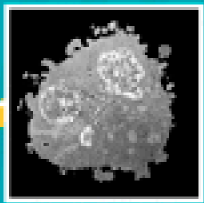
BioEd™

Teacher's Guide



the science of HIV/AIDS

The Virus, the Epidemic and the World

Gregory L. Vogt, Ed.D., and Nancy P. Moreno, Ph.D.

BCM
Baylor College of Medicine

BioEd[SM] Teacher's Guide

the science of HIV/AIDS

The Virus, the Epidemic and the World

by

Gregory L. Vogt, Ed.D.

Nancy P. Moreno, Ph.D.

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/hivaids/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.

BCM Baylor College of Medicine

ISBN-13: 978-1-888997-62-0

BioEd℠

TEACHER RESOURCES FROM THE CENTER FOR EDUCATIONAL OUTREACH AT BAYLOR COLLEGE OF MEDICINE

CCIT The Center for Collaborative and Interactive Technologies

Development of The Science of HIV/AIDS: The Virus, the Epidemic and the World educational materials is supported, in part, by a Science Education Partnership Award from the National Center for Research Resources (NCRR) of the National Institutes of Health (NIH), grant number 5R25 RR018605. The activities described in this book are intended for school-age children under direct supervision of adults. The authors, Baylor College of Medicine (BCM), the NCRR and NIH cannot be responsible for any accidents or injuries that may result from conduct of the activities, from not specifically following directions, or from ignoring cautions contained in the text. The opinions, findings and conclusions expressed in this publication are solely those of the authors and do not necessarily reflect the views of BCM, image contributors or the sponsoring agencies.

Many microscopic images used in this guide, particularly images obtained from the Public Health Image Library of the CDC, are part of an online library containing other images and subject matter that may be unsuitable for children. Caution should be used when directing students to research health topics and images on the Internet. URLs from image source websites are provided in the Source URL list, to the right.

Authors: Gregory L. Vogt, Ed.D., and Nancy P. Moreno, Ph.D.

Creative Director: Martha S. Young, B.F.A.

Editor: James P. Denk, M.A.

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 Slagle, 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 NCRR, NIH, for his assistance and support. In addition, we express our appreciation to Amanda Hodgson, B.S., Victor Keasler, Ph.D., and Tadzia GrandPré, 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. Goldsmith, 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.

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 | k8science.org

BCM Baylor College of Medicine

CFAR CENTER FOR AIDS RESEARCH Baylor-UTHouston

SEPA SCIENCE EDUCATION PARTNERSHIP AWARD
Supported by the National Center for Research Resources, a part of the National Institutes of Health

SOURCE URLs

AMERICAN DENTAL EDUCATION ASSOCIATION
explorehealthcareers.org
p. 20

BAYLOR COLLEGE OF MEDICINE
BIOED ONLINE TEACHER RESOURCES
bioedonline.org | k8science.org
Inside cover, p. ii, 3, 31
MOLECULAR VIROLOGY AND MICROBIOLOGY
bcm.edu/molvir
p. iv

DARTMOUTH COLLEGE
ELECTRON MICROSCOPE FACILITY
dartmouth.edu/~emlab/
p. 1

THE HENRY J. KAISER FAMILY FOUNDATION
kff.org
p. 31, 34

JOURNAL OF NANOBIOTECHNOLOGY
jnanobiotechnology.com/content/3/1/6
p. 7

NATIONAL INSTITUTES OF HEALTH
LIFEWORKS
science.education.nih.gov/lifeworks
p. 20
NATIONAL CENTER FOR RESEARCH RESOURCES
ncrr.nih.gov
p. ii, 8
NATIONAL INSTITUTE OF ALLERGY AND INFECTIOUS DISEASES
www.niaid.nih.gov
aidsinfo.nih.gov
p. 3, 7, 20, 30
NATIONAL INSTITUTE ON DRUG ABUSE
hiv.drugabuse.gov
p. iii, 30
NATIONAL LIBRARY OF MEDICINE
nlm.nih.gov/hmd
p. 19
SCIENCE EDUCATION PARTNERSHIP AWARD
ncrrsepa.org
p. ii, 8

SUMANIS, INC.
ANIMATED TUTORIALS: MICROBIOLOGY
http://sumanasinc.com/webcontent/animation.html
p. 6

U.S. CENTERS FOR DISEASE CONTROL AND PREVENTION (CDC)
HIV/AIDS PREVENTION
cdc.gov/hiv/topics
p. iii, 20, 30, 31, 32, 33, 35, 36, 37
PUBLIC HEALTH IMAGE LIBRARY
phil.cdc.gov
Cover, p. iv, 1, 2, 5, 6, 7, 8, 10, 11, 12, 13, 15, 16, 17, 18, 21, 22, 23, 24, 25, 26, 27, 28, 29, 32, 33, 34, 35, 36, 37, 38, 39

U.S. CENTRAL INTELLIGENCE AGENCY
THE WORLD FACTBOOK
https://www.cia.gov/library/publications/the-world-factbook/geos/us.html
p. 19, 22, 23, 24, 25, 26, 27

WELLCOME IMAGES
images.wellcome.ac.uk
p. 2

WHAT IS PUBLIC HEALTH
whatispublichealth.org
p. 20

WIKIMEDIA COMMONS
commons.wikimedia.org
p. 40

Contents

The Science of HIV/AIDS: The Virus, the Epidemic and the World is a supplementary curriculum unit on the HIV/AIDS pandemic. The Human Immunodeficiency Virus (HIV) that leads to AIDS, or Acquired Immunodeficiency Syndrome, has spread across the globe. More than 30 million people have died of AIDS-related diseases, and a similar number of individuals are living with the infection. Nearly 6,000 new people are infected with HIV every day.

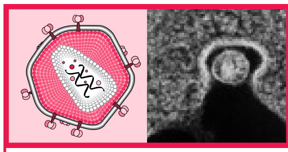
This curriculum unit consists of essays and activities. The essays tell a small part of the HIV/AIDS story. Some present stark facts that may be difficult to absorb. Depending upon students' grade and maturity levels, the unit's essays may be used as teacher background information or student reading assignments. They are especially effective when read aloud.

The unit's activities begin with students constructing paper models of the HIV virus to learn about its structure and function. This first activity is followed by a mathematical exploration of exponential numbers, and then a geographic mapping of the global spread of HIV infection. The module concludes with students creating scientific meeting-style posters or PowerPoint® presentations that compile and present HIV/AIDS data by geographic area. Interspersed throughout the guide are sidebars with related information, links, and other resources.

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/hivaids/ 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.



HIV virus particle. Charles P. Daghlian, Ph.D., Louisa Howard, Dartmouth College.

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.

For an emerging disease to become established, at least two events must occur: 1) the infectious agent has to be introduced into a vulnerable population, and 2) the agent has to have the ability to spread readily from person to person and cause disease. The infection also must be able to sustain itself within the population and continue to infect more people.

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.

Baylor College of Medicine, Department of Molecular Virology and Microbiology, bcm.edu/molvir.

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

* Jones, R.M. 1990. *Teaming Up!* LaPorte, Texas: ITGROUP.

HIV-1. CDC \948 Edwin P. Ewing, Jr., Ph.D., Carey S. Callaway.

Portrait of a Killer

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.

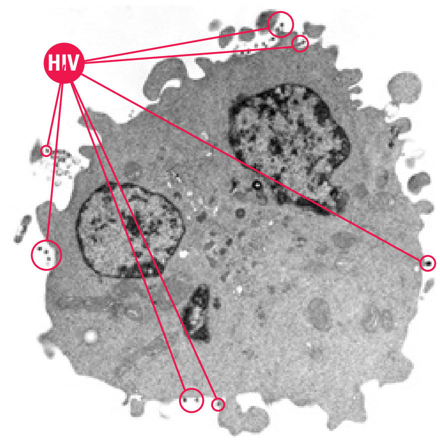
A cluster of patients with the same rare condition raises a medical "red flag." Something new may be happening.

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.

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.

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 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.

1

HIV-1 particles. CDC\948 Edwin P. Ewing, Jr., Ph.D., Carey S. Callaway.

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

SCIENCE EDUCATION CONTENT STANDARDS

Grades 5–8

Life Science

- Living systems at all levels of organization demonstrate the complementary nature of structure and function.
- Disease is a breakdown in structures or functions of an organism. Some diseases are the result of damage by infection by other organisms.
- Every organism requires a set of instructions for specifying its traits. Heredity is the passage of these instructions from one generation to the next.

Grades 9–12

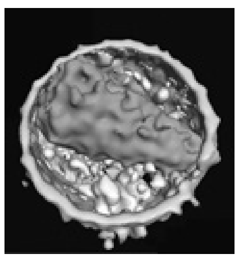
Life Science

- In all organisms, the instructions for specifying the characteristics of the organism are carried in DNA [usually], a large polymer formed from subunits.
- Cells store and use information to guide their functions.

CITATIONS

Image citations, including source URLs, are available at the front of this guide.

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.



The capsid surrounding the RNA-containing core of an HIV particle is revealed using Cryo-electron tomography (left). Photo: Stephen Fuller © Wellcome Images\B0006824.

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 (p. 5) 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.

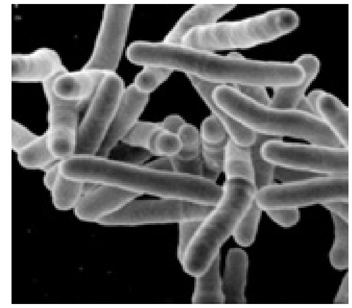
PROCEDURE

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

BACTERIA AND VIRUSES

Viruses, the tiniest microbes, must be magnified about 150,000 times to be seen. They are not considered cells, because they do not have cell walls, cell membranes or nuclei. They also cannot grow or reproduce on their own. Instead, as described above, they invade healthy cells in living organisms and force these cells to produce more viruses. This is how viruses, such as HIV, cause disease. Antibiotics, which are effective against bacteria, cannot destroy viruses.

Bacteria are minute, single-celled organisms much larger than viruses. (Most bacteria must be magnified about 1,000 times to be visible.) Bacterial cells have DNA, a cell membrane and usually a cell wall, but they do not have defined cell nucleus. Some bacteria are capable of movement, and many are valuable as recyclers in ecosystems. Other bacteria have chlorophyll and carry out photosynthesis. Bacterial infections can be treated with antibiotics, but some bacteria have become resistant to common antibiotics.



TB is a disease caused by the bacterium called *Mycobacterium tuberculosis.* The disease mostly affects the lungs. People with weakened immune systems, such as from AIDS, are not able to fight the TB bacteria and ward off infection.
Photo: Rocky Mountain Laboratories, National Institute of Allergy and Infectious Diseases, NIH\Clifton E. Barry, III, Ph.D. Barry, Elizabeth R. Fischer.

many different diseases, including the common cold, flu, small pox, 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

Continued

MICROBES AND DISEASE

Organisms that cause diseases are called "pathogens," from the Greek word pathos, or suffering. Most pathogens are microbes, such as bacteria, viruses or fungi (such as yeast). Sometimes, we call these tiny pathogens "germs."

Not all microbes cause diseases. Many microorganisms, like the bacteria in our digestive systems or photosynthetic algae in the oceans, are helpful. Further, not all illnesses are caused by microbes. For example, diabetes, heart disease related to atherosclerosis, and some kinds of cancer are not believed to be caused by infections.

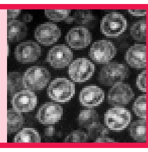
NANOMETERS

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

500,000 times bigger than an 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, $volume = 4/3 \pi radius^3$.
11. Have students collect their HIV virus particle models and save them for use in the "Making Copies of an HIV Particle" activity.

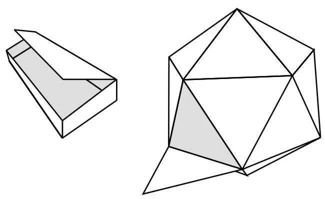


HIV-1 particles. CDC \948 Edwin P. Ewing, Jr., Ph.D., Carey S. Callaway

1 Modeling an HIV Particle

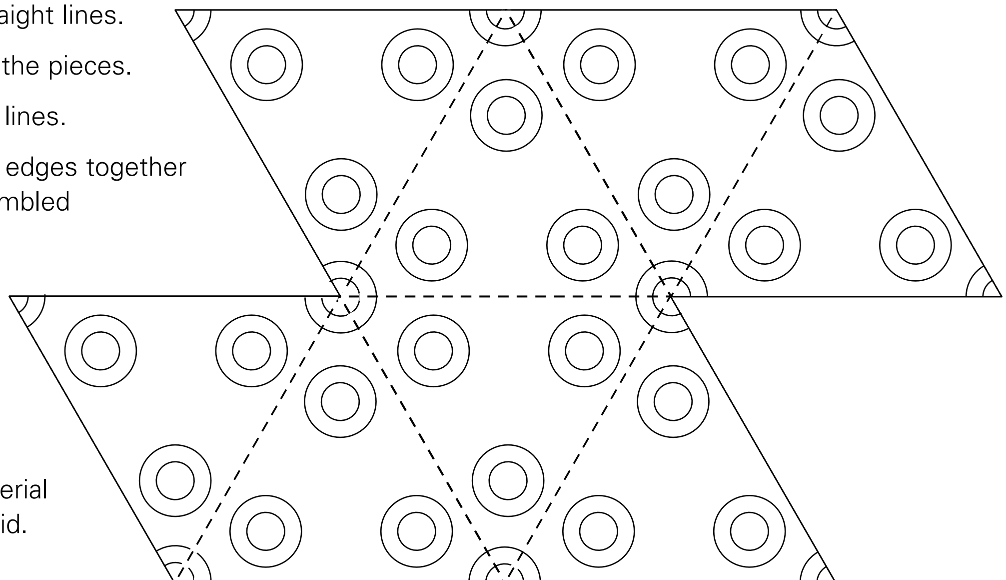
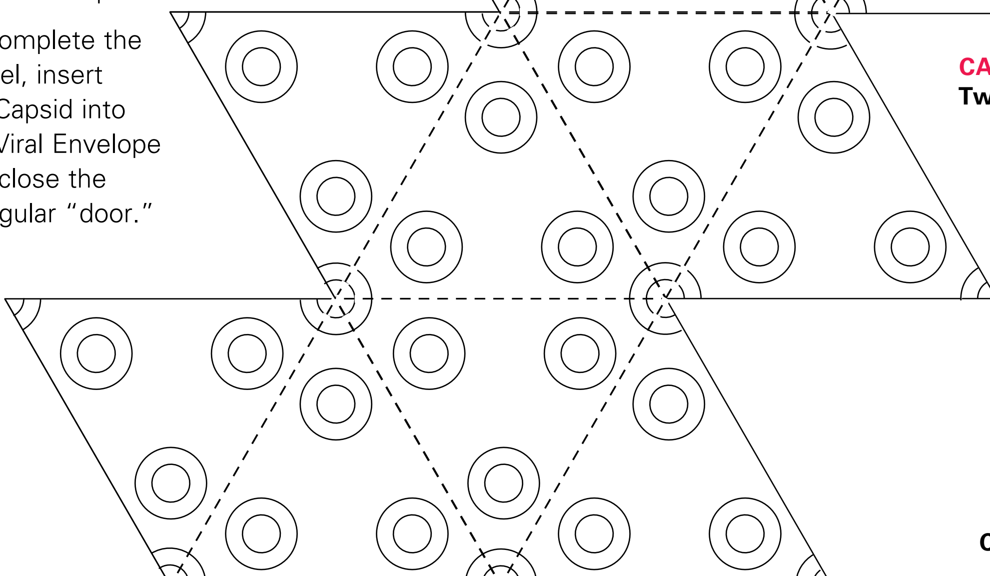
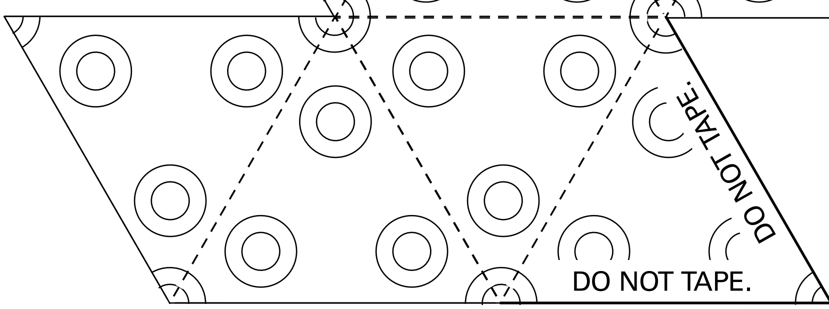
INSTRUCTIONS

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.

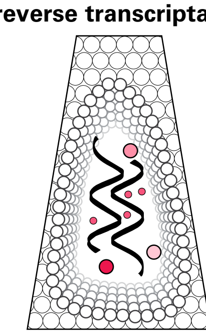


5. Cut out the Capsid Genetic Material piece and insert it into the Capsid. Close the flap.
6. To complete the model, insert the Capsid into the Viral Envelope and close the triangular "door."

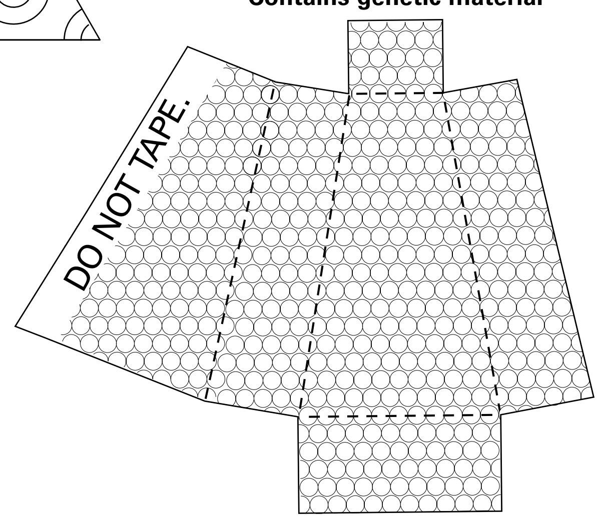
VIRAL ENVELOPE
Outer surface of particle (circles represent spikes)

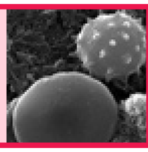




CAPSID GENETIC MATERIAL
Two identical strands of RNA, and enzymes, including reverse transcriptase



CAPSID (Internal Core)
Contains genetic material





Red (round) and white (knobby) blood cells. CDC\7320 Janice H. Carr.

2 ESSAY

The Deadly Cycle

An HIV virus particle is far too small to be seen with an ordinary light microscope. More than one hundred times smaller than the white blood cells they invade, HIV virus particles look like miniature cells—but they are not cells. Rather, HIV particles, like all viruses, are best described as containers of genetic material.

The HIV particle is surrounded by an envelope of cell membrane material, taken from the cell from which it emerged. Inside, the HIV virus contains enough genetic material (in the form of RNA molecules) to direct a host cell to make new virus copies. Viruses cannot live, grow and reproduce on their own. Instead, they must invade the cells of living organisms and force those cells to produce more viruses. This is how viruses cause disease. The term, "virus particle" (or "virion") usually refers to the infectious version of the virus, as it exists outside a host cell.

The surface of an HIV particle typically has between 14 to 73 small projections, referred to as glycoprotein spikes. Glycoproteins (gp) are protein molecules with carbohydrates incorporated into their structure. They are represented by concentric circles on the outside of the paper model used in the previous activity. Two different glycoproteins, gp120 and gp41, comprise each spike on an HIV particle. The numbers, 120 and 41, refer to each protein's molecular weight (an indicator of a molecule's size). The gp120 glycoproteins allow the HIV virus particles to attach to, or "dock" with certain kinds of white blood cells.

HIV cannot survive for long outside the body, and only can be transmitted to another person through body fluids from someone who already has the infection. Once inside the body, HIV particles enter the blood stream and make contact with leukocytes, or white blood cells, the body's chief defenders against infectious diseases. There are five different kinds of leukocytes. However, HIV most often attacks one kind, called a CD4+ cell. CD4+ cells get their name from a particular protein, called CD4, found on the outside cell surface (in other words, these cells are "positive" for the presence of a CD4 protein). CD4+ cells sometimes are referred to as T-cells.

HIV particles—specifically the exterior glycoprotein spikes—attach to CD4 molecules on the surface of CD4+ cells. This connection is similar to that between a lock and key. Once attached, the virus particle fuses with the cell membrane and releases its contents into the cell. After this stage in the infection process, the HIV particle and white blood cell together can begin to reproduce more HIV particles.

Inside the fatty envelope of an HIV particle is a bullet-shaped core, called the capsid. Made of proteins, the capsid holds the virus's genetic material and triggering enzymes. HIV's genetic material consists of two single-stranded RNA molecules (or ribonucleic acid). The viral RNA strands contain just nine genes, compared to the 20,000 or 25,000 genes in humans. Once HIV RNA is inserted into a cell, an enzyme called reverse transcriptase transcribes, or changes the RNA strands into double-stranded DNA. The viral DNA then integrates with the host DNA in one chromosome within the cell's nucleus. From this point, the virus may remain inactive for many years. Eventually, though, the viral DNA is activated and the cell begins replicating the parts required to make new HIV virus particles—by the hundreds of thousands. In essence, HIV hijacks the cell's functions and turns the cell into a kind of virus factory. Raw materials inside the cell are reworked into new strands of RNA, proteins, and enzymes, which gather just inside the cell wall. Then, the new HIV virus particles bud from the wall of the host cell into the bloodstream.

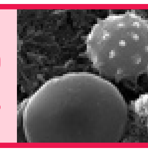
The HIV replication process eventually overwhelms the host cell until it dies. New HIV particles, millions of them, pass through the blood stream to attach and insert themselves into other leukocytes and begin the replication process again. Over time, the number of white blood cells declines to the point where they can no longer provide protection. Other components of the immune system, such as the lymph nodes, also are affected, and the host body becomes less and less able to defend itself against diseases. A person infected with HIV is diagnosed with AIDS when he or she has one or more serious illnesses associated with HIV, such as pneumonia or tuberculosis, and has dangerously low numbers of infection-fighting white blood cells.

For further details about this process, see the Microbiology animated tutorial "Life Cycle of HIV, a Retrovirus" at http://sumanasinc.com/webcontent/animation.html.

Overview

Students will learn the internal structure of HIV and about its replication cycle.

2



Red (round) and white (knobby) blood cells. CDC\7320 Janice H. Carr.

TIME

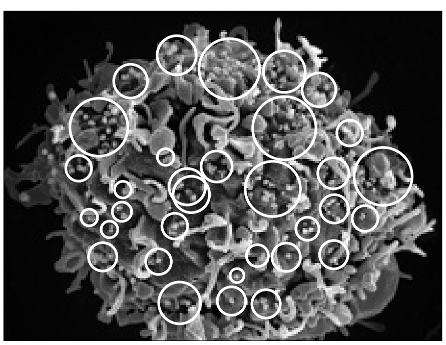
Setup: 30 minutes

Activity: 1 class period

MAKING COPIES OF AN

HIV Particle

Many biologists do not consider viruses to be "living" organisms, because they cannot carry out many of the functions that define life. For example, viruses cannot use food; nor are they able or make copies of themselves ("reproduce") without invading a living cell and redirecting the cell's internal mechanisms to make new virus copies. Outside cells, viruses exist as genetic material (DNA or RNA) surrounded by a protective coat of protein, called a capsid. HIV's capsid contains two strands of RNA.



Numerous tiny HIV particles (in circles) are shown erupting out of a single CD4+ cell.

Photo: National Institute of Allergy and Infectious Diseases, NIH.

Some viruses also wrap themselves in a modified form of the cell membranes from which they emerge. This modified membrane, called an envelope, is studded with proteins that enable the virus to latch onto and infect other cells. HIV and the influenza (flu) virus are examples of viruses that are surrounded by an envelope. The complete, assembled viral package—consisting of the genetic material, capsid and envelope (when present)—is referred to as a "virus particle" (or virion) to distinguish it from the virus components present inside host cells.

MATERIALS

Teacher (see Setup)

- Images of HIV particles for projection or display (see Setup)
- Slides or transparencies of HIV Virus Particle and HIV Replication sheets (p. 10–11)
- LCD or document projector, "smartboard" or overhead projector

Per Student

- Assembled HIV particle model with capsid structure from the activity, "Modeling an HIV Particle"
- Copies of HIV Virus Particle and HIV Replication sheets (p. 10–11)

SETUP

Assemble images of HIV particles into a presentation for projection in your classroom. Images can be found on the following websites.

- Centers for Disease Control and Prevention, Public Health Image Library (phil.cdc.gov)
- *Journal of Nanobiotechnology* (www.jnanobiotechnology.com/content/3/1/6)

You also may download related slides directly from BioEd Online (bioedonline.org). Conduct this as a whole-class activity.

Continued

SCIENCE EDUCATION CONTENT STANDARDS

Grades 5–8

Life Science

- Living systems at all levels of organization demonstrate the complementary nature of structure and function.
- Cells carry on many functions needed to sustain life.
- Disease is a breakdown in structures or functions of an organism. Some diseases are the result of damage by infection by other organisms.
- Every organism requires a set of instructions for specifying its traits. Heredity is the passage of these instructions from one generation to the next.

Grades 9–12

Life Science

- Cells have particular instructions that underlie their functions. Every cell is surrounded by a membrane that separates it from the outside world.
- Cells use and store information to guide their functions. The genetic information stored in DNA is used to direct the synthesis of the thousands of proteins that each cell requires.
- In all organisms, the instructions for specifying the characteristics of the organism are carried in DNA [usually], a large polymer formed from subunits.

HOW CAN AN HIV PARTICLE BE SEEN WHEN IT IS SO SMALL?

Though 800 times smaller across than a human hair, the HIV particle is larger than most other viruses. Even so, it was very challenging to discover what the HIV virus looks like and how it is constructed. You cannot observe a virus particle on the stage of a normal optical microscope, which works with visible light and has a practical limit for magnification.

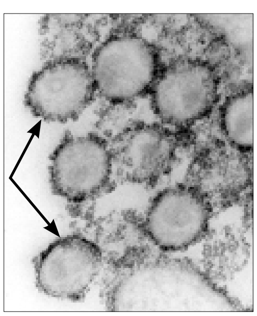
An optical microscope's diffraction limit, or resolution (ability to separate two closely spaced objects) is based on the wavelengths of visible light, which range from about 400 to 700 nm (violet to red). The minimum practical resolution (or distance between two objects) is less, about 200 nm. Any specimens closer together than 200 nm appear as a single object under an optical microscope. Consequently, the useful magnification power of optical microscopes is limited to approximately 1,500x. Pushing to a magnification power higher than that leads to hopelessly fuzzy images that are impossible to resolve clearly. Thus, an HIV particle, which measures 120 nm across, is smaller than optical microscopes will allow us to view, even at maximum resolution.

Researcher Jenelyn Ramos, with the National Center for Macromolecular Imaging at Baylor College of Medicine, uses a transmission electron microscope to isolate and examine virus particles and their components.

The National Center for Research Resources, National Institutes of Health, supports several centers dedicated to visualizing 3-D structures within cells and viruses. Photo: National Center for Macromolecular Imaging.

Because virologists (scientists who study viruses) must be able to "see" objects as small as a single nanometer, they require microscopes with much greater magnification power. However, "seeing" is not quite what they do. Rather, they employ a variety of sophisticated microscopes that create images on a computer screen.

One such instrument is the transmission electron microscope, or TEM, which directs a beam of electrons through a very thin specimen. The electrons interact with the specimen and are shifted slightly as they pass through. Then, they fall onto a fluorescent screen or a detector, similar to a CCD chip in a digital camera, where the TEM's image is created. Typically, electron microscopes are able to produce useful magnifications one million times the actual size. But under special circumstances, 50 million times magnification has been achieved.



In this TEM image of HIV-1 virions, glycoprotein spikes appear darkest gray. Photo: CDC\949 Edwin P. Ewing, Jr., Ph.D.

PROCEDURE

1. Use the student-constructed models as a basis for a class discussion about the structure and function of the HIV particle. For example, ask, *What is contained inside the particle?* [capsid and genetic material] *What does the capsid do?* [contain and protect genetic material] *Why might some virus particles also have an envelope?* [provides a way to dock with certain kinds of cells and fuse with the cell membrane]
2. Discuss the main parts of the HIV particle, and their functions. Refer to the illustration on the student sheet, "HIV Virus Particle," (p. 10) to provide more detail.
3. Project microscopic images of the HIV particle and have students compare the outsides of their models to the images. Mention that the double circles on the exterior of the envelope on their models represent the glycoprotein spikes needed by the virus particle to attach to the CD4+ white blood cells.
4. Have students remove their capsid models from the inside of the viral envelope. Ask them to examine the inside of the capsid. Point out the RNA strands and discuss their function: to transmit genetic information to the host cell. Describe the RNA strands as an instruction manual that directs the cell to make virus components. Also mention the reverse transcriptase enzyme and its function, which is to transform the genetic information on the RNA strands into DNA, the genetic code within each host cell.
5. Depending on the ages of your students, you may want to examine the HIV life cycle in more detail.

Use the "HIV Replication Cycle" sheet as a guide. Following are the steps involved in HIV infection of a cell.

a. **Attachment and entry.** The HIV virus bumps into a CD4+ white blood cell, attaches to it, and injects the capsid and its contents into the cell.

b. **Reverse transcriptase.** Once inside the cell, HIV genetic material (in the form of RNA) is converted into a form that is compatible with the cell's genetic information (DNA). In cells, DNA usually is used to produce new RNA through a process called transcription. When RNA is used as a template to produce DNA, as is the case with HIV infection, the process is referred to as "reverse" transcription.

c. **Integration.** The newly formed viral DNA moves into the cell nucleus, where it is spliced into the cell's human DNA. The HIV genetic material may remain dormant or inactive for many years. In this state, HIV is able to "hide" from the immune system and is unaffected by antiviral treatments.

d. **Transcription and translation.** The viral DNA becomes active and directs the cell's machinery to produce the virus components: viral RNA, viral envelope and capsid. This activation can occur many years after initial infection with HIV, and is not yet completely understood.

e. **Assembly and release.** The viral particle is assembled, fuses to the cell membrane and is released by "budding" off the surface of the cell. During the budding process, the new particle wraps itself in part of the host cell's membrane to create the viral envelope. The new virus particles now circulate within the body and are able to invade other cells.

VIRAL REPLICATION

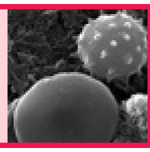
Viruses cannot live, grow and reproduce on their own. Instead, they must invade cells of living organisms and force these cells to produce more viruses. This invasion of healthy cells is how viruses cause disease.

APPLYING BASIC SCIENCE

Researchers use information about the HIV life cycle to develop anti-HIV treatments. One class of drugs blocks the integration of viral DNA into the DNA of the host cell. Another approach prevents the "reverse" transcription of viral RNA into DNA. Many drugs used to fight HIV have harmful side effects, which must be balanced carefully against their value in fighting the virus.

WHAT IS A RETROVIRUS?

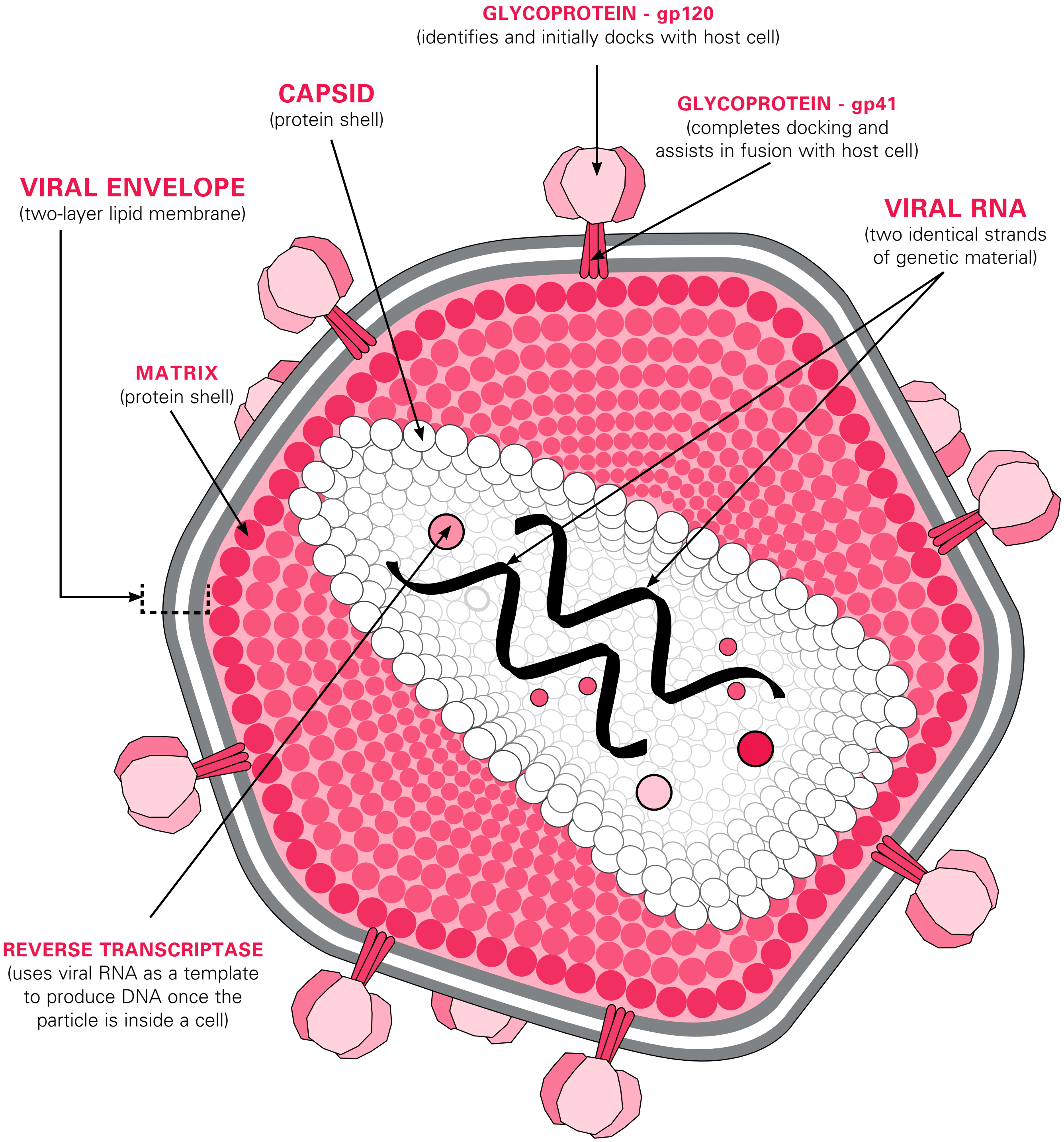
HIV is one of a handful of viruses known to reverse the normal pathway through which genetic information is transmitted within cells. Usually, DNA is used to produce RNA, which then directs the assembly of proteins in cells. HIV, however, is able to use its own RNA as a template to produce viral DNA that can be spliced into the DNA of the human host cell.



Red (round) and white (knobby) blood cells. CDC\7320 Janice H. Carr.

HUMAN IMMUNODEFICIENCY VIRUS (HIV)

HIV Virus Particle



2 HIV Replication Cycle

Red (round) and white (knobby) blood cells. CDC\7320 Janice H. Carr.

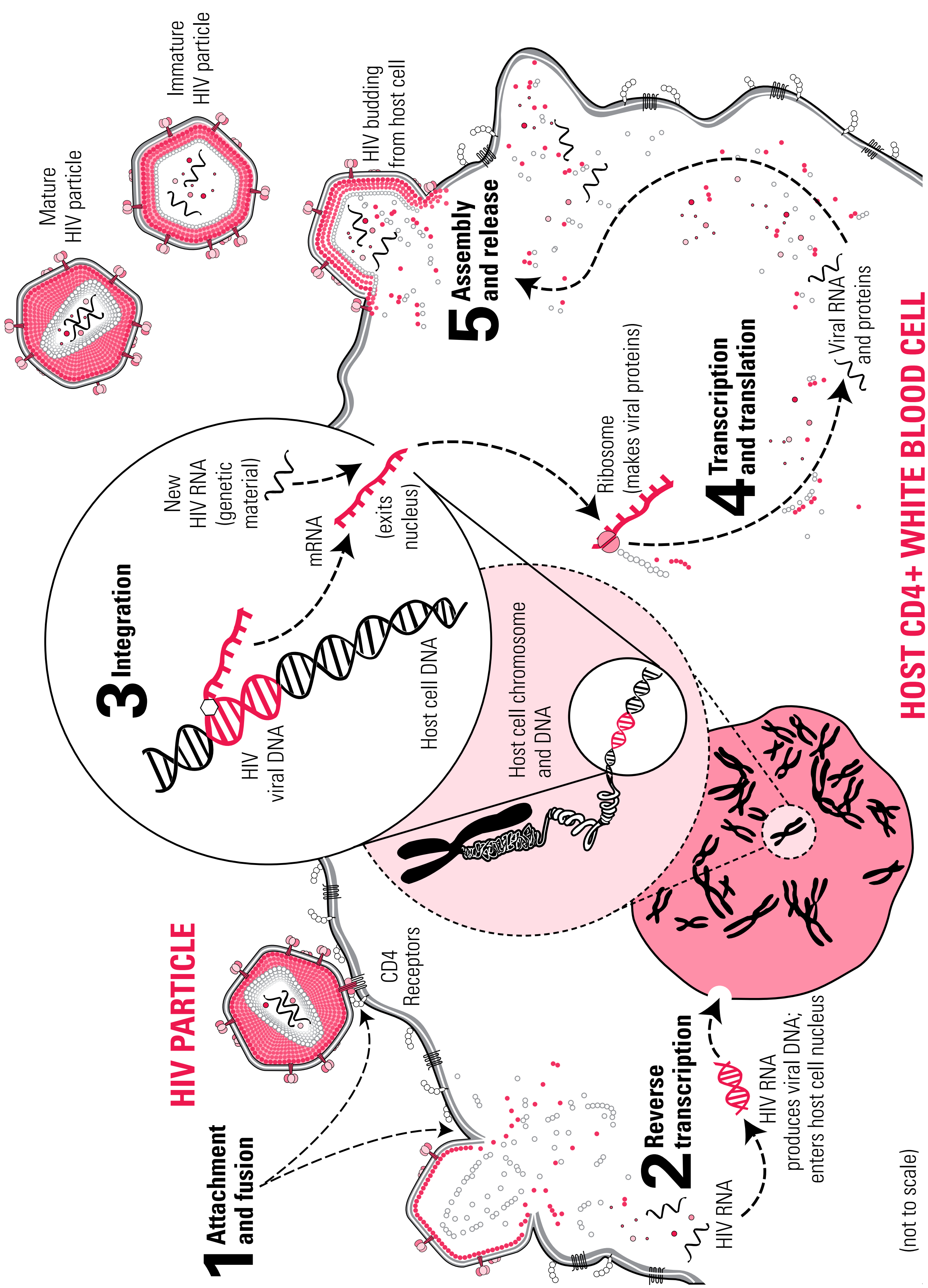
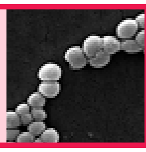


Illustration by G.L. Vogt and M.S. Young © Baylor College of Medicine.



Micrococcus leuteus bacteria. CDC\9761 Betsy Crane, Janice H. Carr.

It's All In the Numbers

Acquired Immunodeficiency Syndrome (AIDS) is not a disease like the measles or flu, and there is no cure. It is the result of a long-term viral infection. A person with AIDS no longer has natural body protections against many diseases that circulate through the human population. People usually don't die directly from HIV infection; rather, AIDS patients tend to suffer from chronic illnesses that accumulate one after another. Invading diseases gang up to waste away their bodies and cause great suffering until they no longer can survive.

Once a person has AIDS, treatment options are mostly reactive. If a person with AIDS has pneumonia or cancer, doctors employ pneumonia or cancer treatments. Often, AIDS patients have multiple illnesses, challenging doctors to find treatments that are effective and compatible. Regardless, over time the battle will be lost.

Because there is no cure or vaccine, worldwide efforts are focused on preventing AIDS from spreading from one person to the next. As noted earlier, AIDS results from infection by the Human Immunodeficiency Virus (HIV), an almost unimaginably small particle of genetic material more than 800 times smaller across than a human hair. HIV is passed from human to human only through body fluid transfer. Blood transfusions, breastfeeding, and sharing of needles among drug users are common routes of transfer of HIV virus particles.

HIV/AIDS: A NUMBERS GAME

Once inside the bloodstream, the virus particle attaches itself to cells that have a particular kind of molecule, called CD4, on their surface. T cells, the white blood cells responsible for directing the body's defense against invaders, have CD4 receptor molecules. In fact, T cells also are referred to as CD4+ cells.

After attaching, the HIV virus particle injects its contents into the cell. The viral material may lay dormant for years but, eventually, it begins to multiply. Actually, the host cell does the multiplying. The particle simply provides the cell with a genetic "how-to" manual for creating copies of the virus.

Each new virus particle triggers the formation of more particles. Their numbers grow until millions of HIV particles are released into the bloodstream to interact with (infect) more CD4+ cells. Once infected, CD4+ cells are less able to defend the body against disease; sometimes, they are simply overwhelmed and die. As the immune system gradually fails, the disease known as AIDS results.

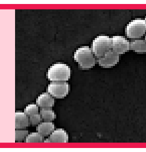
TREATMENT

Anti-HIV treatments usually rely on a combination of three different medications that target the HIV virus itself. Because HIV is capable of rapid genetic change (mutations), it can become resistant to the treatment drugs if medications are not taken on schedule as prescribed. HIV also is difficult to treat because its genetic material becomes incorporated into the DNA of cells within the human immune system. Once inside the nucleus of a CD4+ cell, for example, HIV can remain inactive and unaffected by drugs for years. HIV's ability to "hide" within cells makes it impossible to eliminate completely. If treatment is stopped or disrupted for any reason, HIV is able to emerge from hiding and multiply within the body again.

Overview

Students will learn how to calculate exponential growth and, by extension, how to calculate the spread of HIV/AIDS. (See Answer Sheet on page 16.)

3



Micrococcus leuteus bacteria. CDC\9761 Betsy Crane, Janice H. Carr.

TIME

Setup: 15 minutes

Activity: 1 class period

CALCULATING

Exponential Growth

Under favorable conditions and with sufficient time and resources, populations of all organisms, including infectious agents like viruses, have the potential to increase dramatically over time. Even slow-growing organisms can reach astounding population sizes if reproduction is unchecked. Charles Darwin used elephants, which breed very slowly, as a hypothetical example. Beginning with two elephants, which generally produce only six offspring during a reproductive span of 60 years, an elephant population would number only 54 individuals after 200 years. However, after 1,000 years, the population would have grown to 86,000,000 elephants!

Now consider another example, in which a parent cell divides into two daughter cells every 10 minutes. After 10 minutes, there would be two cells; after 20 minutes, four cells; after 30 minutes, eight cells, and so on. After three hours, there would be close to one million cells. When quantity increases by a fixed percentage at regular time intervals, we have what is referred to as exponential growth. On a graph, exponential growth is represented by an upward curve, not a straight line. In addition to the example of cell division, exponential growth can be observed in the accumulation of compound interest, and in the increasing levels of CO^2 in the atmosphere. Untreated, HIV also is capable of exponential growth once it begins to replicate and spread within the human body.

MATERIALS

Teacher (see Setup)

- LCD or document projector, "smartboard" or overhead projector
- Slides or transparencies of student sheet (p. 15)

Per Student Group

- Calculator or computer access
- Spreadsheet software, if using a computer
- Copies of student sheet, "Dollars or Cents," (p. 15)

SETUP

If not using a document projector, prepare a slide or transparency of the spreadsheets. Also prepare slides or transparencies of the salary graph to show the difference between linear and exponential growth. Have students conduct this activity in groups of 2–4.

PROCEDURE

1. Lead a class discussion about the meaning of exponential growth, as it relates to HIV. Due to exponential growth, the greater the number of HIV particles present, the faster they will increase in number. Use the following example.

   If an HIV particle reproduces itself every minute, at the end of one minute, there will be two particles. After two minutes, there will be four particles; and after 10 minutes, the number will have grown to 1,024. In 20 minutes,

Continued

SCIENCE EDUCATION CONTENT STANDARDS

Grades 5–8

Life Science

- Disease is a breakdown in structures or functions of an organism. Some diseases are the result of damage by infection by other organisms.
- Reproduction is a characteristic of all living systems.

Grades 9–12

Life Science

- Cells use and store information to guide their functions. The genetic information stored in DNA is used to direct the synthesis of the thousands of proteins that each cell requires.
- Changes in DNA (mutations) occur spontaneously at low rates. Some of these mutations make no difference to the organism, whereas others can change cells and organisms.
- Living organisms have the capacity to produce populations of infinite size, but environments and resources are finite.

Science in Personal and Social Perspectives

- The severity of disease symptoms is dependent on many factors, such as human resistance and the virulence of the disease-producing organism.
- Populations can increase through linear or exponential growth.

EXTENSION

Ask students, *What would happen to the two salaries if the employer retained the employee for one extra day?* [The "linear pay" employee's total salary would increase to $930,000, while the "exponential pay" employee's salary would jump to a total of $21,474,847.22. In six additional days, the exponential salary would climb to more than $1 billion.]

there will be more than one million particles, and after 30 minutes, the population will have increased to more than one billion. This is "exponential" growth.

2. Tell students that there are many examples of exponential growth. Pose the following scenario to the class.

   Imagine you have applied for a job. Your future employer offers a temporary position lasting just 30 days. Then, something amazing happens: you're asked to decide if you'd rather be paid in dollars or pennies.

   If you choose to be paid in dollars, you will earn $1,000 on the first day of work, $2,000 on your second day, $3,000 on the third, and so on. For each of your 30 days of employment, your salary will be increased by $1,000.

   If you choose to be paid in pennies, you will earn one cent on the first day of work, two cents on your second day, four cents on the third day, and so on. Each day, your will salary will be exactly double the salary you earned the day before. Which payment plan will you select?

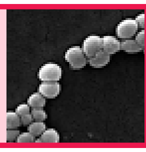
3. Give each student group the "Dollars or Cents" page, which includes the challenge just described. Allow time for students to discuss the options and select one of the job's two possible "pay schedules." Have students calculate their daily salaries, total income earned so far at the end of each day, and the amount of money they will earn for the full 30-day period.

4. Compare the final balances accrued by each salary schedule. If required for clarification, share the following information with students (also see the answer sheet at the end of this activity).

   Being paid in dollars certainly seems like the smart choice. In just five days, you will earn $15,000. By the end of the next five days, your salary will reach $55,000. Adding $1,000 to your salary each day quickly builds up to a 30-day grand total of $465,000! Not bad for a temporary job.

   On the other hand, it takes a lot of discipline (and quick calculations!) to choose to be paid in pennies. Initially, the pay will be dismal. By day 10, you will have only earned a total of only $10.23. It takes three weeks before your salary begins to pick up. On day 20, you will have earned $10.485.75. And from that point on, salary growth becomes spectacular. Just five days later, your salary will pass $335,000. By day 30, you will have earned $10,737,417.61!

5. Revisit your previous discussion of HIV replication. Ask students to explain how the salary analogy applies to virus multiplication within cells in the body. Or, ask each group of students to summarize what they learned about exponential growth by writing a paragraph in their science notebooks or as a homework assignment.

3 

Micrococcus leuteus bacteria. CDC\9761 Betsy Crane, Janice H. Carr.

Dollars or Cents?

Imagine you have applied for a job. Your future employer offers a temporary position lasting just 30 days. Then, something amazing happens. You're asked to decide if you'd rather be paid in dollars or pennies.

If you choose to be paid in dollars, you will earn $1,000 on the first day of work, $2,000 on your second day, $3,000 on the third, and so on. For each of your 30 days of employment, your salary will be increased by $1,000.

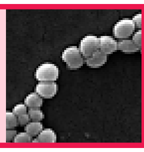
If you choose to be paid in pennies, you will earn one cent on the first day of work, two cents on your second day, four cents on the third day, and so on. Each day, your will salary will be exactly double the salary you earned the day before. Which payment plan will you select?

1. Choose how you wish to be paid.
2. If you pick dollars per day, complete the chart on the left, beginning on Day 4. Add $1,000.00 to your salary each day until the column is completed.

   If you wish to be paid in pennies per day, complete the chart on the right, beginning on Day 4. Double your salary each day until the column is completed.
3. In the "Balance" column of your chart, add each day's salary with the total from the day before and record each new balance through Day 30 to find how much you will earn in total.
4. Compare your salary balance on Day 30 with the balance of someone who picked the other pay schedule. Which of you will make more money? Why?

DAY	PAYMENT: Dollars Per Day	BALANCE
1	$1,000.00	$1,000.00
2	$2,000.00	$3,000.00
3	$3,000.00	$6,000.00
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		
16		
17		
18		
19		
20		
21		
22		
23		
24		
25		
26		
27		
28		
29		
30		

DAY	PAYMENT: Pennies Per Day	BALANCE
1	$0.01	$0.01
2	$0.02	$0.03
3	$0.04	$0.07
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		
16		
17		
18		
19		
20		
21		
22		
23		
24		
25		
26		
27		
28		
29		
30		

3 

Micrococcus leuteus bacteria. CDC\9761 Betsy Crane, Janice H. Carr.

Answer Key

DAY	PAYMENT: Dollars Per Day	BALANCE
1	$1,000.00	$1,000.00
2	$2,000.00	$3,000.00
3	$3,000.00	$6,000.00
4	$4,000.00	$10,000.00
5	$5,000.00	$15,000.00
6	$6,000.00	$21,000.00
7	$7,000.00	$28,000.00
8	$8,000.00	$36,000.00
9	$9,000.00	$45,000.00
10	$10,000.00	$55,000.00
11	$11,000.00	$66,000.00
12	$12,000.00	$78,000.00
13	$13,000.00	$91,000.00
14	$14,000.00	$105,000.00
15	$15,000.00	$120,000.00
16	$16,000.00	$136,000.00
17	$17,000.00	$153,000.00
18	$18,000.00	$171,000.00
19	$19,000.00	$190,000.00
20	$20,000.00	$210,000.00
21	$21,000.00	$231,000.00
22	$22,000.00	$253,000.00
23	$23,000.00	$276,000.00
24	$24,000.00	$300,000.00
25	$25,000.00	$325,000.00
26	$26,000.00	$351,000.00
27	$27,000.00	$378,000.00
28	$28,000.00	$406,000.00
29	$29,000.00	$435,000.00
30	$30,000.00	$465,000.00

DAY	PAYMENT: Pennies Per Day	BALANCE
1	$0.01	$0.01
2	$0.02	$0.03
3	$0.04	$0.07
4	$0.08	$0.15
5	$0.16	$0.31
6	$0.32	$0.63
7	$0.64	$1.27
8	$1.28	$2.55
9	$2.56	$5.11
10	$5.12	$10.23
11	$10.24	$20.47
12	$20.48	$40.95
13	$40.96	$81.91
14	$81.92	$163.83
15	$163.84	$327.67
16	$327.68	$655.35
17	$655.36	$1,310.71
18	$1,310.72	$2,621.43
19	$2,621.44	$5,242.87
20	$5,242.88	$10,485.75
21	$10,485.76	$20,971.51
22	$20,971.52	$41,943.03
23	$41,943.04	$83,886.07
24	$83,886.08	$167,772.15
25	$167,772.16	$355,544.31
26	$355,544.32	$671,088.63
27	$671,088.32	$132,177.20
28	$1,342,177.21	$2,684,354.40
29	$2,684,354.41	$5,368,708.80
30	$5,368,708.81	$10,737,417.61

Trailing the Pandemic

Each week on television, police investigators race to the latest crime scene and dazzle viewers by solving the "who done-it" using sophisticated laboratory tests and computer wizardry. While some of the techniques shown are scientific nonsense, occasionally real crime scene investigation techniques, such as "mapping the evidence," are shown. Brightly colored markers are placed next to evidence or clues, photographed and logged on a scene map. Like following footprints in snow or mud, the sequence of events in a crime sometimes can be deduced from this "map."

In the 1980s, when AIDS cases first began to appear, the affliction was thought to be restricted to homosexual men. But as more cases emerged among different populations, the relationship of the disease to the community became unclear. No longer limited only to gay men, HIV was infecting heterosexual men and women, as well as children, of all races and many countries.

The origins of AIDS were very difficult to trace, because most people infected with HIV show no symptoms for many years. During this time, infected individuals can unknowingly pass HIV particles to others through bodily fluids. While many scientists sought to find cures or treatments for AIDS, others sought to determine the origin of the HIV virus. Knowing where it came from and how it spread could help explain how the virus infects people—and how to combat it. Research agencies, including the World Health Organization and the U.S. Centers for Disease Control and Prevention began tracking the prevalence of infection, country by country.

As hoped, mapping HIV/AIDS populations around the world provided important clues. Epidemiologists (scientists who study factors that affect the health of populations) found that countries with the highest incidence rates were among the earliest to report HIV/AIDS infections. Mapping also confirmed that HIV/AIDS had become a pandemic (Greek: *pan* = "all" + *demos* = "people"), an infectious disease epidemic that has spread through human populations across continents, or even the entire world.

By tracking back to the earliest reported HIV outbreaks, researchers determined the virus originated in Africa. The first known case of HIV infection was detected in a blood sample collected in 1959 from a man in Kinshasa, Democratic Republic of Congo. However, investigators believe HIV may have existed since the 1930s. And still today, there is an astoundingly high percentage of adults living with HIV/AIDS in central and southern Africa.

It has been established that HIV arose from a related virus found in chimpanzees once common in west-central Africa. A subgroup of chimpanzees still living there was found to have simian immunodeficiency virus (SIV). Researchers confirmed the presence of SIV and its close relationship to HIV by collecting and studying chimpanzee feces from ten forest sites in southern Cameroon. SIV was found in five of the sites. Genetic analysis then enabled scientists to trace the virus to individual chimpanzees.

It is not known exactly how the

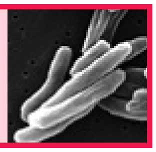
In 1981, Dr. Michael E. Gregg published a report about five cases of the then-rare disease, PCP, among young men in Los Angeles. It was a precursor of the AIDS epidemic. Photo: CDC\10760.

virus transferred to humans, but cultural evidence indicates that it might have occurred in a single incident. Chimpanzees long have been hunted in Africa as a food source. It is probable that the virus was transferred to a human who was butchering an infected chimpanzee. Perhaps the butcher had an open sore or a cut that provided a pathway for the virus contained in the animal's blood. Regardless, somewhere in the viral transference process, SIV mutated into HIV, a virus that causes infection and disease in humans.

From the 1930s to 2009, HIV/AIDS grew from a single case to a global pandemic, with approximately 34 million people now infected by HIV. This number does not include the estimated 30 million people worldwide who have died from AIDS. Due to improved treatments, the infection rate is dropping in some countries. However, these gains are being offset by the rise of infections in other regions, where HIV/AIDS care is minimal. Worldwide, there are approximately 2.7 million new HIV infections (including 53,000 in the U.S.) and about two million HIV-related deaths each year.

Mycobacterium tuberculosis bacteria. CDC\9997 Ray Butler, Ph.D., Janice H. Carr.

4



Mycobacterium tuberculosis bacteria. CDC\9997 Ray Butler, Ph.D., Janice H. Carr.

Overview

Students will act as epidemiologists by mapping the prevalence of HIV/AIDS worldwide.

TIME

Setup: 30 minutes

Activity: 2 class periods

SCIENCE EDUCATION CONTENT STANDARDS

Grades 5–8

Life Science

- Disease is a breakdown in structures or functions of an organism. Some diseases are the result of damage by infection by other organisms.
- A population consists of all individuals of a species that occur together at a given place and time.

Science and Technology

- Many different people in different cultures have made and continue to make contributions to science and technology.

Science in Personal and Social Perspectives

- Societal challenges often inspire questions for scientific research.

History and Nature of Science

- Scientists formulate and test their explanations of nature using observation, experiments, and theoretical and mathematical models.

Grades 9–12

Life Science

- Human beings live within the world's ecosystems. Increasingly, humans modify ecosystems as a result of population growth, technology and consumption.

Science and Technology

- Scientists in different disciplines ask different questions, use different methods of investigation, and accept different types of evidence to support their explanations.

History and Nature of Science

- Individuals and teams have contributed and will continue to contribute to the scientific enterprise. Doing science can be as simple as an individual conducting field studies or as complex as hundreds of people working on a major scientific questions or technological problem.

MAPPING THE Spread of HIV/AIDS

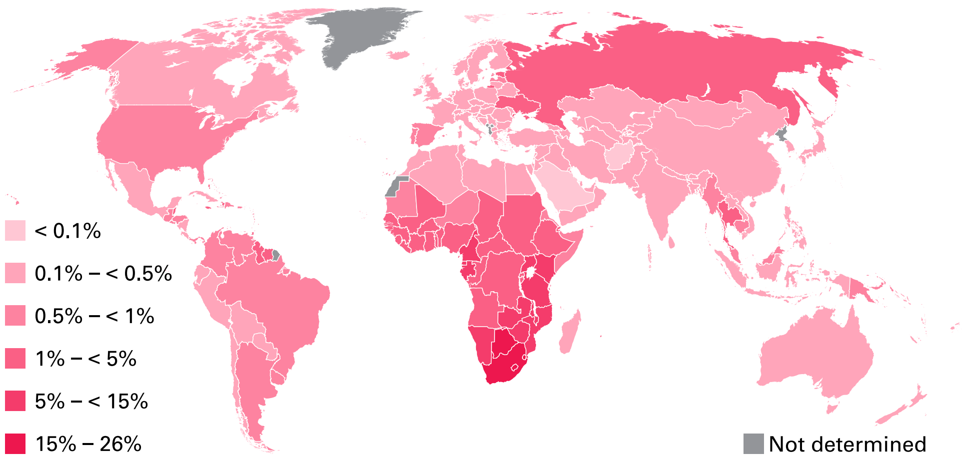
Diseases have haunted the human race throughout history. With the continued expansion of the world's population, international travel and global trade, diseases are able to spread more rapidly now than ever before. Since its origination in the 1930s, HIV has reached every country in the world and killed 30 million people. It is estimated that another 34 million people currently are living and struggling with HIV/AIDS.

This certainly is not the first disease calamity to strike humans. The Spanish Flu pandemic of 1918–19 resulted in the death of an estimated 50 million people, either directly from the disease or from its complications. Before that, yellow fever, small pox and the black plague ravaged populations around the world. Another old killer, malaria, still plays a deadly role in many nations.

Disease detectives, called epidemiologists, help us to understand and defeat these awful illnesses. Epidemiologists study factors that affect the health of populations. Their work is a colossal investigation being conducted in remote natural settings and high-tech laboratories around the world. Epidemiologists collect data to identify outbreaks of old and new diseases, analyze samples, make computer projections, and evaluate possible cures and strategies. Their goal is to identify the cause of disease and determine what to do about it.

The following classroom activity places students in the role of disease detectives, as they investigate trends in HIV infection worldwide. Students will discover that many countries with high HIV infection rates have low levels of per capita income and education, two characteristics often linked with disease. For example, malnutrition and insufficient protection against parasites, often found in economically deprived nations and communities, can limit the immune system's ability to fight off infections. Under these circumstances, individuals are more susceptible to infection by HIV and other pathogens (disease causing organisms). HIV/AIDS treatments are expensive, and are less available in economically disadvantaged countries. Poor children have an increased likelihood of contracting HIV/AIDS from an infected mother during pregnancy or while nursing, because HIV treatments to reduce the chances of HIV transmission are expensive and may not be an option, or even available.

HIV/AIDS also depletes household resources and income. Medical care is expensive and family members who care for the sick may not be able to work. Children may be left to fend for themselves or even become orphaned. And poverty sometimes leads people to participate in risky activities that increase their chances of being exposed to disease. Sustainable economic development, improved standards of living, and



Estimated number of adults (ages 15–49) living with HIV in 2009.

Source: Map generated by M.S. Young, Baylor College of Medicine, using data from The World Factbook, and 2011 political map by the U.S. Central Intelligence Agency. Photo: National Library of Medicine, NIH.

better education are essential to combating the global HIV/AIDS pandemic.

MATERIALS

Per Class (see Setup)

- Set of Adult HIV/AIDS Prevalence Rate, by Country Tables sheets One set will accommodate 10 groups of students (p. 23–27).
- Large political world map mounted in a central location or find and download a world map from the Internet using the search terms, “world,” “map,” and “countries.” Enlarge the map to poster-size so that smaller countries, especially in Europe, can be identified.

Per Team of Students

- Map pins or push pins (or small, colored stick-on dots) in six colors
- Internet access to geography websites, or a current world atlas
- One (or more) Team Cards
- Copy of “Where in the World” (p. 21) and enlarged copy of a blank world map (p. 22)

SETUP

Pins of different colors will be used to identify HIV/AIDS rates in different countries. If using stick-on dots, it may be difficult to find six different colors. Dots in four colors are easy to obtain. Additional colors can be created by gently running colored markers over some of the yellow, green or white dots.

Mount the paper world map on a bulletin board. You and/or groups of students will create a map legend to match the colored pins or dots (see step 4 in Procedure).

Copy the Team Cards sheets onto cardstock and cut out the cards. (The number of cards per team of students will depend on the total number of student teams.) Make copies of the student sheet.

Divide your students into cooperative learning groups of 2 to 4. Place the mapping pins or colored dots in a central location.

Depending on the amount of time and resources available, you may want to conduct this activity as a student group project, with each group receiving its own map and plotting an entire set of dots.

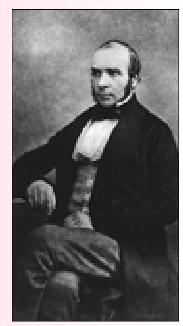
PROCEDURE

1. Ask students, *Does anyone know what “CSI” stands for?* [crime scene investigation] *Have any of you watched one of the different CSI programs on television? How do the investigators on these programs gather information?* Mention that

Continued

MAKING HISTORY: EPIDEMIOLOGISTS

- **Edward Anthony Jenner** (1749–1823), was a doctor and surgeon who noticed that people who had a mild disease called cowpox were less likely to contract the much more deadly smallpox. His observations led to the smallpox vaccine and saving the lives of millions of people.
- **John Snow** (1813–1858) is considered one of the fathers of epidemiology. Dr. Snow first noticed the link between cholera and drinking water. By studying patterns of outbreak and talking to local residents, he traced cholera outbreaks in London to human sewage leaking into a public water pump. He also used a map to show clusters of cholera cases.



- **Beatrice Hahn, M.D.**, led a team of researchers that traced the origin of HIV-1 by collecting and analyzing chimpanzee feces from ten sites in central Africa, showing that a recombination of related viruses led to the origin of HIV.

CAREER FOCUS: EPIDEMIOLOGY

Epidemiologists study outbreaks of disease in human populations. Most people who choose this career have a keen interest in science, medicine and mathematics. They also like solving mysteries and puzzles, are creative and observant, and want to help improve people's lives. Visit these websites for more information on epidemiology careers.

- **American Dental Education Association**
  explorehealthcareers.org
- **Centers for Disease Control and Prevention: Careers in Public Health**
  cdc.gov/excite/careers
- **National Institutes of Health: LifeWorks**
  science.education.nih.gov/lifeworks
- **What is Public Health?**
  whatispublichealth.org

EXTENSION

Have each student "adopt" one country from his/her table and research that country's resources, people, politics, and other conditions that may contribute to the spread of HIV/AIDS and/or other health problems.

students will apply problem-solving strategies and scientific techniques like those used on CSI to collect clues and explain a mystery. Discuss the topic of mapping a crime scene and help students understand how the mapping process informs investigators. Ask, *What does a crime scene map tell the investigators?* [It helps them determine the sequence of events.]

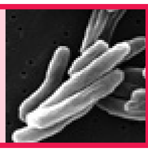
2. Divide the class into 10 HIV/AIDS mapping teams. Provide each team with one of the ten Adult HIV/AIDS Prevalence Rate, by Country tables. If you have fewer than ten teams, give some groups two tables or divide the remaining countries among all teams.
3. Explain that each table lists 16 or 17 different countries for which HIV/AIDS data are available (data are not available for all countries). The number to the right of each country name is the percentage of the adult population in that country living with HIV/AIDS. (For this activity, an "adult" is defined as a person aged 15 to 49.) The data were collected from *The World Factbook* produced by the U.S. Central Intelligence Agency. They are from the year 2009. The percentage of infected adults in each country was calculated by dividing the total adult population by the number of adults living with HIV/AIDS, whether or not they exhibited AIDS symptoms.
4. Create a color legend for the map, or assign one or more students to create the legend. The table below provides suggested percentage ranges to be represented by each color of map pin or adhesive dot. However, you may adjust the legend on your class map to match the colors available.

Suggested Legend

*<0.1%	Purple
0.1% – <0.5%	Blue
0.5% – <1%	Green
1% – <5%	Yellow
5% – <15%	Orange
15% – <26%	Red

*< = less than

5. Have each student team locate its assigned countries on the world map. Then, have students place an appropriately-colored pin or dot in the center of each country to represent the percentage of adults in that country who are living with HIV/AIDS. Some countries may be difficult to locate. A world atlas or access to geography websites will be helpful.
6. When all teams have plotted their countries, have them use the questions on the student page to analyze the total map display.
7. Lead a class discussion of the results. Ask, *Do you see any trends? Where is HIV/AIDS most prevalent?* [central and southern Africa.] *Which country has the highest percentage of adults living with HIV/AIDS?* [Swaziland: 26.1%.] *What are the numbers worldwide?* [34 million people are living with HIV/AIDS.]



Mycobacterium tuberculosis bacteria. CDC\9997 Ray Butler, Ph.D., Janice H. Carr.

4 Where In the World?

INSTRUCTIONS

1. Working as a team, follow the instructions on the card you have received to place colored pins (or dots) on the large world map. The colors represent the percentage of people living with HIV in each of the countries listed in your table. Place the pin (or dot) in the center of each country.

2. When all teams have finished, examine the world map. Do you see any trends in the large map in the distribution of HIV/AIDS? Discuss your observations with your teammates.

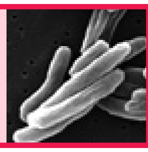
3. Write a short paragraph describing the trends you observed.

4. Use the "World Map" page to illustrate your observations.

5. Based on your observations, speculate on the general region in the world where HIV/AIDS is likely to have originated. Write your answer below.

6. Imagine that you are an epidemiologist. In what ways could you confirm your speculation about the origin of HIV/AIDS? Share your ideas with your team and write them on the back of this sheet of paper.

Source: Wikimedia Commons.

4 

Mycobacterium tuberculosis bacteria. CDC\9997 Ray Butler, Ph.D., Janice H. Carr.

Team Cards

1 Adult* HIV/AIDS Prevalence Rate by Country

* Persons between the ages of 15 and 49 who are infected.

Locate the following countries on the world map. Place a colored pin or colored dot in the center of each country with different colors representing the percentage of people in each country who are living with HIV/AIDS.

Afghanistan	0.01
Bermuda	0.30
Botswana	24.80
Chad	3.40
Denmark	0.20
El Salvador	0.80
France	0.40
Guyana	1.20
Indonesia	0.20
Jordan	0.10
Luxembourg	0.30
Mauritius	1.70
Rwanda	2.90
Singapore	0.10
Sudan	1.10
Togo	3.20
Venezuela	0.70

Source: *The World Factbook,* U.S. Central Intelligence Agency (2009 estimates).

2 Adult* HIV/AIDS Prevalence Rate by Country

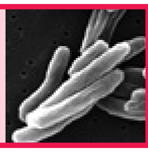
* Persons between the ages of 15 and 49 who are infected.

Locate the following countries on the world map. Place a colored pin or colored dot in the center of each country with different colors representing the percentage of people in each country who are living with HIV/AIDS.

Algeria	0.10
Bahamas, The	3.10
Bulgaria	0.10
Chile	0.40
Congo, Democratic Republic of the	4.20
Ecuador	0.40
Ghana	1.80
Israel	0.20
Kazakhstan	0.10
Lesotho	23.60
Mali	1.50
Niger	0.80
Oman	0.10
Panama	0.90
Saudi Arabia	0.01
Tanzania	5.60
United States	0.60

Source: *The World Factbook,* U.S. Central Intelligence Agency (2009 estimates).

Team Cards



Mycobacterium tuberculosis bacteria. CDC\9997 Ray Butler, Ph.D., Janice H. Carr.

3 Adult* HIV/AIDS Prevalence Rate by Country

* Persons between the ages of 15 and 49 who are infected.

Locate the following countries on the world map. Place a colored pin or colored dot in the center of each country with different colors representing the percentage of people in each country who are living with HIV/AIDS.

Angola	2.0
Bangladesh	0.10
Cambodia	0.50
Cote d'Ivoire	3.40
Germany	0.10
Guinea-Bissau	2.50
Haiti	1.90
Japan	0.10
Kyrgyzstan	0.30
Malawi	11.00
Morocco	0.10
New Zealand	0.10
Paraguay	0.30
Serbia	0.10
Sri Lanka	0.10
Tajikistan	0.20
United Kingdom	0.20

Source: *The World Factbook,* U.S. Central Intelligence Agency (2009 estimates).

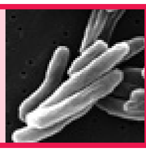
4 Adult* HIV/AIDS Prevalence Rate by Country

* Persons between the ages of 15 and 49 who are infected.

Locate the following countries on the world map. Place a colored pin or colored dot in the center of each country with different colors representing the percentage of people in each country who are living with HIV/AIDS.

Argentina	0.50
Benin	1.20
Brunei	0.10
Central African Republic	4.70
Czech Republic	0.10
Equatorial Guinea	5.0
Finland	0.10
Guinea	1.30
Hong Kong	0.10
Iraq	0.10
Madagascar	0.10
Mozambique	11.50
Norway	0.10
Qatar	0.10
Sierra Leone	1.60
Switzerland	0.40
Vietnam	0.40

Source: *The World Factbook,* U.S. Central Intelligence Agency (2009 estimates).



Mycobacterium tuberculosis bacteria. CDC\9997 Ray Butler, Ph.D., Janice H. Carr.

Team Cards

5 Adult* HIV/AIDS Prevalence Rate by Country

* Persons between the ages of 15 and 49 who are infected.

Locate the following countries on the world map. Place a colored pin or colored dot in the center of each country with different colors representing the percentage of people in each country who are living with HIV/AIDS.

Armenia	0.10
Belize	2.30
Brazil	0.60
Cape Verde	0.04
Djibouti	2.50
Fiji	0.10
Guatemala	0.80
Iceland	0.30
Jamaica	1.70
Lebanon	0.10
Namibia	13.10
Nepal	0.40
Peru	0.40
Senegal	1.00
Slovakia	0.10
Syria	0.10
United Arab Emirates	0.20

Source: *The World Factbook,* U.S. Central Intelligence Agency (2009 estimates).

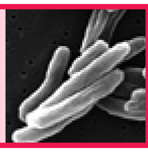
6 Adult* HIV/AIDS Prevalence Rate by Country

* Persons between the ages of 15 and 49 who are infected.

Locate the following countries on the world map. Place a colored pin or colored dot in the center of each country with different colors representing the percentage of people in each country who are living with HIV/AIDS.

Australia	0.10
Belarus	0.30
Bolivia	0.20
Canada	0.30
Congo, Republic of the	3.40
Egypt	0.10
Ethiopia	2.10
Greece	0.10
Ireland	0.20
Kuwait	0.10
Lithuania	0.10
Russia	1.0
South Africa	17.80
Spain	0.50
Svalbard	0.00
Uzbekistan	0.10
Yemen	0.10

Source: *The World Factbook,* U.S. Central Intelligence Agency (2009 estimates).



Mycobacterium tuberculosis bacteria. CDC\9997 Ray Butler, Ph.D., Janice H. Carr.

Team Cards

7 Adult* HIV/AIDS Prevalence Rate by Country

* Persons between the ages of 15 and 49 who are infected.

Locate the following countries on the world map. Place a colored pin or colored dot in the center of each country with different colors representing the percentage of people in each country who are living with HIV/AIDS.

Austria	0.40
Barbados	1.40
Burkina Faso	1.20
Cameroon	5.30
Cuba	0.10
Dominican Republic	0.90
Eritrea	0.80
Gambia, The	2.0
Italy	0.30
Laos	0.20
Maldives	0.10
Mongolia	0.10
Nigeria	3.60
Portugal	0.60
Swaziland	25.90
Thailand	1.30
Uruguay	0.50

Source: *The World Factbook,* U.S. Central Intelligence Agency (2009 estimates).

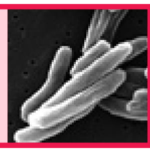
8 Adult* HIV/AIDS Prevalence Rate by Country

* Persons between the ages of 15 and 49 who are infected.

Locate the following countries on the world map. Place a colored pin or colored dot in the center of each country with different colors representing the percentage of people in each country who are living with HIV/AIDS.

Azerbaijan	0.10
Bosnia and Herzegovina	0.10
Colombia	0.60
Cyprus	0.10
Estonia	1.20
Honduras	0.80
Iran	0.20
Libya	0.30
Netherlands	0.20
Philippines	0.10
Romania	0.10
Slovenia	0.10
Sweden	0.10
Trinidad and Tobago	1.50
Turkey	0.10
Ukraine	1.10
Zambia	13.50

Source: *The World Factbook,* U.S. Central Intelligence Agency (2009 estimates).



Mycobacterium tuberculosis bacteria. CDC\9997 Ray Butler, Ph.D., Janice H. Carr.

Team Cards

9 Adult* HIV/AIDS Prevalence Rate by Country

* Persons between the ages of 15 and 49 who are infected.

Locate the following countries on the world map. Place a colored pin or colored dot in the center of each country with different colors representing the percentage of people in each country who are living with HIV/AIDS.

Bahrain	0.20
Bhutan	0.20
Burma	0.60
China	0.10
Croatia	0.10
Georgia	0.10
Hungary	0.10
India	0.30
Korea, South	0.10
Latvia	0.70
Macedonia	0.10
Malta	0.10
Pakistan	0.10
Papua New Guinea	0.90
Somalia	0.70
Tunisia	0.10
Zimbabwe	14.30

Source: *The World Factbook,* U.S. Central Intelligence Agency (2009 estimates).

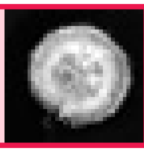
10 Adult* HIV/AIDS Prevalence Rate by Country

* Persons between the ages of 15 and 49 who are infected.

Locate the following countries on the world map. Place a colored pin or colored dot in the center of each country with different colors representing the percentage of people in each country who are living with HIV/AIDS.

Belgium	0.20
Burundi	3.30
Comoros	0.10
Costa Rica	0.30
Gabon	5.20
Kenya	6.30
Liberia	1.50
Malaysia	0.50
Mauritania	0.70
Mexico	0.30
Moldova	0.40
Nicaragua	0.20
Poland	0.10
Suriname	2.40
Turkmenistan	0.10

Source: *The World Factbook,* U.S. Central Intelligence Agency (2009 estimates).

5 

Aspergillus niger fungus. CDC\3965 Lucille K. Georg.

E S S A Y

Myth or Fact?

When bad things happen, people naturally search for answers, explanations, and something or someone to blame. This can be helpful. If we know the cause of a tragedy, such as the HIV/AIDS pandemic, we can try to prevent it from happening again, or at least minimize its harmful effects. For example, knowledge of HIV's origins, and means of transmission has helped researchers to find effective treatments and preventative measures.

Unfortunately, the long process of discovery and development also has produced an abundance of misinformation that is very difficult to correct. Especially these days, when technology allows almost instantaneous global distribution of Internet content—both true and untrue—it can be difficult to tell reliable information from pure fabrication.

The initial discovery of AIDS in a group of homosexual men led to the belief that only homosexual men were at risk. But then, HIV/AIDS was found in intravenous drug users. Still later, HIV began to spread through minority groups and entire nations. Each new discovery led to new rumors and myths, some motivated by personal bias rather than an interest in the truth. Fear, denial, and misinformation have hindered education efforts and are partially are responsible for the rapid worldwide spread of the virus. HIV/AIDS causes approximately 2 million deaths per year. More than 34 million persons were living with HIV/AIDS as of 2009.

Like many words, the term, myth, has many meanings. Historically, a myth is a legendary story, usually concerning a hero or event, used to communicate some societal rule or phenomenon of nature. In modern use, myth also means a false story that results from a misunderstanding or a deliberate attempt to mislead. Myths relating to HIV/AIDS are rooted in fear, lack of knowledge, and sometimes, intentional deception. Knowing the difference between HIV/AIDS facts and myths is literally a matter of life and death.

HIV/AIDS MYTHS

- AIDS is a punishment from God.
- An HIV diagnosis is a death sentence.
- HIV/AIDS was created for germ warfare.
- Only homosexual males and drug users are affected by HIV/AIDS.
- HIV/AIDS is no longer a problem in the United States.
- Women cannot give men HIV.
- You can get HIV from a kiss, a cough, a sneeze, tears, a toilet or shower, a swimming pool, a mosquito bite, contaminated ketchup bottles, or a hug.
- Drug companies are withholding an HIV/AIDS cure to make more money.
- HIV prevention does not work.
- You can tell if someone has HIV by his or her appearance.
- Since there are drugs to treat HIV/AIDS, people no longer have to worry about being infected.
- HIV is the result of a government conspiracy to eliminate certain groups of people.
- If someone is taking HIV medications, they can't spread the virus to others.

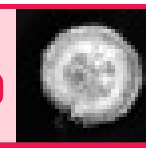
HIV/AIDS FACTS

- Anyone can acquire HIV.
- HIV infections are preventable.
- HIV is transmitted through unprotected sex with a carrier of HIV.
- HIV is transmitted through contaminated blood transfusions and the sharing of needles among drug users.
- HIV can be transferred from mother to child during pregnancy and nursing.
- Though extremely rare, HIV can be transmitted accidentally to medical workers who are stuck with needles used with patients with HIV/AIDS.
- Modern drug therapies can hold HIV at bay indefinitely if administered consistently.
- For treatments to be effective, HIV patients must take all of their medications exactly as prescribed, always on time and without missing doses.
- Birth control pills do not protect against HIV infection. Condoms, when used properly, reduce the transmission of HIV. Abstinence is 100% effective in preventing sexually transmitted HIV.
- Researchers have not yet developed a vaccine to prevent HIV infection.
- HIV is not a death sentence.
- Education is the best way to prevent HIV/AIDS.

Overview

Students will use statistical tables of HIV/AIDS data to create presentations about HIV/AIDS in relation to the United States.

5



Aspergillus niger fungus. CDC\3965 Lucille K. Georg.

TIME

Setup: 15 minutes

Activity: 2–4 class periods

HIV/AIDS IN THE United States

The Centers for Disease Control and Prevention (CDC) estimate that more than one million people in the United States are living with HIV. About one in five (21%) of these people are unaware of their HIV-positive status. It is not surprising, then, that each year, upwards of 56,000 more Americans become infected with HIV. And despite improved medications, more than 18,000 people in the U.S. die each year from AIDS-related causes.

The burdens of HIV/AIDS are not distributed equally across all segments of the U.S. population. Among racial/ethnic groups, African Americans face the highest rates of infection. Hispanics/Latinos also have a disproportionately large representation among the population of Americans living with HIV/AIDS.

Unfortunately, many young people do not understand how HIV is transmitted or treated. This lack of knowledge, when combined with alcohol and/or drug use, can be especially dangerous for adolescents, who are more likely to engage in high-risk behaviors, such as unprotected sex, when they are “under the influence.” Improving students’ basic knowledge, understanding of risks, and decision-making skills can help reduce rates of teen pregnancy and infection by STDs, including HIV. In this activity, students will discuss common misconceptions and truths about HIV/AIDS, and will examine authentic CDC data about the epidemic in our country.

MATERIALS

Per Team of Students (see Setup)

- Colored markers
- Rulers
- Poster paper
- Set of student sheets (p. 32–40)

SETUP

Select the CDC data tables you will use with your class. Please note, the first few pages of data tables cover the incidence of new HIV infections related to age, sex, and race/ethnicity. The last page specifically covers major transmission categories and includes statistical references on sexual transmission and injection drug use. You may choose to use or not use this page. Photocopy one set of the data tables you select and blank graphs for each student team. Have students work in teams of 2 to 4.

PROCEDURE

1. Announce to your students that they will be participating in a classroom HIV/AIDS research conference.
2. Divide the class into teams and provide each team with the HIV/AIDS data tables you have selected. The data describe the incidence of new HIV infections for the United States in the years 2006, 2009, and the prevalence of AIDS in the U.S. in the year 2007.
3. Challenge each team to review the data in the CDC tables and produce a graph, chart or some

Continued

SCIENCE EDUCATION CONTENT STANDARDS

Grades 5–8

Life Science

- Disease is a breakdown in structures or functions of an organism. Some diseases are the result of damage by infection by other organisms.
- A population consists of all individuals of a species that occur together at a given place and time.

Science in Personal and Social Perspectives

- Students should understand the risks associated with biological hazards (viruses and bacteria, for example), and with personal hazards (such as drinking).
- Individuals can use a systematic approach to thinking critically about risks and benefits.
- Important personal and social decisions are made based on perceptions of benefits and risks.

Grades 9–12

Life Science

- Behavioral biology has implications for humans, as it provides links to psychology, sociology and anthropology

Science in Personal and Social Perspectives

- Many diseases can be prevented or controlled.
- Personal goals, peer and social pressures, ethnic and religious beliefs, and understanding of biological consequences can all influence decisions about health practices.

History and Nature of Science

- Science distinguishes itself from other ways of knowing through the use of empirical standards, logical arguments, and skepticism, as scientists strive for the best possible explanations about the natural world.

MORE INFORMATION

See the following sources 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/hivaids/ 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.

DIFFERENT RESULTS

While sources of HIV/AIDS statistical information may not agree exactly, they do agree on trends. In many parts of the world, data collection has to rely on small samples, and the methods used for estimates may yield different results. However, whether the number of new HIV infections is 2.7 or 3.0 million, the trend is still tragic in its magnitude.

other document that illustrates the relationship between the data in two or more of the tables. Students should be careful to note whether a table is reporting data by percentage or raw number. Each team's goal is to create a presentation on the HIV/AIDS pandemic as it relates to the U.S. Presentations should explain students' observations clearly, in a way the entire class will be able to understand. If desired, the U.S. data can be related to worldwide numbers examined in the previous activity, "Mapping the Spread of HIV/AIDS."

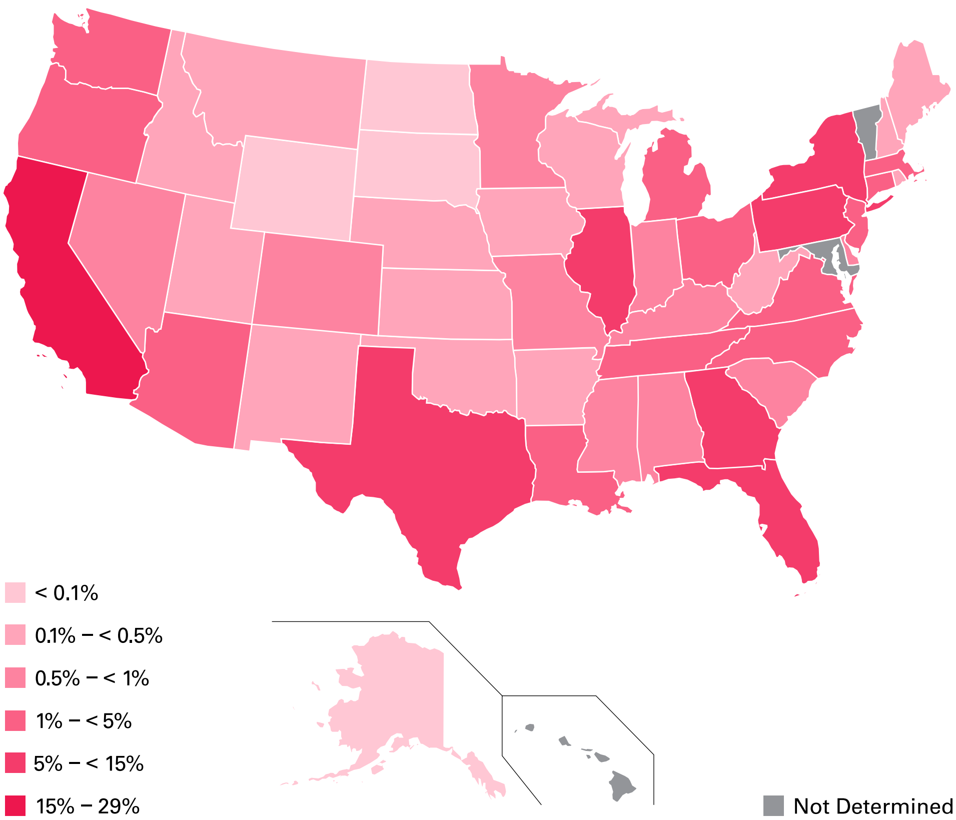
4. Discuss different ways to interpret and present the data through tables, graphs, diagrams etc. For example, students might elect to use graphs in the form of bar charts, pie charts, scatter plots, etc. Also, allow students to be creative in their choices of media used to communicate their findings (e.g., posters, flip-charts, PowerPoint® presentations, artwork, video, etc.).
5. Help students understand how to read and compare the different tables. They will see the abbreviation, "N," used to refer to the total number of subjects represented in a table.

   Because different statistical methods were used to derive information for the tables, some tables relating to the same topic have different "N" values. For example, in some tables, the numbers for Asian/Pacific Islander and American Indian/Alaska Native groups are too small to allow for accurate estimates. Consequently, totals for those racial/ethnic groups are not included in some tables, which reduces the tables' "N" value.

   The table presenting the incidence of new HIV infections presents data as a rate per 100,000. This means, as an example, that for each 100,000 Hispanic/Latino persons in the United States, 40 individuals acquired a new HIV infection in 2009. (Note: some tables present data as percentages rather than raw numbers.)
6. Conduct a class "HIV/AIDS Research Conference," during which students share their presentations, explain the data they used and present their conclusions.
7. Discuss each team's findings with the entire class. Some of the questions below may help to promote student responses and learning.
   - What do your data show?
   - Based on the data, which groups are at greatest risk for contracting HIV?
   - How do these totals relate to the population as a whole?
   - Are males or females more likely to become infected with HIV?
   - Is any age or racial/ethnic group untouched by HIV/AIDS?
   - Why are HIV and AIDS reported separately in the tables?
   - Is HIV transmission limited to homosexual contact?

Sample Conclusions

- The prevalence of HIV infection in the U.S. is well below that in some nations, but it is nevertheless a major health issue in our country.
- Although Black/African Americans make up only 13% of the total U.S. population, they accounted for a disproportionately high number (45%) of the new HIV infections in 2006.



U.S. HIV Infections 2007 – 50 States and the District of Columbia.

Source: Map generated by M.S. Young, Baylor College of Medicine, using public data gathered by The Henry J. Kaiser Family Foundation.

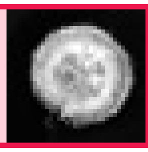
- While males are more likely than females to become infected with HIV, the increase in the rate of infection among Black/African American females is the highest for all racial/ethnic groups.
- HIV and AIDS are reported separately in the tables because a person infected with HIV may not have AIDS. Without diagnosis and consistent medical treatment, the virus, HIV, leads to the disease, AIDS. Due to improved HIV detection and treatment, and to the deadly effects of AIDS itself, the number of people living with HIV is much greater than the number living with AIDS.
- The infection rate (per 100,000 people) for Black/African Americans is 7.5 times greater than the infection rate for white Americans. The rate of infection for Hispanic/Latino populations is 2.5 times greater than the rate for white Americans.
- Among all racial/ethnic groups in the U.S., Black/African American females currently are at greatest risk of becoming infected with HIV.
- Based on the final tables, homosexual activity still is the most common way for HIV to be transmitted. However, heterosexual contact and needle sharing among drug addicts also are major transmission routes.

EXTENSIONS

- Talk with your students about the ways to prevent HIV infection. The U.S. Centers for Disease Control and Prevention provide explicit information on prevention measures. Your school or school district may have specific recommendations about how to discuss this topic with students (http://cdc.gov/hiv/topics).
- Invite a public health medical professional to visit your class. Have student teams present their findings again, and discuss the results with this guest.

TEACHING RESOURCES

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

5 

Aspergillus niger fungus. CDC\3965 Lucille K. Georg.

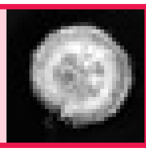
Statistics

2006: U.S. New HIV Infections Male-Female		
Male	41,099	73%
Female	15,201	27%
TOTAL	**N=56,300**	**100%**

2006: U.S. New HIV Infections Age Group		
13 – 29	19,142	34%
30 – 39	17,453	31%
40 – 49	14,075	25%
50 or older	5,630	10%
TOTAL	**N=56,300**	**100%**

2006: U.S. New HIV Infections Race-Ethnicity		
American Indian/Alaskan Native	563	1%
Asian/Pacific Islander	1,126	2%
Black/African American	25,335	45%
Hispanic/Latino	9,571	17%
White	19,705	35%
TOTAL	**N=56,300**	**100%**

Source: U.S. Centers for Disease Control and Prevention

5 

Aspergillus niger fungus. CDC\3965 Lucille K. Georg.

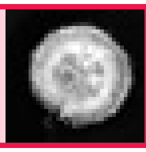
Statistics

2006: U.S. New HIV Infections Male-Female/Age Group/Race-Ethnicity (N=54,220)*						
Age Group	**Black/ African American**		**Hispanic/Latino**		**White**	
Male	**Number**	**%**	**Number**	**%**	**Number**	**%**
13 – 29	6,760	42	3,010	41	4,050	25
30 – 39	4,170	26	2,520	34	5,600	34
40 – 49	3,680	23	1,410	19	4,640	29
50 or older	1,510	9	480	6	1,980	12
Female	**Number**	**%**	**Number**	**%**	**Number**	**%**
13 – 29	2,810	32	820	36	1,050	32
30 – 39	2,670	30	720	31	1,060	32
40 – 49	2,360	27	440	19	840	25
50 or older	960	11	320	14	360	11

* Insufficient data for making predictions regarding American Indian/Alaskan Native and Asian/Pacific Islander groups.

2009: U.S. New HIV Infections Male-Female/Race-Ethnicity (per 100,000 people)			
Male	**Black/ African American**	**Hispanic/Latino**	**White**
	104	40	16
Female	**Black/ African American**	**Hispanic/Latino**	**White**
	40	12	3

Source: U.S. Centers for Disease Control and Prevention

5 

Aspergillus niger fungus. CDC\3965 Lucille K. Georg.

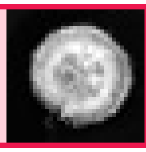
Statistics

2007: U.S. HIV Infections
50 States and District of Columbia

State	Number	%*
Alabama	529	0.9
Alaska	27	0.0*
Arizona	771	1.3
Arkansas	206	0.3
California	17,588	28.7
Colorado	382	0.6
Connecticut	932	1.5
Delaware	480	0.8
D.C.	1,629	2.7
Florida	5,165	8.4
Georgia	3,204	5.2
Hawaii	NA	NA
Idaho	39	0.1
Illinois	3,576	5.8
Indiana	406	0.7
Iowa	93	0.2
Kansas	110	0.2
Kentucky	414	0.7
Louisiana	797	1.3
Maine	46	0.1
Maryland	ND*	ND
Massachusetts	777	1.3
Michigan	623	1.0
Minnesota	289	0.5
Mississippi	471	0.8
Missouri	460	0.8
Montana	92	0.2
Nebraska	78	0.1
Nevada	369	0.6
New Hampshire	52	0.1
New Jersey	1,571	2.6
New Mexico	92	0.2
New York	5,197	8.5
North Carolina	1,746	2.8
North Dakota	9	0.0
Ohio	852	1.4
Oklahoma	199	0.3
Oregon	1,477	2.4
Pennsylvania	3,694	6.0
Rhode Island	130	0.2
South Carolina	542	0.9
South Dakota	17	0.0
Tennessee	841	1.4
Texas	3,495	5.7
Utah	92	0.2
Vermont	ND	ND
Virginia	823	1.3
Washington	620	1.0
West Virginia	55	0.1
Wisconsin	220	0.4
Wyoming	15	0.0

*Note: 0.0% is less than or equal to 30 cases. ND = Not determined.

Source: Public data gathered by The Henry J. Kaiser Family Foundation



Aspergillus niger fungus. CDC\3965 Lucille K. Georg.

Statistics

2007: U.S. AIDS Cases 50 States and District of Columbia: Age at Diagnosis		
Age at Time of Diagnosis	**Estimated New AIDS Cases in 2007**	**Cumulative Number AIDS Cases Through 2007**
Under 13	28	9,209
13 – 14	80	1,169
15 – 19	455	6,089
20 – 24	1,927	38,175
25 – 29	3,380	120,464
30 – 34	4,187	201,906
35 – 39	5,888	219,601
40 – 44	6,813	177,250
45 – 49	5,749	112,896
50 – 54	3,636	63,408
55 – 59	2,040	34,160
60 – 64	980	18,249
65 or older	800	18,853
TOTAL	**35,963**	**1,021,429**

2007: U.S. AIDS Cases Geographic Region		
Region	**AIDS Cases Diagnosed 2007***	**Persons Living With AIDS 2007**
Midwest	11%	11%
Northeast	25%	29%
South	46%	40%
West	17%	20%

* Percentages rounded off = 99%

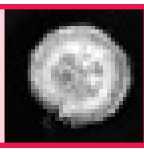
MIDWEST
Illinois, Indiana, Iowa, Kansas, Michigan, Minnesota, Missouri, Nebraska, North Dakota, Ohio, South Dakota, Wisconsin

NORTHEAST
Connecticut, Maine, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, Vermont

SOUTH
Alabama, Arkansas, Delaware, District of Columbia, Florida, Georgia, Kentucky, Louisiana, Maryland, Mississippi, North Carolina, Oklahoma, South Carolina, Tennessee, Texas, Virginia, West Virginia

WEST
Alaska, Arizona, California, Colorado, Hawaii, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, Washington, Wyoming

Source: U.S. Centers for Disease Control and Prevention


Aspergillus niger fungus. CDC\3965 Lucille K. Georg.

5 Statistics

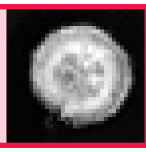
2007: U.S. AIDS Cases 50 States and District of Columbia: Race-Ethnicity		
Race-Ethnicity	**Estimated New AIDS Cases in 2007**	**Cumulative Number AIDS Cases Through 2007***
American Indian/Alaskan Native	158	3,492
Asian/Pacific Islander	551	8,232
Black/African American	17,507	426,003
Hispanic/Latino	6,921	169,138
White	10,407	404,465
Total Cases	**35,544**	**1,011,330**

* Totals may vary for same data set due to incomplete information.

2007: U.S. AIDS Cases Transmission Category: Children Age 13 or Younger at Diagnosis		
Transmission Category	**Estimated AIDS Cases in 2007**	**Cumulative Number AIDS Cases Through 2007**
Perinatal*	24	8,434
Other: Blood transfusions or not known	4	775
Total Cases	**28**	**9,209**

* Perinatal means shortly before birth to shortly after (passed from mother to child).

Source: U.S. Centers for Disease Control and Prevention

5 

Aspergillus niger fungus. CDC\3965 Lucille K. Georg.

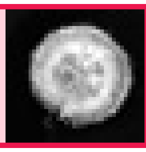
Transmission Categories

2006: U.S. New HIV Infections Transmission Category	
Heterosexual Contact	31%
Male-Male Sexual Contact	53%
Injection Drug Use	12%
Male-Male Sexual Contact with Injection Drug Use	4%

2006: U.S. New HIV Infections
Race-Ethnicity/Sex/Transmission Category

Transmission Category	Black/ African American		Hispanic/Latino		White	
Male	**Number**	**%**	**Number**	**%**	**Number**	**%**
Heterosexual Contact	3,290	20	970	14	990	6
Male-Male Sexual Contact	10,130	63	5,360	76	13,230	81
Injection Drug Use	2,010	12	730	10	1,010	6
Male-Male Sexual Contact with Injection Drug Use	690	4	360	5	1,050	6
Female	**Number**	**%**	**Number**	**%**	**Number**	**%**
Heterosexual Contact	7,340	83	1,910	83	2,310	70
Injection Drug Drug Use	1,470	17	400	17	990	30

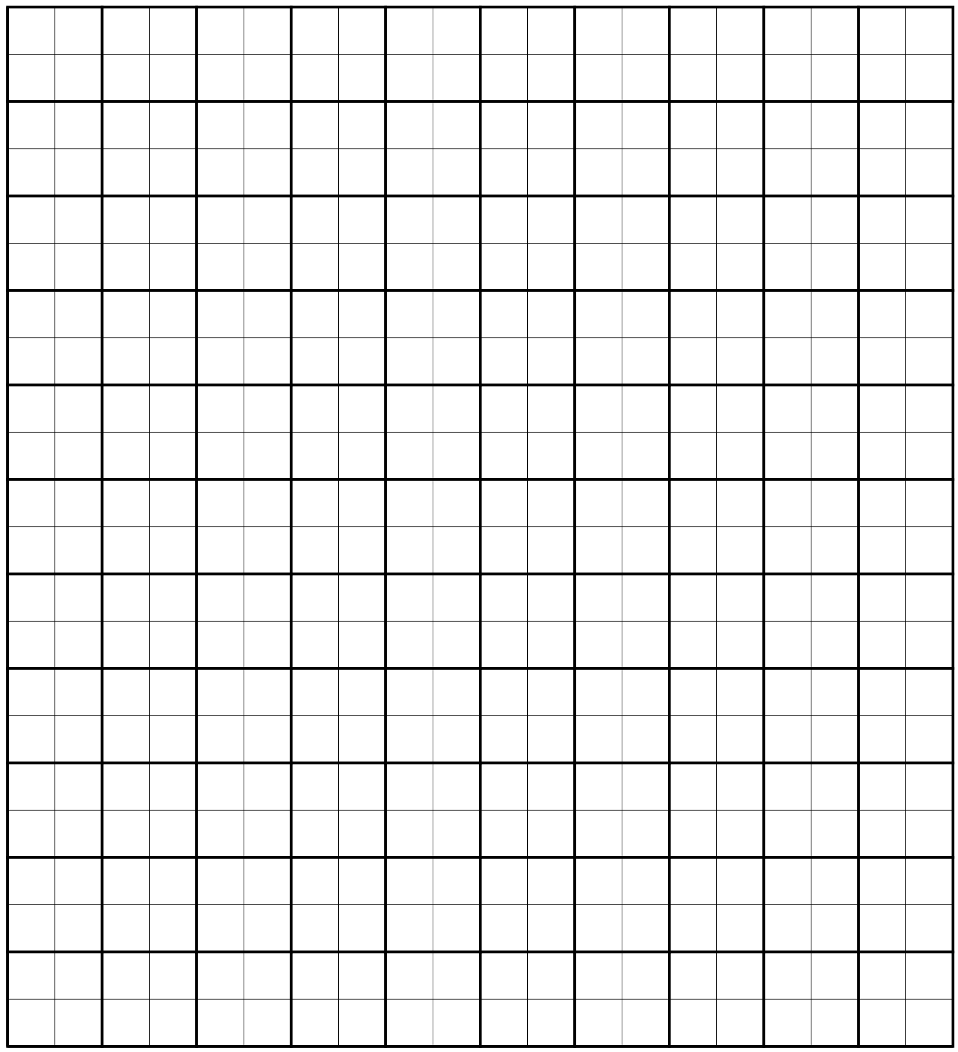
Source: U.S. Centers for Disease Control and Prevention



Bar Graph

Aspergillus niger fungus. CDC\3965 Lucille K. Georg.

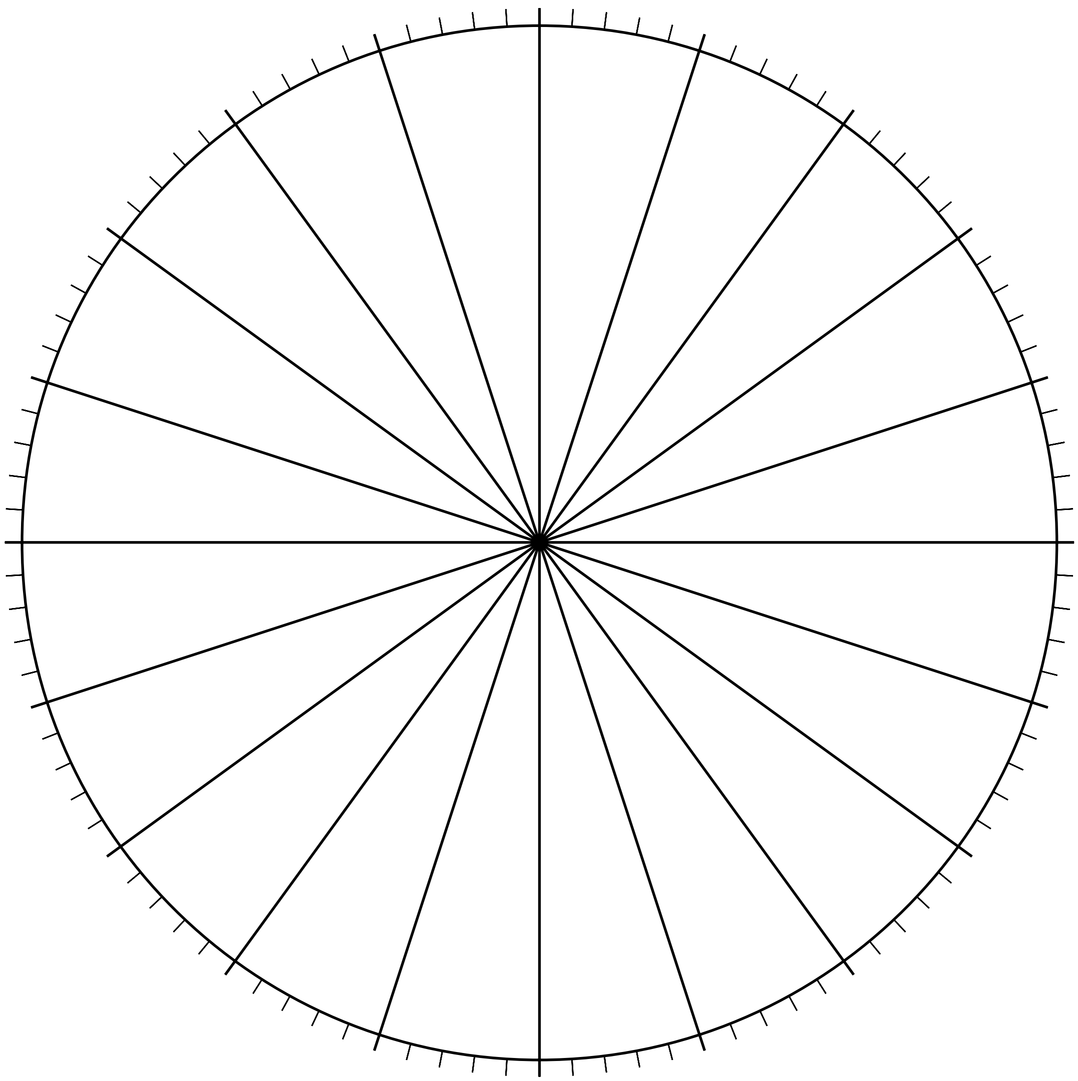
Each horizontal and vertical axis of the graph below has 20 divisions. The graph can be used to display numbers or percentages.



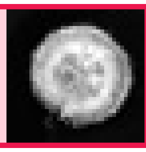
5 Pie Chart

Aspergillus niger fungus. CDC\3965 Lucille K. Georg.

The chart below has 20 large and 100 small divisions (100%). Color or shade one division for each percent you want to illustrate (for example, 15% = 15 small divisions).

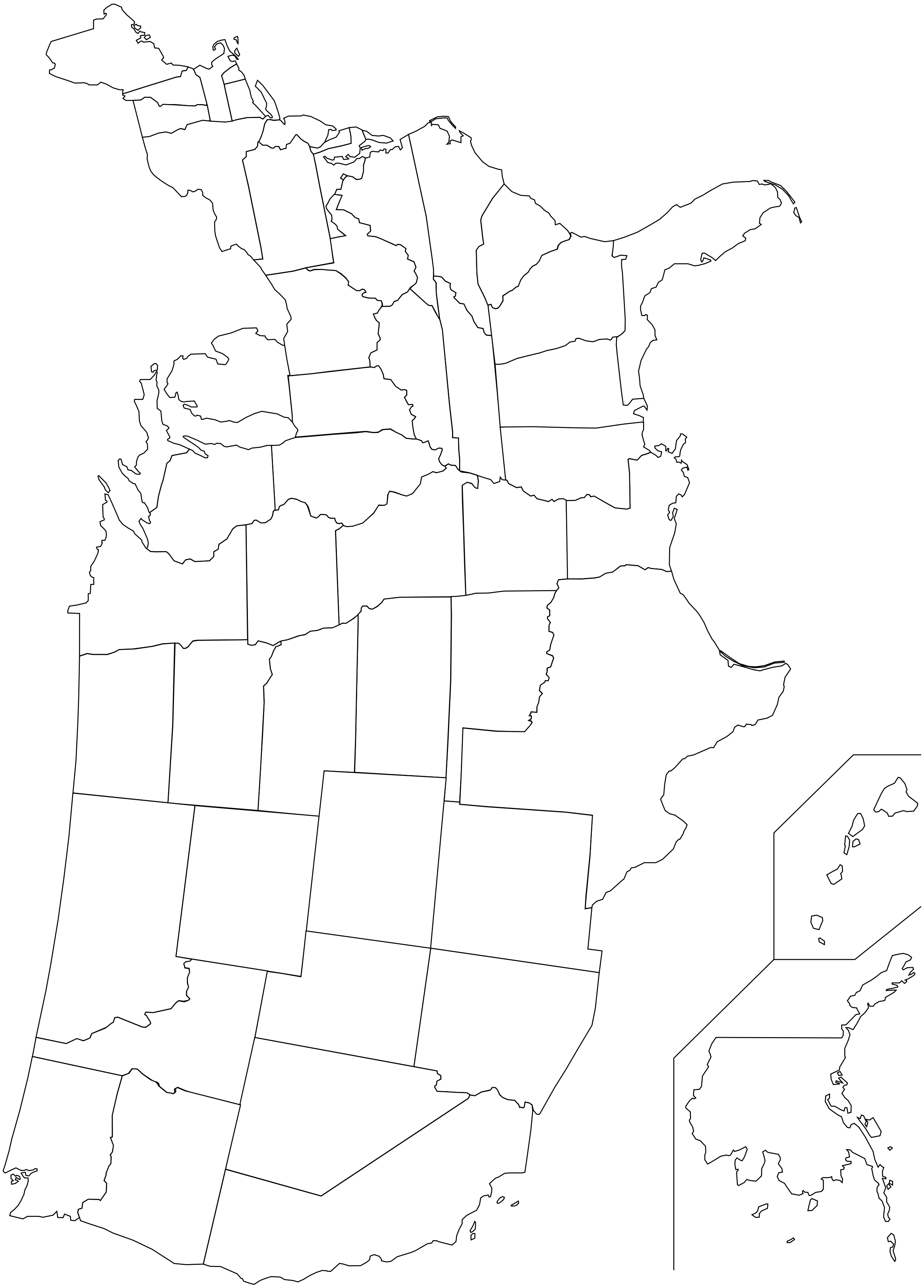


5



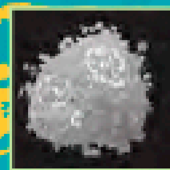
United States Map

Aspergillus niger fungus. CDC\3965 Lucille K. Georg.



Source: Wikimedia Commons.

THE SCIENCE OF HIV-AIDS



BioEd℠

Teacher Resources *from* the
Center *for* Educational Outreach
Baylor College *of* Medicine

ISBN-13: 978-1-888997-62-0

BCM
Baylor
College *of*
Medicine

CFAR
CENTER FOR AIDS RESEARCH
Baylor–UT Houston

SEPA SCIENCE EDUCATION PARTNERSHIP AWARD

Supported by the National Center for Research Resources, a part of the National Institutes of Health