RESOURCES
Free, online presentations, downloadable activities in PDF format, and annotated slide sets for classroom use are available at www.bioedonline.org or www.k8science.org.

CONTENT ADVISORY
See the following resources for additional information about HIV/AIDS and advice for discussing HIV/AIDS with students.

- National Institute of Allergy and Infectious Diseases, National Institutes of Health (NIH), offers resources on understanding HIV/AIDS: niaid.nih.gov/topics/hiv/aids and aidsinfo.nih.gov.

- National Institute on Drug Abuse, NIH, offers facts about drug abuse and the link between it and HIV/AIDS: hiv.drugabuse.gov.

- The Centers for Disease Control and Prevention provides up-to-date information on HIV/AIDS prevention: cdc.gov/hiv/topics.
ACKNOWLEDGMENTS

This guide was developed in partnership with the Baylor-UT Houston Center for AIDS Research, an NIH-funded program (AI036211). The authors gratefully acknowledge the support and guidance of Janet Butel, Ph.D., and Betty Stalley, Ph.D., Baylor-UT Houston Center for AIDS Research; William A. Thomson, Ph.D., BCM Center for Educational Outreach; and C. Michael Fordis, Jr., M.D., BCM Center for Collaborative and Interactive Technologies. The authors also sincerely thank Marsha Matyas, Ph.D., and the American Physiological Society for their collaboration in the development and review of this guide; and L. Tony Beck, Ph.D., of NCCR, NIH, for his assistance and support. In addition, we express our appreciation to Amanda Hodgson, B.S., Victor Keasler, Ph.D., and Tadzia GrandPre, Ph.D., who provided content or editorial reviews; and J. Kyle Roberts, Ph.D., and Alana D. Newell, B.A., who guided field test activities and conducted data analyses. We also are grateful to the Houston-area teachers and students who piloted the activities in this guide.

We are indebted to many scientists and microscopists who contributed SEM and TEM images to the CDC's Public Health Image Library, including Ray Butler, Ph.D., Janice H. Carr, Betsy Crane, Edwin P. Ewing, Jr., Ph.D., Lucille K. Georg, Cynthia S. Goldman, M.S., and Elizabeth H. White, M.S. We especially thank Charles P. Daghlian, Ph.D., and Louisa Howard, Electron Microscope Facility, Dartmouth College, for providing SEM and TEM images used in this publication.

No part of this book may be reproduced by any mechanical, photographic or electronic process, or in the form of an audio recording; nor may it be stored in a retrieval system, transmitted, or otherwise copied for public or private use without prior written permission of the publisher. Black-line masters reproduced for classroom use are excepted.

Center for Educational Outreach, Baylor College of Medicine
One Baylor Plaza, BCM411, Houston, Texas 77030 | 713-798-8200 | 800-798-8244 | edoutreach@bcm.edu
bioedonline.org | kbscience.org

SOURCE URLs

AMERICAN DENTAL EDUCATION ASSOCIATION
explorehealthcareers.org

BAYLOR COLLEGE OF MEDICINE
BIOED ONLINE TEACHER RESOURCES
bioedonline.org | kbscience.org

BAYLOR-UT CENTER FOR AIDS RESEARCH
bcm.edu/cfar

MOLECULAR VIROLOGY AND MICROBIOLOGY
bcm.edu/molvir

DARTMOUTH COLLEGE
ELECTRON MICROSCOPE FACILITY
dartmouth.edu/~emlab/

THE HENRY J. KAISER FAMILY FOUNDATION
kff.org

JOURNAL OF NANOBIOTECHNOLOGY
jnanootechnology.com/content/3/1/6

NATIONAL INSTITUTES OF HEALTH
LIFEWORKS
science.education.nih.gov/lifeworks

NATIONAL CENTER FOR RESEARCH RESOURCES
ncrr.nih.gov

NATIONAL INSTITUTE OF ALLERGY AND INFECTIOUS DISEASES
www.niaid.nih.gov
aidsinfo.nih.gov

NATIONAL INSTITUTE ON DRUG ABUSE
hiv.drugabuse.gov

NATIONAL LIBRARY OF MEDICINE
nlm.nih.gov/hmd

SCIENCE EDUCATION PARTNERSHIP AWARD
ncrrsepa.org

SUMANIS, INC.
ANIMATED TUTORIALS: MICROBIOLOGY
http://sumanasinc.com/webcontent/animation.html

U.S. CENTERS FOR DISEASE CONTROL AND PREVENTION (CDC)
HIV/AIDS PREVENTION
cdc.gov/hiv/topics
PUBLIC HEALTH IMAGE LIBRARY
phil.cdc.gov

U.S. CENTRAL INTELLIGENCE AGENCY
THE WORLD FACTBOOK

WELLCOME IMAGES
images.wellcome.ac.uk

WHAT IS PUBLIC HEALTH
whatispublichealth.org

WIKIMEDIA COMMONS
commons.wikimedia.org
INTRODUCTION

Microbial Challenges

Infectious diseases have plagued humans throughout history. Sometimes, they even have shaped history. Ancient plagues, the Black Death of the Middle Ages, and the “Spanish flu” pandemic of 1918 are but a few examples.

Epidemics and pandemics always have had major social and economic impacts on affected populations, but in our current interconnected world, the outcomes can be truly global. Consider the SARS outbreak of early 2003. This epidemic demonstrated that new infectious diseases are just a plane trip away, as the disease was spread rapidly to Canada, the U.S. and Europe by air travelers. Even though the SARS outbreak was relatively short-lived and geographically contained, fear inspired by the epidemic led to travel restrictions and the closing of schools, stores, factories and airports. The economic loss to Asian countries was estimated at $18 billion.

The HIV/AIDS viral epidemic, particularly in Africa, illustrates the economic and social effects of a prolonged and widespread infection. The disproportionate loss of the most economically productive individuals within the population has reduced workforces and economic growth in many countries, especially those with high infection rates. This affects the health care, education, and political stability of these nations. In the southern regions of Africa, where the infection rate is highest, life expectancy has plummeted in a single decade, from 62 years in 1990–95 to 48 years in 2000–05. By 2003, 12 million children under the age of 18 were orphaned by HIV/AIDS in this region.

Despite significant advances in infectious disease research and treatment, control and eradication of diseases are slowed by the following challenges:

- The emergence of new infectious diseases
- An increase in the incidence or geographical distribution of old infectious diseases
- The re-emergence of old infectious diseases
- The potential for intentional introduction of infectious agents by bioterrorists
- The increasing resistance of pathogens to current antimicrobial drugs
- Breakdowns in public health systems.

Using Cooperative Groups In The Classroom

Cooperative learning is a systematic way for students to work together in groups of two to four. It provides organized group interaction and enables students to share ideas and to learn from one another. Students in such an environment are more likely to take responsibility for their own learning. Cooperative groups enable the teacher to conduct hands-on investigations with fewer materials.

Organization is essential for cooperative learning to occur in a hands-on science classroom. Materials must be managed, investigations conducted, results recorded, and clean-up directed and carried out. Each student must have a specific role, or chaos may result. The Teaming Up! model* provides an efficient system for cooperative learning. Four “jobs” entail specific duties. Students wear job badges that describe their duties. Tasks are rotated within each group for different activities so that each student has a chance to experience all roles. For groups with fewer than four students, job assignments can be combined.

Once a model for learning is established in the classroom, students are able to conduct science activities in an organized and effective manner. Suggested job titles and duties follow.

Principal Investigator
- Reads the directions
- Asks the questions
- Checks the work

Maintenance Director
- Follows the safety rules
- Directs the cleanup
- Asks others to help

Reporter
- Records observations and results
- Explains the results
- Tells the teacher when the group is finished

Materials Manager
- Picks up the materials
- Uses the equipment
- Returns the materials

IMAGINE YOU ARE A DOCTOR...

A young man arrives at your hospital in a very weak, deteriorated condition. His body resembles that of a concentration camp survivor. After running a few tests, you determine the patient is suffering from pneumocystis pneumonia, a very rare lung infection, especially in people with healthy immune systems. As a doctor, you refer to the infection as PCP. Over the coming weeks, several more patients arrive at your hospital, suffering from the same condition. All eventually die. You infer that every recent PCP patient had a weakened immune system.

A cluster of patients with the same rare condition raises a medical “red flag.” Something new may be happening.

Across the country, other doctors encounter larger than the usual numbers of PCP patients, and other people with a different rare disease, Kaposi’s sarcoma (or KS). KS is a form of cancer. It causes purple, red, brown and black skin lesions (sores) to appear over the entire body and in the mouth. The lesions are painful and disfiguring. They make eating difficult, and often are accompanied by unrelenting headaches. Ultimately, the KS patients die. Like PCP, Kaposi’s sarcoma is exceedingly rare in people with healthy immune systems. Doctors treating KS patients infer that these people had weakened immune systems.

WHAT IS HIV?

In the strictest sense, HIV, the Human Immunodeficiency Virus, is not a life form. Until it invades a human host, it’s just a protein-coated mass of genetic material, no more alive than a grain of sand. Under a microscope, HIV appears insignificant, approximately 120 times smaller than the white blood cells it invades. But it is frighteningly powerful. Once inside a cell, HIV’s genetic material serves as a biological “how-to” manual. The virus replicates itself hundreds of thousands of times, until the cell can no longer contain all the individual viruses. The new viruses push out, or “bud,” through the cell wall. In the process, they steal part of the cell’s outer envelope (cell membrane), which they use to create an outer protective layer.

This really happened. The first recognized cases of the syndrome we today call AIDS, or acquired immunodeficiency syndrome, appeared in homosexual men in California in 1981. Soon after, similar clusters of AIDS cases occurred in New York. Then, men and women of Haitian origin began checking into Miami hospitals with symptoms of both PCP and KS. They, too, had AIDS, which was spreading across the country. It is estimated that by the time of its discovery, the new virus called HIV already had infected hundreds of thousands of men, women and children in the United States, and millions more people around the world.

HIV

This is a blood cell infected with HIV. Notice how tiny the HIV particles are compared to the cell!
Photo: Charles P. Daghlian, Ph.D., and Louisa Howard, Dartmouth College.

Over a period of years, new HIV copies spread through the host body to infect more and more cells.

Gradually, the body’s white blood cells, the “backbone” of a person’s immune system, are destroyed. When the immune system is working, it attacks and fights off invading diseases. But when it is weakened or destroyed, it can no longer protect the body. Ultimately, HIV infection leads to a condition called AIDS, or acquired immunodeficiency syndrome. Untreated, AIDS opens the body to progressively rare and devastating illnesses until death results.
Overview

Students will learn about the basic structure of the human immunodeficiency virus by constructing three-dimensional paper models of an HIV virus particle.

TIME
Setup: 20 minutes
Activity: 1–2 class periods

MODELING AN
HIV Particle

This activity will help students visualize the Human Immunodeficiency Virus (HIV) by having them construct 3D HIV particle models from paper. The model to be used represents a complete viral particle. It is a 20-sided polyhedron, called an icosahedron, which approximates the shape of the virus. The completed, three-piece model is about 500,000 times larger than an actual HIV virus particle. Students will combine their finished models into one mass in a first step toward estimating how many HIV particles could be contained inside a white blood cell before being released into the blood stream to attack new cells.

MATERIALS
Per Student
• “Modeling an HIV Particle” sheet printed on white card stock paper
• Scissors
• Cellophane tape (one roll can be shared by two or three students)
• Metric ruler with straight edge
• Fine point ballpoint pen with which to score cardstock before folding
(felt- or gel-tipped pens are not appropriate)
• Colored markers or pencils for coloring the models (not crayons)

SETUP
Make enough copies of the HIV particle model on card stock paper for each student. Make a few extra copies to use as “spare parts” and for demonstration. (Teacher Tip: You may wish to enlarge the cutout of the virus model for demonstration purposes.) Have students work together in groups of 2–4 to assist each other, especially during model assembly and taping. Each student should make his or her own virus model.

PROCEDURE
1. Ask students, Have you ever seen a virus? [It is not possible to observe viruses directly, because they are extremely small.] Encourage students to share what they already know about viruses. List their ideas on the board. Make sure that the following facts are included.
• Viruses are small infectious agents that require living cells to make copies of themselves (replicate)
• Viruses replicate by invading living cells
• Most viruses are too small to see with a microscope
• Viruses are responsible for many different diseases.

CITATIONS
Image citations, including source URLs, are available at the front of this guide.
including the common cold, flu, smallpox, and HIV/AIDS.

- All viruses consist of genetic material (DNA or RNA) surrounded by a protective coat.

2. Discuss the purpose of the activity with your students. They will learn about the Human Immunodeficiency Virus (HIV) by constructing a paper model that enables them to visualize a single HIV particle. The model will show both the exterior and interior of the particle and serve as a starting point to learn about the virus’s function.

3. Demonstrate how to cut and fold the model. Stress that the more carefully students cut out their models and score the folds, the better the models will look. Students should cut along the solid lines and use the ruler straight edge and ballpoint pen to score the dashed fold lines. Pressing the pen tip into the paper produces a crease that makes accurate folding easy.

4. Have students color their models prior to assembly. While virus particles do not have color, researchers often create colored models to emphasize certain structures. [See the presentation “Viruses (NCMI)” on BioEd Online, www.bioedonline.org, for examples of virus models.]

5. Demonstrate how the virus envelope is formed. Start by creasing along the edges of each triangle, and then reopening the creases. Begin taping with two adjacent triangles. Bring their adjoining straight edges together and hold with a small piece of tape. Continue taping triangles until the model gradually forms a spherical shape. Repeat until all triangles but one are taped together. The remaining triangle serves as a “door” to the inside of the virus.

6. Have students follow the same cutting, folding, and taping procedures for the HIV capsid. They also should press the capsid insert into the capsid. If the insert is loose, a small dab of glue or a small reversed tape ring will hold it in place. Temporarily slip the capsid inside the model.

7. Discuss the model’s appearance and structures as a class. Explain that the model is approximately 500,000 times bigger than an...
4

actual HIV particle. Ask, How big do you think the actual HIV particle is? [about 120 nanometers] List a few comparisons, measured in nanometers, for visualization (see “Nanometers,” left sidebar). A nanometer is one one-billionth of a meter (approximately 0.04 billionths of an inch). Ask, How tall are you in nanometers? [Your height in meters times one billion.]

8. Have each student measure the diameter of his/her virus model. Ask, Since the model is not a sphere, what is the best way to measure it? Discuss different ways to measure the model’s diameter (point to point, point to side, edge to edge, side to side).

9. Tell students that the white blood cell invaded by the HIV particle is 120 times larger than the particle. Ask, Compared to the HIV model, how big is a white blood cell?

10. Have all students place their HIV models into a pile to see how large the mass of models becomes. Count the number of particles in the pile. Then ask, How many HIV particles do you think it would take to fill a white blood cell? How could you find out? (It would take about 1.7 million HIV particles to fill one white blood cell completely. This calculation is based on a comparison of the volume of an HIV particle with that of a white blood cell. To compute these values with students, use the equation, volume=4/3πradius³.)

11. Have students collect their HIV virus particle models and save them for use in the “Making Copies of an HIV Particle” activity.

NANOMETERS

To compare the size of an HIV particle to other objects, divide the size of each object below by 120 nm (the size of one HIV particle).

- **Visible light wavelength:** 400 to 700 nm
- **Human hair:** 100,000 nm wide
- **Period on a page:** 500,000 nm
- **Penny:** 19,000,000 nm wide
- **Basketball:** 239,506,000 nm wide
INSTRUCTIONS

1. Carefully cut out the Viral Envelope and Capsid pieces along the outer, solid straight lines.
2. Use markers or pencils to color the pieces.
3. Score and fold along the dotted lines.
4. Use small pieces of tape to join edges together EXCEPT where indicated. Assembled part shapes are shown below.
5. Cut out the Capsid Genetic Material piece and insert it into the Capsid. Close the flap.
6. To complete the model, insert the Capsid into the Viral Envelope and close the triangular "door."

VIRAL ENVELOPE
Outer surface of particle (circles represent spikes)

CAPSID GENETIC MATERIAL
Two identical strands of RNA, and enzymes, including reverse transcriptase

CAPSID (Internal Core)
Contains genetic material

Illustrations by G.L. Vogt and M.S. Young © Baylor College of Medicine

© 2012 Baylor College of Medicine
BioEd Online | KB Science