2015. The report of the task force offers extensive background and describes both successful and unsuccessful efforts to control malaria.

**Questions for Investigation 3:**
1. In order to better understand malaria, the class will divide into groups to review the task force report, *Coming to Grips with Malaria in the New Millennium*, found in the resources below. Other reports from UNICEF, WHO and the United Nations on malaria may be reviewed as well. In *Coming to Grips with Malaria in the New Millennium*, read the Executive Summary and Chapter 6 on Priority Challenges. Your role is to become an “expert” on one aspect of malaria control below, as addressed in this report and other international health resources.

Divide these topics so that they are distributed among individuals or small groups:

- Health burden
- Economic burden
- Previous malaria control initiatives
Control strategies- prevention,
Control strategies- medical management,
Control strategies- epidemic management,
Control strategies- education
Examples- Ethiopia
Examples- Madagascar
Examples- Vietnam
Examples- South Africa
Examples- Tanzania

You will share your expertise with other groups as the class develops a strategy for malaria control that addresses both immediate and long-term objectives to reduce malaria illnesses and deaths for both adults and young children. Your instructor may ask your group to develop a short paper or presentation about your topic. The class may use their collective knowledge to create a concept map [Cmap Tools <http://cmap.ihmc.us/download>] for the topics above.

2. Malaria control is a current challenge now and will continue to be a challenge. Many research efforts are underway to improve diagnosis, treatment and prevention of malaria. Effective malaria control requires an understanding of mosquito biology and behavior, human physiology and behavior, and Plasmodium biology.

Malaria researchers focus on these topics and more:
   a) Mosquito biology and genome
   b) Mosquito behavior and control
   c) Human immune response to malaria parasite
   d) Plasmodium genome
   e) Plasmodium response to human immune system

Use the internet as a starting point to identify a new strategy for understanding and controlling malaria based on one of the five areas above. Research the approach you’ve identified by looking for articles in scientific journals and scientific news sources, and from information available on the websites of the research leaders.

Scientists often present their early research findings in “Poster Presentations” at scientific meetings that bring together hundreds or even thousands of scientists interested in similar issues. This gives them the opportunity to get feedback on their ideas and to present new findings.

Develop a research poster (Purrington, 2011) as if you were the scientific researcher. Your poster should have a title that identifies the project, the name and academic affiliation of the real researchers involved in the project, a hypothesis that they are testing, and a description of the work they have done or are planning to do. If you can, include a diagram or chart to explain the project. Include a conclusion that explains how your research will contribute to the control of malaria or its complications.

Be prepared to answer questions about “your” project if your instructor organizes a poster session.

Resources for this investigation:

Although dengue is the world’s most common mosquito-transmitted viral disease, its death toll is far less than that of malaria. WHO estimates that 2.5 billion people may be at risk of dengue, but many first infections go undiagnosed (WHO, 2008). In the last 30 years, dengue has appeared in the Americas as outbreaks rather than as an endemic disease. From January through March, 2008, in Rio de Janeiro, Brazil, for example, 32,615 cases of dengue fever were reported, with 245 cases of dengue hemorrhagic fever and 47 deaths due to dengue and its complications (PAHO, 2008). Other outbreaks have occurred in Bolivia, Mexico, the Dominican Republic and in Key West, Florida, USA (Pan American Health Organization, 2011). In contrast to the life cycle of the Plasmodium parasites that cause malaria, the lifecycle of dengue virus is simple.

There are three levels of dengue infection that vary from mild to severe. The initial infection usually causes the mildest form of the disease, dengue fever. This disease rarely leads to death and subsides after a week. Subsequent infections can lead to more serious disease. Dengue hemorrhagic fever usually begins like dengue fever, but becomes worse after several days. Symptoms include hemorrhages from the nose and mouth and bleeding under the skin which looks like bruising. Hemorrhagic fever can cause death. The most severe form of disease caused by dengue virus is dengue shock syndrome which presents the symptoms of dengue fever plus severe bleeding, a drop in blood pressure causing shock, and possible death.

The first infection with dengue virus usually results in a mild illness. There are four subtypes of the dengue virus, however, and the human immune system
overreacts if an individual is later infected with a different subtype. The combination of the viral infection and the immune response in a second infection may cause the more serious symptoms of dengue hemorrhagic fever or shock.

There is no treatment or cure for dengue and no vaccine is yet available. Control of mosquito populations is currently the only strategy for limiting its impact. The *Aedes* mosquitoes that are the most common vectors for dengue virus have very different habits than the *Anopheles* mosquitoes that spread malaria; the *Aedes* mosquitoes are day-biters and breed in puddles and small containers of water, while *Anopheles* mosquitoes are most active at dawn and dusk. Dengue is primarily a disease of urban slums; the mosquitoes thrive in situations of poor sanitation, in houses without screens on windows, where trash accumulates, and where water is collected in open containers.

**Questions for Investigation 4:**
The prevalence of dengue is increasing worldwide as *Aedes* populations are changing. The maps in Figure 2 contrast *Aedes* mosquito ranges before 1970 and then in 2002. Maps for countries with Dengue Hemorrhagic Fever outbreaks are shown in Figure 3.
Figure 3. American countries with laboratory-confirmed hemorrhagic fever prior to 1981 and from 1981 to 2003.

Map: American countries with laboratory-confirmed hemorrhagic fever, prior to 1981 and from 1981 to 2003

American Countries with laboratory confirmed dengue hemorrhagic fever, prior to 1981 and from 1981 to 2003

Source: WHO/PAHO/CDC, Aug. 2004
Use the resources below from the CDC, WHO and the Pan American Health Organization (PAHO) to answer the following questions:

1. What conditions could be responsible for the changes in the range of *Aedes aegypti* mosquitoes shown in the map in Figure 2?
2. How does the distribution of *Aedes aegypti* mosquitoes compare to the distribution of countries with dengue hemorrhagic fever in Figure 3?
3. Could dengue and dengue hemorrhagic fever become a problem in the United States? What efforts are being taken to prevent it?
4. What mosquito control strategies are most effective against the mosquitoes that are vectors for dengue?
5. Are there other diseases that could be spread by *Aedes aegypti*?

**Resources for this investigation:**


Ooi, E-E., Goh, K-T., & Gubler, D.J. Dengue prevention and 35 years of vector control in Singapore [electronic version]. *Emerging Infectious Disease*, 12(6), 887-893.


**Investigation 5: New Mosquito Borne Viral Outbreaks**

1. Several recent outbreaks of mosquito borne illnesses in different parts of the world illustrate the complexity of predicting outbreaks when mosquitoes travel, disease agents mutate, and weather patterns change. Use the resources of the Centers for Disease Control, PAHO, and WHO to research one of the following:
   - Spread of West Nile virus in the United States
   - Emergence of Chikungunya in Reunion Island and in Italy
   - Outbreak of Zika virus in Yap

Prepare a poster or written report on the disease you research. Make sure you include a map and figure to illustrate your information. What do you infer from these outbreaks about the arrival of a new viral disease in previously unexposed population?
References:


Malaria Atlas Project. Accessed May 2011, from: <http://www.map.ox.ac.uk/>


HIV/AIDS: Barriers and Opportunities for Control

Marion Fass, Julie Seiter, Ethel Stanley, and Margaret Waterman

Learning objectives:
Analyze the impact of deaths from AIDS on a country’s population; past, present and future.
Describe the prevalence of HIV/AIDS in the US and discuss the demographic groups that are affected.
Compare and contrast the prevalence of HIV/AIDS in the US and Africa and availability of antiretroviral drugs in these two regions.
Evaluate the pros and cons of available preventive strategies for HIV/AIDS.

Introduction
Viruses exist, it seems, simply to make more viruses and by this measure, the human immunodeficiency virus (HIV) is probably one of the world’s most successful viruses. HIV began infecting humans sometime in the 20th century. Since then, HIV has infected more than 58 million people, more than 25 million of whom had died by 2008. What we call AIDS (acquired immunodeficiency syndrome) is the end stage of infection with HIV. The connection between the HIV and AIDS was identified only in 1983.

The global epidemic of HIV/AIDS highlights the interaction between host, agent and environment. HIV’s unique biological characteristics, its modes of transmission and the social conditions of the populations it infects and affects have all contributed to its spread.

In this article we will explore the social impact of HIV/AIDS on individuals and populations, examine the biology of the retrovirus as well as the human immune response, and investigate some of the biological and social strategies for prevention and treatment of HIV/AIDS.

HIV/AIDS and Population Structure
Investigation 1: Ghana, Lesotho and Botswana
One way to characterize a society is to look at the age distribution of the population. The population pyramids (also called “age pyramids”) shown in Figure 1 contrast the populations of two African countries, Ghana and Lesotho in 1950 and 2007. Ghana had an HIV/AIDS prevalence rate of 1.9% in 2007 while Lesotho had a rate of 22.3% (Kaiser Family Foundation). In these diagrams, each bar represents the percentage of people in that country in a 5 year age range. A high prevalence of HIV/AIDS affects the population distribution by decreasing life expectancy. In Figure 2 the effect of high infection rates is shown by the shift in age distribution of deaths.

Botswana is one of the wealthiest and most stable countries in southern Africa. Since 2002, the government of Botswana and their international collaborators have provided antiretroviral drugs to treat HIV/AIDS in Botswana. Although acceptance of drugs was slow originally, the program now reaches 80% of the people in need. Many researchers believe that access to drugs reduces the stigma that people with HIV/AIDS experience: when HIV/AIDS isn’t such a death-sentence, people are willing to be tested and more willing to discuss their experiences (Wolfe et al., 2008).

Figure 3 shows the age structure of Botswana as it was in 2005 and as it would have been without HIV/AIDS. In 2006 in Botswana, 24% of adults 15-49 were infected with HIV (Wolfe et al., 2008).

**Questions for investigation 1: Ghana, Lesotho and Botswana**

1. Look at the population pyramids for Ghana and Lesotho in Fig. 1:
   a. How did the age structure of the populations compare in 1950? What percentage of the population was under 20 in 1950?
   b. Contrast these to the pyramids for 2007. Which segment of the population has been impacted the most? What evidence do you have?
   c. What other social, political or healthcare changes might have been going on to affect the age structure of the population?

![Figure 3. Age pyramid for Botswana, 2005, with and without AIDS. The graph shows the number of people in each of the age groups from 0-4 to 80+. The dark bars represent the actual population in 2005. In this chart, the light bars indicate the projected population of Botswana in 2005 without the impact of HIV/AIDS. (Adaptation of figure from Baingana and Bos, 2006)](image-url)
2. Use Figure 3, the study of Botswana for these questions:
   a. What was the projected population between the ages of 20 to 45 with and without the impact of HIV/AIDS?
   b. How does the projection for Botswana compare with Figure 4-2?
   c. Write a paragraph to describe what you infer from this graph about how HIV has affected the population of Botswana. Look at all ages for this analysis.

Prevalence and Incidence of HIV/AIDS
Do you know someone living with HIV/AIDS? Do you know someone who has died of AIDS?

The Centers for Disease Control and Prevention (the official name of the CDC) estimates in 2009 that there were more than 1 million people infected with HIV living in the US. From the number of cases, epidemiologists calculate prevalence rate, defined as the number of cases of a condition at a particular point in time divided by the total number of individuals in the population at that point in time, then converted to percent.

Researchers estimate that 56,300 new people became infected in 2006 (August 6, 2008 issue of the Journal of the American Medical Association (JAMA), but that the newly diagnosed people are not evenly distributed in the US population. The number of new cases during a period of time (for example, one year) divided by the total number of individuals in the population (then converted to percent) is called the incidence rate.

Investigation 2: HIV/AIDS incidence in the US
1. Look at one of the data sets from the resources below. Then pick out 3 topics in the following list below and explain the trends that you see.
   a. Estimated Percentage of New HIV Infections by Race/Ethnicity
   b. Estimated Percentage of New HIV Infections by Sex
   c. Estimated Percentage of New HIV Infections by Transmission Category
   d. Estimated Percentage of New HIV Infections by Sex and Transmission Category
   e. Estimated Percentage of New HIV Infections by Age

Resources for this investigation:


<http://www.avert.org/usa-states-cities.htm>


Investigation 3: HIV/AIDS in your community.
Use data from Avert or the CDC to look at and/or calculate the following:

1. Look at the incidence rate and prevalence of HIV/AIDS in your community or a nearby city.
2. Contrast the prevalence in your community to those of: Miami, FL; Newark, NJ; Denver, CO; and, Seattle, WA.

3. What might account for the differences in prevalence of HIV in the cities you researched?

4. Since 1995, people in the US have had access to antiretroviral drugs that controlled HIV in the body and dramatically reduced the death rate of people living with HIV/AIDS. These drugs are now being made available to people worldwide. How do you think that the availability of drugs for HIV in the US has affected the prevalence of the disease? How might it have affected the incidence?

Resources for the investigation:


Investigation 4. Contrasting the impact of HIV/AIDS in the US and other nations

1. Look at the map below (Figure 4) or locate a map online to contrast the adult prevalence rate in the US with Russia, China, Kenya, Senegal, India, and South Africa. Make a table listing the adult prevalence rates.

2. Use other resources to label the names of the countries on the map that are in the darkest/highest prevalence areas.

Resources for this investigation:


**Investigation 5. How do your observations compare with an expert?**

Professor Hans Rosling, the developer of Gapminder, has analyzed HIV prevalence data from UNAIDS to provide some surprising insights. Watch the video, “HIV: New Facts and Stunning Data Visuals” (Gapminder, 2009).

1. Compare Professor Rosling’s observations in this video with the observations you’ve made about HIV in the US and in Africa. How does his analysis affect your views of the problem? Discuss three observations that he made.

**Resource for this investigation:**


**Prevention of HIV/AIDS**

Not all countries are affected equally by HIV/AIDS. Figure 1 showed the impact of HIV on the shape of age pyramids in more and less affected countries. The **prevalence** (percent of infected people) for HIV in Ghana is only 1.9% (1.7-2.2) while in Lesotho it is 22.3% (21.9-24.1) (UNAIDS, 2008a). Although the countries had similarly distributed populations in 1950, they became very different by 2007.

Why is HIV/AIDS so prevalent in some countries and not in others? Steps taken by officials in Senegal, in West Africa, help illustrate the complexity of preventing the spread of HIV/AIDS. The Senegalese developed an AIDS policy in the early 1980s, engaged early in AIDS education (Figure 5), and began to screen blood for HIV in 1987. The current prevalence of HIV/AIDS in Senegal is only 1%.
HIV prevention posters from Senegal are straightforward, and advocate the use of condoms for prevention. Translation: “I urge my partner to use a condom to protect me from STIs and HIV/AIDS.”

Stephanie Nolen’s (2007) stories from 28 Stories of AIDS in Africa identify some of the challenges of prevention and treatment of HIV. Although treatments have increased the lifespan of people infected with HIV, the epidemic will not be controlled without consistent efforts at disease prevention. Some strategies for HIV prevention are well documented, effective, and adapted to a variety of cultures, while others are still being tested.

All HIV prevention strategies involve biomedical and behavioral components; they must be effective, acceptable, and used correctly. No one strategy works for all people and many strategies must be combined to effectively control HIV in a community. No preventative vaccine is available as of this writing.

Investigation 6: Prevention of Mother to Child Transmission

One example of an effective, acceptable HIV prevention strategy is the prevention of mother to child transmission (PMTCT) of HIV using antiretroviral drugs (United Nations Children's Fund, 2007). These drugs interrupt the replication process of the virus. Although it is effective, the availability of medical services and the stigma of HIV/AIDS are barriers to universal access to drugs for pregnant women. If untreated, about 15-30% of babies born to HIV positive (HIV+) mothers will become infected during development and/or delivery and an additional 5-20% may be infected during breastfeeding. With testing and treatment of pregnant women, the rate of infection can be reduced to less than 2% (United Nations Children's Fund, 2007).

In the United States, with the implementation of routine HIV screening of pregnant mothers and the treatment of mothers and newborns, the number of babies born who are infected with HIV has dropped to less than 50 per year. UNICEF and other organizations have advocated for treatment of pregnant mothers, and this has become part of the United Nations Millennium Development Goals. Figures 6 and 7 below from UNICEF illustrate the great progress made in the last decade; they also make it easy to identify where progress still needs to be made.
Questions for Investigation 6: Prevention of Mother to Child Transmission
1. While the percentage of women treated to prevent mother-to-child transmission has increased greatly, there are still many undiagnosed or untreated women who deliver. Look at Figure 7 and identify the four countries with the highest number of infected mothers who will deliver without preventive measures. List these countries and calculate the estimated number of women.

Investigation 7: Other prevention strategies
1. Complete Table II, Prevention Strategies Evaluation Chart, working individually or in a group. Divide up the class into research teams to gather more information about these strategies and share your findings with the class. Consult the resources listed below.
Table II. Prevention strategies evaluation chart.

<table>
<thead>
<tr>
<th>Strategy</th>
<th>Who controls it?</th>
<th>Where has it been tested? When?</th>
<th>How effective is it?</th>
<th>How hard is it to adhere to or to use consistently?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male condom</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ARV drugs for preventing mother to child transmission</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Treatment of STIs</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vaginal microbicides</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male circumcision</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Providing schooling for girls</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female condom</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Screening of blood supply</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Provision of clean needles to IV drug users</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Investigation 8: Synthesis HIV prevention: A complex approach

The basics of HIV prevention are clear. Avoid having sex or injecting drugs with infected partners and you won’t get HIV. This advice is harder to follow than it is to write; the numbers of people with HIV infection has continued to rise in many parts of the world.

Your final project is one that pulls together all that you have learned: you will create an HIV prevention program for a disadvantaged neighborhood in Rio de Janeiro, Brazil. In preparation for the program, your co-workers have done a study of knowledge and attitudes of women in the community (Cianelli, 2008). You can use this to develop a program for men, women or teens. You have 3 years and a grant for $150,000 for staff and supplies.

a. Research programs that have been effective as you plan your educational messages: for raising awareness; engaging in prevention behaviors; to encourage people to be tested; or, to help people with HIV to take their pills. You can decide both the population group you want to target and the strategies to use. Sometimes direct health education isn’t the only way to go; job programs, women’s education, or changes in drug laws may be more effective.

b. Develop an outline of your program.

c. Write a one page justification of the strategies you have chosen.

Resource for this investigation:

Extended Activities
E-1. HIV/AIDS in different countries

As we have seen, HIV is not only a problem in Africa, but also in many other countries around the world. In many countries, HIV/AIDS is localized to particular regions of the country or to particular populations. Choose one of the countries listed below and develop a two page profile of HIV in that country.

a. Who are the most infected?

b. How long has HIV been recognized as a problem by policy makers?

c. Are antiretroviral drugs available to people living with HIV/AIDS?

d. What other factors make HIV a particular problem in this region?

Thailand
Russia
Poland
India
Brazil
Australia
China

Resource for this investigation:
References:


Learning objectives:
Contrast viruses and eukaryotic cells.
Describe the replication cycle of HIV.
Analyze the changing relationship between the amount of virus and immune activity in an individual during the time course of HIV/AIDS from infection to death.
Discuss the progressive damage that HIV/AIDS does to the immune system.
Apply knowledge of HIV replication to explain the action of HAART to treat HIV/AIDS.
Discuss the evidence that circumcision reduces the spread of HIV.
Evaluate the advantages of an effective microbiocide to be used by women in preventing HIV/AIDS.

Introduction to the Biology of HIV/AIDS
We have seen that preventive measures aimed at slowing down the transmission of HIV from person to person often have cultural and social aspects. Several of these measures also interrupt the host-agent-disease cycle – a biological aspect. To find a cure for HIV, or to develop an effective vaccine, or to create effective anti-viral drugs, we must understand the complex biology of both the agent, HIV, and the immune system capabilities of the host.

While all viruses target particular cells in their hosts, HIV targets the cells of the human immune system – the very system we rely on to fight off viruses and other foreign invaders!

The following sections introduce viruses, the structure and replication cycle of Human Immunodeficiency Virus, the immune response to foreign molecules, and the course of HIV infection in a human.

Investigation 1: Some basic virology
All viruses are obligate, intracellular parasites of cells. That means that they require a living cell in order to reproduce. Outside of their host cells, the viral particles are inert with no capacity for using energy. A single virus is called a virion or a viral particle. The simplest viruses consist only of genetic material, either DNA or RNA, and a protein coat called a capsid that surrounds the genetic material. Many viruses have a membrane-like structure as well, called a viral envelope, surrounding the capsid (Figure 1). A few, like HIV, also contain copies of enzymes within the capsid that are unique to the virus (not already found in a host cell).
Figure 1. Drawing of a virus attached to a cell. The capsid with spikes is visible and the genetic material is located inside the capsid. 

The outermost layer of all viruses (whether a capsid or an envelope) has viral attachment glycoproteins (sometimes called envelope proteins). These viral molecules are mainly protein with a small piece of carbohydrate attached. Viral glycoproteins match up with receptor proteins on the outside of host cells. In fact, it is this specific match between host cell receptors and viral attachment glycoproteins that determines which cells are hosts of a particular virus. Typically, viruses can only infect specific types of cells in one species of host, although some viruses, like influenza viruses, can infect more than one host species. Every kingdom of organisms has viruses that attack its member species.

Viruses must enter a living host cell in order to replicate because they do not have the necessary enzymes and structures to replicate on their own. Once in the host cell they control the cell’s metabolism, energy, and resources, while using cellular structures to read viral genes. These viral genes code for viral nucleic acids and proteins that will be used to assemble new viral particles within the host cell. Once replication of new virus particles is complete, they leave the host cell. Some viruses leave by budding off the plasma membrane, while others burst from the cell, thereby destroying the host.

Questions for Investigation 1:
1. Compare the picture of the virus above to a picture of a cell in your textbook or on the web. Which structures are the same? Which are not found in the virus?  
2. How does the virus make up for the parts it doesn’t have?

Resources for this investigation:
If you are not familiar with DNA and the usual way that the genes of a cell are transcribed and translated, you should review the basics of molecular biology in a general biology text or at a reputable website, or you might view a video online, such as Transcription and Translation at <http://www.youtube.com/watch?v=41_Ne5mS2ls> or interact with a simulation such as the one at <http://learn.genetics.utah.edu/content/begin/dna/transcribe/>.

Investigation 2: HIV biology
The HIV is a member of the retrovirus family. Retroviruses contain RNA, reverse transcriptase enzyme, and an envelope with glycoprotein spikes. In the illustration of HIV in Figure 2, the envelope is labeled as lipid membrane and the protein coat is labeled as capsid. Those labeled gp120 are the viral attachment glycoproteins of HIV. HIV contains two identical pieces of RNA within the capsid.

After a retrovirus enters the host cell, the virus’s own reverse transcriptase uses the viral RNA as a template to make a double-stranded DNA molecule. The flow of genetic information goes from RNA to DNA, which is the opposite of what happens in a normal cell, and the name of the enzyme reflects this reversed flow.

The double-stranded viral DNA is transported into the cell’s nucleus where it is
inserted, or integrated, into the cell’s DNA. This viral DNA is now called a provirus. Often, it may remain in the host cell DNA for many years before becoming active. When the host cell synthesizes a new copy of its own DNA, the provirus is copied right along with it. This type of replication, where the viral DNA is dormant for an extended period within the host nucleus is a feature of only some kinds of viruses. Others do not interact at all with the host’s DNA.

Reverse transcriptase does not have the “proofreading” capabilities of the enzymes used in normal cell replication. Thus a high rate of transcription errors occur during the process of copying viral RNA to DNA. These errors cause mutations in the new viral RNA that is produced during viral replication, which is why the HIV virus can mutate so quickly.

The host cells of HIV are cells of the human immune system: macrophages and T helper cells. Macrophages are non-specific initiators of the immune response and may engulf HIV as it arrives. Helper T cells have a particular receptor protein called CD4, which also can bind HIV. Thereby, the gp120 glycoprotein on the HIV surface attaches to the CD4 receptor protein enabling the HIV to infect the cell.

A diagram of the HIV replication cycle is show in Fig. 2. View the animation of the HIV replication cycle and explore other resources for this investigation to understand the basic steps.

Figure 2. Structure of an HIV virus. <http://www.niaid.nih.gov/topics/HIV/AIDS/Understanding/Biology/Pages/structure.aspx>

![Structure of HIV](http://www.niaid.nih.gov/topics/HIV/AIDS/Understanding/Biology/Pages/structure.aspx)
Question for Investigation 2: The replication cycle of HIV

1. HIV works by hijacking the cell’s normal ability to make new proteins. Look at the descriptions of major steps in the HIV
replication cycle and identify the organelles and cell structures that are involved in HIV replication. For each of the HIV replication below, identify the organelles in the host cell that are involved and match them with the replication processes.

a. **Binding and Fusion:** HIV begins its life cycle when the GP120 glycoprotein on the HIV envelope binds to a **CD4 receptor** and one of two **co-receptors**, CCR5 or CXCR4, on the surface of a CD4⁺ T-lymphocyte. The virus then fuses with the host cell. After fusion, the virus releases RNA, its genetic material, into the host cell.

b. **Reverse Transcription:** An HIV enzyme called reverse transcriptase converts the single-stranded HIV RNA to double-stranded HIV DNA.

c. **Integration:** The newly formed HIV DNA enters the host cell's nucleus, where an HIV enzyme called integrase "hides" the HIV DNA within the host cell's own DNA. The integrated HIV DNA is called a provirus. The provirus may remain inactive for several years, producing few or no new copies of HIV.

d. **Transcription:** When the host cell receives a signal to become active, the provirus uses a host enzyme called RNA polymerase to create copies of the HIV genomic material, as well as shorter strands of RNA called messenger RNA (mRNA). The mRNA is used as a blueprint to make long chains of HIV proteins.

e. **Assembly:** An HIV enzyme called protease cuts the long chains of HIV proteins into smaller individual proteins. As the smaller HIV proteins come together with copies of HIV's RNA genetic material, a new virus particle is assembled.

f. **Budding:** The newly assembled virus pushes out ("buds") from the host cell. During budding, the new virus is encapsulated in part of the cell's outer envelope. This envelope, which acts as a covering, is studded with protein/sugar combinations called HIV glycoproteins. These HIV glycoproteins allow the virus to bind CD4 and co-receptors. The new copies of HIV can now move on to infect other cells.

**Resources for this investigation:**


**Investigation 3: HIV Infection and the Body’s Response**
HIV’s main host cells are macrophages and the helper T cells (T_H) of the human immune system. T_H cells are also known as T4 cells, or as CD4 cells, because of the CD4 receptors on their membranes. T_H cells secrete chemical messengers that control the action of other classes of immune system cells. The amount of T_H cells is measured by the “CD4 count,” one indicator of the health of the immune system and progress of the disease. A normal CD4 count is between 800 and 1000 cells/mm³.

During the initial infection the HIV replicates quickly and releases millions of new viral particles in the first few weeks (Figure 4). The population of viral particles in the blood may reach 10,000,000/ml. At this time infected persons may not know
they are infected, but now is when they are most likely to spread the disease to others because of the high concentration of HIV in the blood. The population of T\textsubscript{H} cells declines rapidly as they are infected and destroyed.

After the initial T\textsubscript{H} cell decline, the body starts making antibodies against HIV, and these reduce the number of HIV particles in the blood. The T\textsubscript{H} population recovers and continues to produce an immune response that keeps viral levels low and steady. By this time, some infected T\textsubscript{H} cells have viral DNA integrated in their genome. These HIV genes remain latent until activated at a later time and produce virus.

Over time the host’s immune response fails due to infection of the helper T cells and viral levels rise again. The patient begins to experience opportunistic infections such as *Candida albicans* yeast infections of the mouth or vagina, persistent diarrhea, fever, weight loss and reactivation of previous infections such as shingles and tuberculosis. Without treatment, as many as 100 billion HIV particles are produced each day in the lymph tissue and attacked by macrophages and antibodies. As many as 2 billion T cells are produced each day in response to the growing viral load. As HIV out competes the T cells, the host can no longer produce enough T cells to keep the virus under control. In the U.S., clinical AIDS is diagnosed when a person’s CD4 count falls below 200/mm\textsuperscript{3}.

The time for progression from the initial infection with HIV to clinical AIDS varies widely, from months to years. Treatment with antiviral drugs (discussed in Investigation 4), can dramatically change the course of the infection by reducing the ability of the virus to replicate and thereby allowing the health of the immune system in HIV positive people to recover.
Questions for Investigation 3:
1. Look at Figure 4 and describe the relationship between the amount of virus, represented by the “HIV RNA copies” and the number of T\textsubscript{H} cells in the blood, as represented by the CD4 count (remember that CD4 receptors are on the surface of the T\textsubscript{H} cells.) What is going on in the first 2-3 months? What happens during the final 2-3 years?

2. At what time in the disease experience would the infected individual be most likely to pass HIV to another person? Use the data on “HIV RNA copies” to justify your answer.

3. Explain why an inactive case of TB might become active as the HIV infection progresses. Refer to specific components of the immune system.

Investigation 4. Treating HIV Infections
When developing drugs to treat HIV, scientists focus on specific steps in the life cycle of the virus which might be inhibited to stop viral replication. The best drugs interrupt functions that are specific to the virus and do not occur in the human host.

A combination of three or more medications from different classes is recommended for treatment of HIV. This regimen, called Highly Active Antiretroviral Therapy (HAART), is tailored for patients depending on age, type of HIV infection and other factors. HAART was introduced in 1995 and dramatically reduced AIDS-related deaths.

Using a combination of drugs from at least two different classes of antiviral drugs significantly reduces the chance of the evolution of resistance since two types of mutations would have to simultaneously occur for the strain to survive the treatment.

Questions for investigation 4
1. Why is it important to target functions that only occur during viral replication and not in normal human cells?

2. On the diagram of the HIV life cycle (Figure 3), label the site of action for the following classes of anti-AIDS drugs: A. fusion of the virus to the cell; B. integration of the viral genes into the cell’s chromosome; C. nucleoside reverse transcriptase inhibitors; D. non-nucleoside reverse transcriptase inhibitors; E. protease inhibitors; and F. integrase inhibitors.

3. Why is it important that the HIV infected patients take their pills as prescribed?

4. The Reverse transcriptase enzyme which copies the RNA into complementary DNA cannot proofread and correct errors. This causes a high rate of mutations. How does a high rate of mutations make HIV more difficult to control?

Resources for this investigation:


Investigation 5: Circumcision as prevention

Two new strategies for prevention of HIV build upon our understanding of the interaction between the immune system and HIV.

Across Sub Saharan Africa health workers and community leaders are recommending that young men and boys get circumcised in order to reduce their risk of getting HIV. The Zulu king in South Africa has recommended that all Zulu men become circumcised (CNN, 2010). These changed recommendations are: (1) based on epidemiological observations of patterns of male circumcision and HIV rates in Sub Saharan Africa, where cultural patterns differ by ethnic groups and (2) based on a series of experimental studies done in the early 2000s based on these observations.

Obviously it’s challenging to ask a group of men to change their cultural preferences in this area. But the data are strong that rates of new infections by heterosexual encounters can be reduced by 60% when compared with men who are not circumcised.

Questions for Investigation 5: Studying the study

Two studies in 2007 in the medical journal, The Lancet, reported results of randomized controlled trials of male circumcision. Read one of these studies and answer the following questions:

1. What is the advantage of a randomized, controlled study as described in the article you read? What is the control group? How did the control group differ from the experimental group?

2. What were the ethical challenges faced by these researchers?

3. The study designers faced a challenge in recruiting men at risk for HIV into this study. What did they do to find men to enroll, and how did they encourage them to enroll?

4. What is the biological mechanism that makes this work? (Hint: Are there cells around the foreskin that might increase risk of infection?)

5. How might this strategy for reducing rates of new male infections affect women at risk?

6. How do you think mothers will change behavior for newborn boys?
Resources for this investigation:
These Lancet articles are free online but you will need to register.


Investigation 6: HIV Prevention for Women
Epidemiologists have noted that in Sub-Saharan Africa, women are infected with HIV/AIDS at a higher rate than men. The reasons are both biological and sociological, and the options for prevention methods that women can control are limited. The female condom has been accepted enthusiastically in some communities, but there has been a call for the development of a microbicide that women can use unobtrusively. Several strategies are under development, but progress has been slow.

Questions for Investigation 5:
Family Health International and the Campaign for Microbicides both provide biological information about this important strategy and track the progress of clinical trials. Review these websites to answer the questions below:

1. Why are vaginal microbicides important in the effort to control new HIV infections? How do they affect a woman’s ability to avoid infection with HIV?

2. What are 3 biological approaches that are being tried in the development of microbicides?

3. What are 3 of the challenges in designing ethical and responsible studies to determine the effectiveness and the acceptability of these new products?

Resources for this investigation:


References:


Marion Field Fass is Professor and Chair of the Biology Department and Chair of the Health and Society Program. She is interested in the intersection of individual biology, public health, sustainability and environmental factors that lead to the emergence of new diseases. She has engaged with the interdisciplinary perspectives necessary to understand these relationships, and the opportunities to build curricula for undergraduate students that combine scientific investigations with social and cultural understanding and that motivate students to work for social justice. Her research has focused on the measurement of community health needs and on methods of assessment of student learning. Marion is a SENCER (Science Education for New Civic Engagements and Responsibilities) Leadership Fellow and regularly serves as faculty for SENCER Summer Institutes. She was the PI of a grant from the Teagle Foundation that investigated the relationships between learning in the major and all college goals. She is currently co-PI on a Keck/Project Kaleidoscope Facilitating Interdisciplinary Learning grant. Her courses include Human Biology, Microbiology, Emerging Diseases, Global Health and a first-year course on Slow Food (Beloit College Magazine, Summer 2008).

Julie Seiter joined the faculty of Oakland Community College in 1994. Her primary teaching responsibilities are microbiology, environmental science and global health and she has taken an active role in curriculum development in biology. She received her Ph.D. from Wayne State University with a major in food microbiology and a minor in chemistry. Her B.S. and M.S. were in botany and biology respectively. During her post-doctoral work with James M. Jay she focused on rapid assessment methods for detecting microbially contaminated meat. Before joining academia, Dr. Seiter spent 9 years at BASF Corporation as a research scientist and senior research scientist followed by 3 years at an independent testing laboratory. In both positions she was involved with hands-on research and testing of food products as part of ongoing food safety programs. Her passion about global health results from the intersection of her interests in microbiology, environmental science and food safety.
Ethel D. Stanley is the Director of the BioQUEST Curriculum Consortium which actively supports educators interested in the reform of undergraduate biology education through collaborative development of curricula. Dr. Stanley leads or collaborates on multiple BioQUEST projects, which feature teaching strategies that support inclusivity, open-ended inquiry and numeracy while using simulations, tools, data, cases and other resources for problem posing, problem solving, and peer review. Dr. Stanley earned her MS in botany at Wayne State University and her Ed.D. in science education at Illinois State University. To her leadership of reform in biology education, Dr. Stanley brings over two decades of teaching experience at Millikin University and Oakland Community College where she taught innovative courses for preservice teachers, biology majors and majors outside of the sciences. She has served as President of the Association of College and University Biology Educators, Chair of the Teaching Section of the Botanical Society of America, and Editor of *Bioscene: The Journal of College Biology Teaching*. She presents on reform in biology education nationally and internationally, as well as works with teachers and college faculty in professional development workshops. She has co-authored three books and over 30 articles on biology education, visual learning and investigative case based learning.

Margaret Waterman is a science teacher educator and professor of biology at Southeast Missouri State University. Before coming to Southeast, she taught biology at Kenyon College and Emory University and did faculty development work at the University of Pittsburgh and Harvard Medical School. Her M.S. in plant pathology and Ph.D. in science education were completed at Cornell University. Dr. Waterman is recognized for her work on problem based and investigative case based learning (ICBL) in the sciences. She works with science faculty and high school teachers on developing materials and approaches for using ICBL to integrate new content, approaches and skills in biology curriculum. In addition to numerous presentations at scientific and education organizations in the U.S., Dr. Waterman has presented internationally on investigative case based learning and sustainability education, and has worked with school teachers in India, Peru, South Africa and Singapore. She was President of the Association of College and University Biology Educators and has written over 30 papers and book chapters on undergraduate science education. With Collaborator Dr. Ethel Stanley of the BioQUEST Curriculum Consortium, she has developed ICBL approaches and materials and conducted grant-funded research and development. Their book *Biological Inquiry: A workbook of investigative cases*, 3rd ed. (2010) is used by undergraduates around the world. Their website at [http://bioquest.org/icbl](http://bioquest.org/icbl) has a catalog of more than 50 cases ready for use.
The last decade has witnessed the emergence of global health as an important field of academic study. Heightened awareness amongst students and the public of the global health agenda has been coupled with increased flow of resources into the field, leading to a burgeoning in the number of institutions worldwide offering programmes in global health. We thus face the challenge of how best to educate health professionals to prepare them for the global marketplace.

The term ‘global health’ involves many disciplines within and beyond the health sciences. The knowledge base includes the biological basis of infectious diseases, non-communicable diseases, the social, economic, political, and environmental determinants of health and health inequities, global actors and agencies in public health and the impact of humanitarian emergencies and interventions. The disciplinary framework has also expanded beyond the traditional health professions to embrace such areas as business, law and the social sciences (Merson & Page, 2009). The fact that global health is interdisciplinary in content and approach is one of its attractions. However, it is also one of its challenges in terms of delivery of education programmes.

Furthermore, imparting knowledge and understanding is not enough. We require a future health workforce that can take a broad view across the spectrum of public health, with an ability to work collaboratively and use their skills to influence policy-making at all levels, local, national and international (Beaglehole et al. 2004). Thus we need to ensure that educational approaches foster critical thinking and equip students to make appropriate decisions in complex and often unpredictable situations.

This special issue of Biology International presents a collection of interdisciplinary resources across the global health spectrum. Using statistics and case studies for a variety of topics, the student is invited to reflect on health conditions in rich and poor countries, apply knowledge, evaluate evidence and draw appropriate conclusions. Thus the development of skills in analysis and critical thinking is promoted. From a student perspective, this approach facilitates engagement at different levels depending upon prior experience. For a teacher, the assembly of a wealth of interdisciplinary information in a format that can be easily understood and readily disseminated instills confidence to venture beyond the boundaries of their personal expertise.

This will be of particular value to staff teaching in smaller or less well-resourced institutions who cannot necessarily call on experts across all of the cognate disciplines of global health to contribute to education programmes. Although the resources are designed to be introductory, the approach is sufficiently flexible for them to be easily adapted for delivery at higher levels, including Masters.

The scope of the articles in this special issue is wide-ranging, embracing infectious disease, maternal health, biology and control of disease vectors and nutrition. One area that may require attention in the future is a greater focus on how research findings can be translated into public health policy and practice. This is an area of rapidly growing importance, not least due to pressures from research funders to demonstrate the ‘impact’ of their investment. A detailed
discussion has recently been published of the role of communication and stakeholder engagement in translating research in HIV/AIDS and Sexual and Reproductive Health (Theobald et al. 2011). These insights also have important implications for other health issues. As we prepare our health professionals to enter the global health arena, we must give them not only subject knowledge, but also the tools to help them close the gap between research and practice and deliver ‘real world’ solutions to global health challenges.

References


Susan Assinder was appointed in 2008 as the first Director of Education in the Liverpool School of Tropical Medicine. She is responsible for the strategic development of a complex teaching effort of Masters programmes and professional development courses delivered both in Liverpool and in-country, particularly in sub-Saharan Africa and the Middle-East. Her scientific background is in molecular microbiology and she previously worked for over 20 years as a lecturer in molecular genetics. Outside of conventional teaching and learning, Dr. Assinder has for many years pursued an interest in promoting public engagement with science, winning the BBSRC Science Communicator award in 1995 and the 2010 Peter Wildy Prize for Microbiology Education. She has produced two activity books for schools, 'DNA - The Recipe for Life' and 'How the Mushroom Got its Spots - An Explainers' Guide to Fungi'. She has worked extensively on education activities with the Society for General Microbiology and is currently a member of the Society of Biology Education, Training & Policy Committee and the American Society for Microbiology International Education Committee.
Biology International

The Official Journal of the International Union of Biological Sciences

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