

## FILM GUIDE FOR TEACHERS

### KEY CONCEPTS

- Most viruses infect a limited number of species, or hosts, but occasionally they adapt and spread to other hosts.
- Viruses cause disease in some hosts and not others.
- Viruses that spill over from an animal source, or reservoir, to humans are called zoonotic viruses. A large percentage of emerging infectious diseases in humans are viral zoonoses.
- The spillover of viruses from wild animals to humans is increasing for multiple reasons, including the growth of human populations and encroachment into wild areas.
- Outbreaks of disease in dense urban areas can lead to more widespread disease epidemics.
- To understand how outbreaks begin and spread, public health officials collect evidence from basic biological research, interviews, monitoring people's health status, and purposefully designed studies.
- Strategies to prevent or contain viral outbreaks include vector control, quarantine, vaccination, and contact tracing.
- To help predict and avoid viral outbreaks, public health officials identify animal reservoirs of the virus and monitor viral strains to detect more virulent or transmissible forms that may emerge.
- Better understanding of the basic biology of infectious disease can lead to effective disease prevention, stemming of outbreaks, and treatments.
- Global partnerships and investments in public health programs are vital in preventing disease outbreaks.

### CURRICULUM CONNECTIONS

Curriculum	Standards
NGSS (April 2013)	HS LS2.C, HS ETS1.A, B, and C
AP Biology (2012–2013)	1.C.3, 2.D.3, 3.C.3, 4.B.4
IB Biology (2009)	6.3, 11.1, F.6
EPHS Core Competencies (2015)*	HS-EPHS1-1, HS-EPHS2-2, HS-EPHS3-1, HS-EPHS4-1
NHES (2004)**	1.12.3, 1.12.5, 2.12.2, 2.12.6, 2.12.10, 8.12.2

\* Epidemiology and Public Health Science: Core Competencies for High School Students, 2015

(<https://www.cdc.gov/careerpaths/k12teacherroadmap/pdfs/ephs-competencies.pdf>)

\*\*National Health Education Standards, 2004 (<http://www.cdc.gov/healthyschools/sher/standards/index.htm>)

### CURRICULUM RESOURCES FROM BIOINTERACTIVE

**Click and Learn: Retroviruses and Viral Diversity (30 minutes in class or homework)**

<https://www.hhmi.org/biointeractive/retroviruses-and-viral-diversity>

Explore the diversity of viruses and how they can be classified based on a number of shared characteristics, such as the presence of an envelope, their geometric structure, the type of genome, and mode of replication.

**Video: Virus Hunter: Monitoring Nipah Virus in Bat Populations (9 minutes)**

<https://www.hhmi.org/biointeractive/virus-hunter>

This video follows Dr. Jon Epstein as he monitors bat populations in Bangladesh for the presence of Nipah virus. Nipah virus caused an outbreak in Bangladesh in 2004, and since then outbreaks have occurred almost every year.

**2010 Holiday Lecture Series: Viral Outbreak: The Science of Emerging Disease (50 minutes)**

<https://www.hhmi.org/biointeractive/viral-outbreak-science-emerging-disease>

In this video and multimedia presentation, watch two leading virus researchers explain how they use both simple and sophisticated technologies to detect and fight infectious agents.

**Lecture: Emerging Infections: How Epidemics Arise (59 minutes)**

<https://www.hhmi.org/biointeractive/emerging-infections-how-epidemics-arise>

Dr. Donald Ganem analyses the complex causes of epidemics—how changes in the environment and in human social behavior can give rise to new infectious diseases.

**Classroom Resource: West Nile Virus—Vectors and Hosts Game (one 50-minute class period)**

<https://www.hhmi.org/biointeractive/classroom-resource-west-nile-virus-vectors-and-hosts-game>

This game illustrates the complexity of viral infections that involve multiple vectors and hosts. Students play either a mosquito (vector) or one of several hosts—robin, blue jay, crow, horse, or human—to simulate how viral infection spreads. Each student playing a host is given a playing card that explains his or her role. The student is then responsible for acting out the results of West Nile infection as described on the playing card.

**Classroom Resource: The Mosquito Life Cycle (The activity takes 8 to 14 days to complete. You will need only a few minutes of observation each day, but you will need to make daily observations.)**

<https://www.hhmi.org/biointeractive/classroom-activities-mosquito-life-cycle>

Understanding the mosquito life cycle is essential to effective pest control and disease prevention strategies. In this activity, students will rear mosquitoes, observe their progression through life stages, record how long it takes adults to emerge, and calculate the sex ratio.

**Animation: Dengue Fever Re-Emergence in the Americas (24 sec)**

<https://www.hhmi.org/biointeractive/dengue-fever-re-emergence-americas>

Since the 1960s, dengue fever has spread to many countries and total case numbers have exploded. Use this short animation to show how rapidly re-emerging diseases can spread.

**Click and Learn: Stopping Mosquito-Borne Disease (30 minutes in class or homework)**

<https://www.hhmi.org/biointeractive/stopping-mosquito-borne-disease>

Interactively explore how to control mosquito-borne diseases.

**Viral Lifecycle (68 sec)**

<https://www.hhmi.org/biointeractive/viral-lifecycle>

Use this short animation to show how delivering a single virus to a cell allows the virus to infect the cell, replicate, and give rise to many progeny viruses. These viruses can then infect many neighboring cells.



## PRIOR KNOWLEDGE

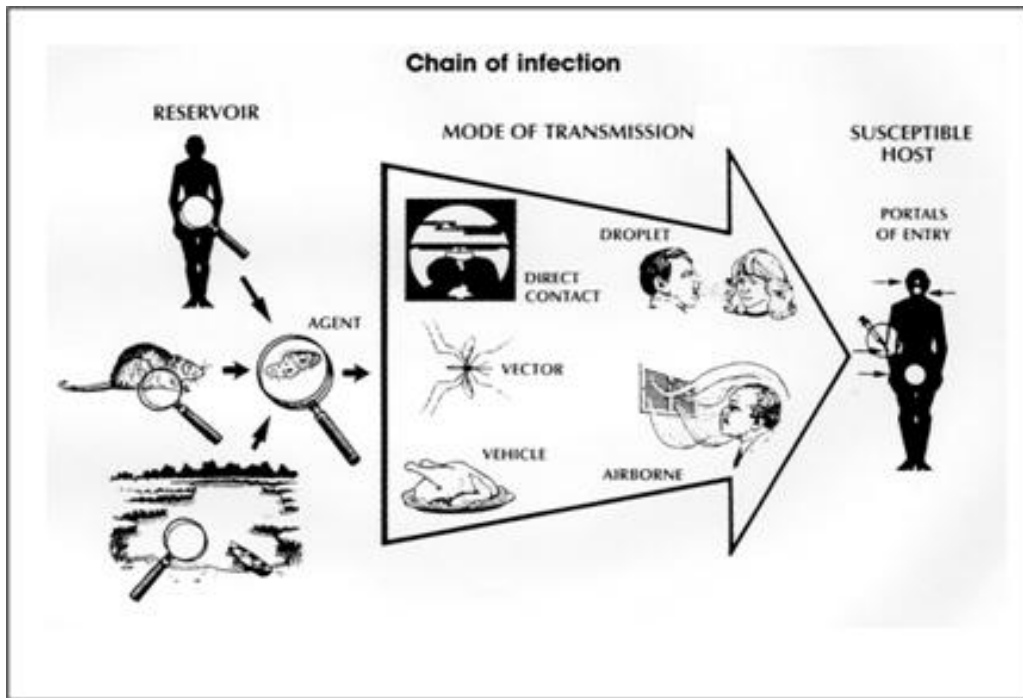
This film is intended for a general audience. However, for students to get the most out of the film and associated supplements, it would be helpful for them to be familiar with the following concepts before viewing the film:

- Infection by microorganisms can cause disease.
- How viruses reproduce.
- A general understanding that spread of an infectious disease depends on transmission of the disease-causing agent from host to host.

## BACKGROUND

Throughout human history, infectious disease has been a major cause of illness and death. The efforts to hunt down and defeat outbreaks of infectious diseases highlighted in the film are part of the clinical discipline of **epidemiology**. Epidemiologists identify patterns of disease and treatment effects among populations, form hypotheses about the causes and transmission of disease, and test those hypotheses through carefully designed studies.

When an infectious **agent** is implicated as the cause of a disease, epidemiologists seek to understand the chain of infection (Figure 1). The film focuses on viruses, but infectious agents also include prions, archaea, bacteria, fungi, and protozoa. Identifying the agent often involves trying to isolate and grow the agent in culture, visualize the agent through microscopy, characterizing the agent through chemical analyses, or, as is becoming more common, searching for the identity of the agent through DNA or RNA sequence analysis. Once the infectious agent is identified, epidemiologists then look for the main source of the agent in nature (**natural reservoir**). Reservoirs can be humans, other animals, or even nonliving environments, such as soil. Viruses can only reproduce in living organisms that they infect (**hosts**); the natural reservoirs of viruses are typically hosts that don't have symptoms when infected. The way an agent is passed from host to host is called the **mode of transmission**. Disease-causing agents may be transmitted in many ways, including through the air (airborne), direct contact with an infected host or their body fluids, contact with a contaminated inanimate object or food (**vehicle**), or through another living organism such as a mosquito (**vector**). The agent may enter the victim through different routes, such as through an insect bite (if insects are a vector), a cut in the skin, orally, or via the mucous membranes in the nose.



**Figure 1.** Diagram highlighting the components of the chain of infection.

Source: Centers for Disease Control and Prevention. Principles of epidemiology, 2nd ed. Atlanta: U.S. Department of Health and Human Services; 1992. <http://www.cdc.gov/OPHSS/CSELS/DSEPD/SS1978/Lesson1/Section10.html#TXT119>

Health officials design studies to understand the chain of infection in an outbreak. One common study design mentioned in the film is a case-control study in which many individuals with a disease are compared to individuals without the disease who are of the same age, from the same area, and involved in similar activities. Both groups of people are asked about exposures and symptoms, and are tested for the presence or absence of certain infections. Researchers look for associations among disease symptoms, exposures, and infections.

Epidemiologists also play a role in developing and implementing strategies to contain and diffuse outbreaks. They carefully explore the elements in the chain of infection and decide which parts are susceptible to intervention. One set of containment strategies involves controlling or eliminating the infectious agent. For example, if the outbreak is a bacterial disease caused by contaminated food, that food would be eliminated from the supply. A second set of strategies involves blocking the mode of transmission and may include quarantine, or eliminating the breeding grounds of a vector, such as a mosquito. Preventing susceptible hosts from being infected represents a third set of strategies and includes approaches such as wearing surgical gloves or using insect repellent. Another set of strategies involves boosting a host's defenses such as through the use of vaccines.

After an outbreak is over, epidemiologists maintain careful surveillance to quickly identify new outbreaks, including careful screening of reservoir populations over a wide geographic area. Surveillance, like all the efforts undertaken by epidemiologists, requires a great deal of teamwork, communication, and resources.

The scourge of infectious diseases remains a major issue affecting humans across the globe. Most infectious agents infect one to several species; the list of hosts for one agent is called its host range or host specificity.

Infectious agents can evolve to infect different hosts. Infectious diseases that are transmitted from animal hosts to humans are called **zoonotic diseases**. Nearly 70% of emerging infectious diseases, either newly identified diseases or ones that rapidly increase in incidence or geographic range, are zoonotic diseases. Over 65% of emerging zoonotic diseases that have occurred since 1980 are caused by viruses, which is somewhat surprising given that, in total, viruses make up less than 15% of known human pathogens. Almost all (94%) of the emerging zoonotic viruses have RNA instead of DNA as their genetic material. RNA viruses tend to have higher mutation rates than DNA viruses, which means that they generally evolve more quickly. This potentiates their ability to infect new hosts, including humans.

The film highlights three examples of emerging diseases caused by RNA viruses: Zika, Ebola, and Nipah. The Zika virus was first discovered in monkeys from the Zika forest in Uganda in 1947, and the first known cases of infection in humans were in 1952. The virus came prominently to the public's attention in 2015 when a widespread outbreak occurred in Brazil and then spread throughout the Americas. The outbreak was associated with cases of microcephaly and Guillain-Barré syndrome. Microcephaly is a rare condition (in the absence of Zika, a typical rate is about 2 to 12 in 10,000 births in the U.S.) in which severely abnormal brain development results in an infant with a small, misshapen head. Guillain-Barré syndrome is a rare autoimmune condition that results in paralysis of varying duration and severity. The reservoirs for Zika virus are likely humans and monkeys, and mosquitoes are the vector for transmission, although several cases of sexual transmission have been documented.

Ebola is a deadly disease that is caused by four of the five viruses in the genus *Ebolavirus*. Since its discovery in 1974, over 20 outbreaks of the disease have been documented, mostly in small, isolated villages in Central Africa. The outbreak in 2014 in West Africa was a crisis of much greater proportion, claiming over 11,000 lives, and came close to causing a global pandemic. The reservoir for the Ebola virus is likely bats; an outbreak usually begins when a person comes into contact with an infected animal. From there, transmission occurs from human to human through contact with body fluids. No vaccines or drugs for Ebola are currently commercially available, but good supportive care, including rehydration therapy, can significantly improve survival rates.

Nipah virus infection causes extreme swelling of the brain (encephalitis) resulting in permanent impairment or death in a very high proportion of people infected. The virus was first identified in Malaysia and Singapore in 1999 when 300 people who came into close contact with infected pigs developed encephalitis and respiratory illnesses. Since then, outbreaks have occurred in Bangladesh and India on an almost annual basis. Currently, treatment is limited to supportive care. The reservoir for the virus is fruit bats (flying foxes in the genus *Pteropus*), and the virus can spill over into domestic pigs and people. Transmission can occur through direct contact with infected fruit bats or their excretions (as in the raw date palm sap featured in the film), infected pigs, or infected people.

## DISCUSSION POINTS

- Students may be interested in the wide range of careers for people involved in public health. The film highlights several opportunities, including scientists doing basic biological research on pathogens and hosts, contact tracers who seek to understand and stop the chain of infection, animal biologists and veterinarians who study animals that may serve as disease reservoirs, health care workers who treat

patients with infectious diseases, technologists who develop and use tracking and database systems, and many more. You may wish to share the following website from the Centers Disease Control and Prevention (CDC) with students highlighting public health careers: <https://jobs.cdc.gov/career-fields>

- Many students are interested in discussions of the ethics involved in making public health decisions. Resources are limited, which means that difficult decisions must be made about which diseases to monitor and how to prepare for different types of outbreaks. Allocating resources in public health raises numerous ethical issues. You may wish to emphasize to students how the information gleaned from scientific research may inform these discussions, but that making the decisions involves having reasoned conversations and weighing different options which will always be a complex endeavor without easy answers.
- Many students from high-income countries may not fully appreciate the extent to which infectious diseases still impact many low-income countries. The World Health Organization reports that, in 2012, the three most common causes of death in low-income countries were infectious diseases: lower respiratory infection, HIV/AIDS, and diarrheal diseases. In contrast, in high-income countries, the leading causes of death were heart disease, stroke, and lung cancer. The lack of appreciation for the tremendous killing power of infectious diseases affects many public debates such as the funding of public health initiatives and the value of immunization programs.
- You may wish to draw students' attention to the degree to which epidemiologists employ the practices of science highlighted in the Next Generation Science Standards and how often they need to reevaluate their assumptions and prior conclusions. The nature of scientific knowledge, especially as it relates to studying natural populations, is reflected in the way health experts discussed some of the findings in the film. For example, when discussing the animal reservoir for the Ebola virus, the film highlighted the sources of evidence that led to this claim; bats are reported near the source of Ebola outbreaks, and both antibodies against Ebola viruses and genetic material from Ebola viruses have been found in bats. Nevertheless, Dr. Epstein says, "collectively there's scientific evidence to show that bats are *probably* a natural reservoir." Similarly, instead of saying definitively that the Zika virus causes microcephaly, the narrator says, "By mid-April 2016, evidence was strong for a connection between prenatal Zika virus infection and microcephaly" because numerous studies were still ongoing. This second example also highlights some of the challenges in doing research on human populations. Directly infecting pregnant women would provide the most direct evidence for demonstrating a link between the Zika virus and microcephaly, but of course this is highly unethical. Students may be interested in discussing how other fields of science may lead to more definitive evidence for causation than is possible in epidemiology.
- The film highlights the potentially deadly consequences of human interactions with wildlife. You may wish to discuss with students why eliminating wildlife is not a solution for addressing the problem of emerging infectious diseases. Ask students what important functions bats play in ecosystems (Dr. Epstein mentions several of them in the film), and how could humans change their behaviors to reduce the chances of spillover.

## EXPLORE MORE

Vaccines – Calling the Shots <http://www.pbs.org/wgbh/nova/body/vaccines-calling-shots.html>

NOVA Disease Detective interactive <http://www.pbs.org/wgbh/nova/body/disease-detective.html>

CDC's Teacher Roadmap to teaching epidemiology

<https://www.cdc.gov/careerpaths/k12teacherroadmap/epidemiology.html>

CDC's Solve the Outbreak App <https://www.cdc.gov/mobile/applications/sto/index.html>

National Institutes of Health's Curriculum Supplement Series. "Emerging and Re-Emerging Infectious Diseases"

<https://science.education.nih.gov/supplements/nih1/diseases/default.html>

## AUTHOR

Paul M. Beardsley

Cal Poly Pomona

Pomona, CA