Virus Hunter

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Interactive Video
Educator Materials

OVERVIEW

This interactive video explores how scientists identify which bat populations are infected with Nipah virus and could transmit the virus to humans. As students watch the video, they are prompted to answer questions that require them to predict steps in the research process and interpret data. Students also make connections to their own experiences and to other infectious diseases.

Videos can be used for teaching by stopping at appropriate time points and asking questions to cue student attention, encourage critical thinking, and make the students part of the story. This interactive video, which was created using BioInteractive's *Interactive Video Builder* tool, incorporates embedded questions at automatic pause points. Students can answer the questions directly in the interactive video or in the "Student Worksheet."

After finishing the video, students can review their answers and add to their explanations if their thinking has changed.

This document contains multiple resources for using the interactive video with students, including the following (use links to go directly to each section):

- teaching tips for how to use the video with students
- summaries and questions for each section of the video
- assessment guidance, including answers for the embedded questions

Additional information related to pedagogy and implementation can be found on this resource's webpage, including suggested audience, estimated time, and curriculum connections.

KEY CONCEPTS

- A pathogen is a microorganism that causes disease.
- A reservoir is a species in which a pathogen survives and replicates, often without causing disease.
- A zoonotic pathogen can be transmitted to humans from other animals. It may have more opportunities to spread disease when humans live in close proximity to other animals.
- Mutations in a pathogen may make it more likely to spread, resulting in disease outbreaks.
- Studying pathogens in reservoir species may help determine where outbreaks are likely to occur.

STUDENT LEARNING TARGETS

- Identify the causes of zoonotic diseases.
- Describe the characteristics of a reservoir species.
- Explain how a mutation in a virus can help it spread more easily.
- Propose ways to reduce the spread of zoonotic diseases.

PRIOR KNOWLEDGE

Students should be familiar with:

- infectious microorganisms, like viruses and bacteria
- the connection between genetic mutations and changes in traits
- basic viral biology and replication

BACKGROUND

Nipah virus was first identified in 1999 after an outbreak in Malaysia. Since then, it has caused outbreaks throughout Southeast Asia. People infected with Nipah virus have a range of symptoms, from asymptomatic or mild, to flu-like symptoms, to acute respiratory disease, encephalitis, and death. In some outbreaks, up to three-quarters of people infected with Nipah virus have died.

Nipah is a **zoonotic virus**, meaning it can be transmitted to humans from other animals. It is known to infect and cause disease in humans. Fruit bats (also called flying foxes) of the genus *Pteropus* are a **reservoir species** for Nipah virus. The virus can live and reproduce in the bats without making them sick. Infected bats can then transmit the virus to humans. Scientists are working to identify which bat populations are infected with Nipah virus, what proportion of the bats in those populations have the virus, how the virus is spread from bats to humans, and which virus mutations make it more likely to spread to humans.

The video follows the research of Jonathan Epstein and his colleagues at EcoHealth Alliance, an environmental health nonprofit organization that includes scientists from all over the world. Ariful Islam is a senior scientist and the Bangladesh Programs Coordinator at EcoHealth Alliance. In the video, he is shown collaborating with local bat hunters to catch bats and then taking and analyzing blood samples.

Figure 1. *Left:* Jonathan Epstein. *Right:* Ariful Islam.

Teaching Tips

- Students can work on the questions individually or in small groups.
- Students should type responses into the answer boxes that appear during the interactive video.
  - If students are not using the interactive video individually (e.g., you are projecting the video to the entire class), they can write their responses in the "Student Worksheet" instead.
- **The interactive video will not proceed until an answer is submitted.** You must type at least one letter into the answer box to continue.
  - If some questions do not fit the context of your course, you can direct students to skip those questions by typing "I am skipping this question." in the answer box.
- If students are answering questions within the interactive video, they will be prompted to submit their answers at the end of the video. They will have the opportunity to review and add further explanation to each answer if their thinking has changed.
  - Once they are done, they can download a report of their answers. The report can be saved as a PDF or printed. You can have students submit the PDF or screenshots/photos of the report.
- The original video without embedded questions is available under *Virus Hunter: Monitoring Nipah Virus in Bat Populations*.

SUMMARIES AND QUESTIONS

The interactive video has multiple sections. After each section, the video automatically pauses and prompts students to answer an **embedded question**. This document provides additional **extension questions** that do not appear in the video, which can be used for discussion prompts and written assessments.

Below are summaries of the sections and their associated embedded/extension questions. Answers for the embedded questions are provided in the "Assessment Guidance" section.

Section 1 (0:00–1:30)

Summary

- Jonathan Epstein is a scientist who studies viruses, such as Nipah virus.
- Nipah virus causes an infectious disease that has had recurrent outbreaks in Bangladesh since 2004.
- The disease is zoonotic, meaning it can be transmitted from animals to humans.

Embedded Question

Disease-causing microorganisms (including certain viruses, bacteria, protists, and fungi) are called **pathogens**. A **zoonotic pathogen** spreads disease from animals to humans. List some diseases that you think might be caused by zoonotic pathogens.

Extension Questions

- Epstein notes that the number of emerging infectious diseases (diseases that have recently, or could soon, become more common in humans) has increased. What could be causing this increase?
- Bangladesh is not the only place where the number of infectious diseases has increased. What new and emerging infectious diseases have you heard about where you live?
- For each zoonotic pathogen you listed in the embedded question, identify whether it is a virus, bacterium, protist, fungus, or something else.
- What are some treatment options for each type of pathogen (virus, bacterium, protist, or fungus)?
- How are infectious diseases spread? Describe some ways that one organism could transmit a pathogen to another.

Section 2 (1:31–1:47)

Summary

Fruit bats may be a reservoir species for Nipah virus in Bangladesh.

Embedded Question

A **reservoir** is an animal species in which a pathogen survives and replicates, often without causing disease. What data would support the conclusion that fruit bats are the reservoir species for Nipah virus?

Extension Question

Scientists who study infectious diseases often investigate populations of wild animals that carry the pathogen. What might they learn from studying the pathogen in animal populations?

Section 3 (1:48–2:37)

Summary

- Antibodies against Nipah virus have been found in the blood of fruit bats.
- Replicating Nipah virus has been found in the bats' bodily fluids (blood and excretions).
- No other wild animals have been shown to carry Nipah virus.

Embedded Question

Certain viruses have evolved to cause only mild or no symptoms in their reservoir species. Why might this be advantageous for the virus?

Extension Questions

- Based on the video, is there conclusive evidence that fruit bats are a reservoir species for Nipah virus in Bangladesh? Why or why not?
- If fruit bats are a reservoir species for Nipah virus, would you expect all fruit bats to carry the virus? Why or why not?
- Imagine that a new infectious disease appears where you live. How might scientists identify the reservoir species? What evidence might they search for?

Section 4 (2:38–2:54)

Summary

- A small proportion of the fruit bats in Bangladesh are infected with Nipah virus.
- Unlike humans, bats do not appear to get sick from the virus.

Embedded Question

List some ways in which a human might be exposed to a virus from a reservoir species. Think about how the human and the reservoir species might come in contact, directly or indirectly.

Extension Questions

- Only 4% of the fruit bats in Bangladesh are infected with Nipah virus. How do these data inform approaches to protect nearby human populations? How might these approaches change if 67% of the bats had the virus?
- Nipah virus doesn't make fruit bats sick, but it can harm and even kill humans. How might a virus have such distinct effects in two different species?

Section 5 (2:55–5:11)

Summary

- Nipah may be transmitted when humans hunt and eat bats. But Nipah outbreaks in Bangladesh occur seasonally even though hunting happens year round.
- It's more likely that Nipah is transmitted through date palm sap, which is collected around the same times that the outbreaks occur. Bats may shed virus into the sap through their saliva and urine. People who drink the sap can then get infected.
- To figure out which bat populations have the virus, Epstein collects and analyzes samples from bats. He works with local bat hunters who know the ecology and behavior of the bats.

Embedded Question

What do you think the scientists and bat hunters will do with the wild bats that they capture?

Extension Questions

- What are some of the advantages of working with local bat hunters? How is local knowledge important for science?
- If Nipah virus is transmitted from bats to humans through date palm sap, what could be done to reduce the risks of an outbreak?
- Does the evidence prove that no Nipah outbreaks in Bangladesh are caused by bat hunting? Why or why not?

Section 6 (5:12–6:50)

Summary

Epstein and the bat hunters capture fruit bats, collect samples, and release the bats back into the wild.

Embedded Question
If you had the tools to analyze the blood of the bats, what data would you collect and why?

Extension Questions
- How might Epstein and the bat hunters protect themselves from bats infected with Nipah virus?
- Different tests can be used to study Nipah virus in the bats' blood samples. What might be the advantages and disadvantages of different types of tests (e.g., PCR tests to detect viral nucleic acids, ELISA tests to detect viral antigens, etc.)?

Section 7 (6:51–7:06)
Summary
Samples collected from bats are analyzed in the laboratory. These data can reveal if the virus's genetic makeup is changing.

Embedded Question
How could a mutation in Nipah virus make it more infectious in humans? Describe what changes could help the virus spread more easily among people.

Extension Question
What regions of the virus's genome would you study if you wanted to monitor the risks that mutations in Nipah virus pose to humans? (You don't need to name specific regions. Just describe what parts of the virus they would encode.)

Section 8 (7:07–7:16)
Summary
Mutations in the virus may make it more infectious.

Embedded Question
Would a human vaccine for the Nipah virus permanently protect a human population from disease? Why might we need to continue developing new vaccines, especially when there is a nearby reservoir species?

Extension Question
How might a virus evolve to make the vaccine ineffective?

Section 9 (7:17–7:42)
Summary
Scientists are also monitoring bat populations close to large cities, such as Dhaka in Bangladesh. A Nipah outbreak there could affect millions of people.

Embedded Question
How could community members and scientists help reduce the virus's spread among people?

Section 10 (7:43–end)
Summary
- The proximity of humans and wildlife can lead to "spillover events" where animals transmit new pathogens to humans.
- However, we can't just get rid of wildlife because they are important to ecosystems and our own health.

Embedded Question

Where you live, what examples are there of human populations being close to wildlife? How might this lead to disease?

Extension Questions

- The video notes that "understanding how our activities can contribute to spillover may help reduce future outbreaks." What are some ways in which human activities could cause an outbreak?
- Why do you think Epstein says we can't afford to get rid of wildlife? For example, why might killing all bats to eliminate Nipah virus be a bad idea?

ASSESSMENT GUIDANCE

Sample responses to the embedded questions are provided below. They include a lot more detail than what is expected in students' answers. The additional detail is meant to provide additional information that you may want to discuss with students. For additional extension questions, which could be used for discussion prompts or written assessments, refer to the "Summaries and Questions" section.

1. Disease-causing microorganisms (including certain viruses, bacteria, protists, and fungi) are called **pathogens**. A **zoonotic pathogen** spreads disease from animals to humans. List some diseases that you think might be caused by zoonotic pathogens.
   Answers will vary depending on students' prior knowledge. Students may mention some of the following diseases. (Note that students just need to list the disease names. We have provided additional information that goes beyond what is expected of students.):
   - ***Anthrax is caused by bacteria. It can be transmitted to humans from herbivores (such as cattle, sheep, camels, and antelopes) by ingestion, inhalation, or skin contact with spores.***
   - ***Bovine spongiform encephalopathy ("mad cow disease") is caused by a prion. (Prions are virus-like particles but do not contain any genetic material; they are infectious proteins.) It can be transmitted to humans from cows by eating contaminated meat.***
   - ***Brucellosis is caused by bacteria. It can be transmitted to humans from sheep, goats, cows, and camels by drinking unpasteurized/raw dairy products.***
   - ***Cat-scratch disease is caused by bacteria. It can be transmitted to humans from cats through a scratch or bite.***
   - ***Middle East respiratory syndrome (MERS) is caused by a coronavirus. It can be transmitted to humans from camels. COVID-19 is also caused by a coronavirus and likely to be a zoonotic disease; however, the animal of origin is not yet known.***
   - ***Dengue is caused by a virus. It can be transmitted to humans through a mosquito bite.***
   - ***Ebola is caused by a virus. It is transmitted to humans from bats through contact with bodily fluids, such as blood.***
   - ***Hantavirus diseases are caused by viruses. They can be transmitted to humans from rodents (notably deer mice, white-footed mice, and cotton rats) through urine, droppings, and saliva.***
   - ***Influenza ("flu") is caused by viruses. Different types of flu can be transmitted to humans from various animals, including ducks, chickens, and pigs.***
   - ***Lyme disease is caused by bacteria. It can be transmitted to humans through a blacklegged (or deer) tick bite.***
   - ***Malaria is caused by the* Plasmodium *parasite. It can be transmitted to humans through a mosquito bite.***
   - ***Plague is caused by bacteria. It can be transmitted to humans from rodents through fleas.***
   - ***Rabies is caused by a virus. It can be transmitted to humans from animals such as bats, racoons, skunks, and foxes through saliva (by biting).***

- ***Salmonellosis is caused by* Salmonella *bacteria. It can be transmitted to humans through chicks and ducklings, reptiles (iguana, turtles, snakes), and amphibians (frogs and toads).***
- ***West Nile virus disease is caused by a virus. It can be transmitted to humans from birds through a mosquito bite.***
- ***Zika is caused by a virus. It can be transmitted to humans from mosquitoes.***

2. A **reservoir** is an animal species in which a pathogen survives and replicates, often without causing disease. What data would support the conclusion that fruit bats are the reservoir species for Nipah virus?
   Answers will vary depending on students' past experiences and prior knowledge. Some possible answers include:
   - ***Nipah virus is found in fruit bats but not in other animals.***
   - ***Fruit bats infected with Nipah virus do not get very sick or die, giving the virus more time to survive and replicate in the bats.***
   - ***There is evidence of a mechanism by which Nipah virus could be transmitted from bats to humans.***

3. Certain viruses have evolved to only cause mild or no symptoms in their reservoir species. Why might this be advantageous for the virus?
   If members of the reservoir species get sick or die from the virus, they will be less likely to interact with other individuals, making it more difficult for the virus to spread. Conversely, if the virus causes few or no symptoms in the reservoir species, it will continue to multiply and spread.

4. List some ways in which a human might be exposed to a virus from a reservoir species. Think about how the human and the reservoir species might come in contact, directly or indirectly.
   Answers will vary depending on the environmental context, means of interaction, and transmission mechanisms of the virus. Some possible answers include:
   - ***eating an infected animal from the reservoir species***
   - ***coming into contact with the blood, saliva, excretions, or respiratory droplets of an infected animal (e.g., by eating the same food, breathing the same air, or touching the same objects)***
   - ***being bitten by an insect (e.g., mosquito or tick) that previously bit an infected animal***

5. What do you think the scientists and bat hunters will do with the wild bats that they capture?
   Students may have different ideas about the research plans. The video mentions monitoring Nipah virus in Bangladesh. Therefore, a possible answer is that the scientists and bat hunters will want to determine if these bats have the virus, so they will collect samples from the bats and search for the virus.

6. If you had the tools to analyze the blood of the bats, what data would you collect and why?
   Students will generate different responses, which may include:
   - ***Data on the presence or absence of Nipah virus in each bat so that they can calculate how many bats in a population have the virus. This could then tell you whether the virus is likely to be transmitted to humans.***
     - ***Some students may mention that this could be done through an antibody-based test that recognizes a virus antigen, such as an enzyme-linked immunosorbent assay (ELISA) or a blot test. Scientists could also detect the virus by doing a polymerase chain reaction (PCR) assay that identifies specific viral nucleic acid sequences.***
   - ***Genetic sequence data for Nipah virus in each bat. By determining the sequence of the virus genome, scientists could identify new mutations, monitor how the virus evolves over time, and get insights into how the virus becomes more or less able to infect humans.***

7. How could a mutation in Nipah virus make it more infectious in humans? Describe what changes could help the virus spread more easily among people.
   Students will generate different responses, which may include:
   - ***The mutation makes the virus more likely to recognize, bind to, and enter human cells.***
   - ***The mutation helps the virus replicate more quickly.***
   - ***The mutation makes the virus better able to evade the body's defenses (i.e., the immune system) or resist medical treatment.***
   - ***The mutation helps the virus infect more cells and tissues in the body. For example, it might gain the ability to infect lung cells, which would increase the likelihood that the virus could be transmitted by coughing or sneezing.***
   - ***The mutation makes the virus cause milder symptoms in humans. If infected people don't get as sick, they're more likely to interact with other people and spread the virus.***

8. Would a human vaccine for the Nipah virus permanently protect a human population from disease? Why might we need to continue developing new vaccines, especially when there is a nearby reservoir species?
   The vaccine could protect a human population from Nipah virus for some time, but probably not permanently. Even if everyone in the population receives the vaccine, the virus can continue to replicate and mutate in the reservoir species (the wild fruit bats). Eventually, the virus could gain a new mutation that allows it to resist or be unaffected by the vaccine. That's why we may need to continue developing new vaccines.

9. How could community members and scientists help reduce the virus's spread among people?
   Students will generate different responses, which may include:
   - ***Collect date palm sap in ways that prevent bats from drinking the sap or urinating in it.***
   - ***Treat the sap in ways that would destroy the virus before people drink it.***
   - ***Use public education campaigns to spread awareness on how to avoid contact with bats and bats' bodily fluids (e.g., wash hands frequently, do not go near the bat population, etc.).***
   - ***Develop and administer a vaccine against Nipah virus for people living near the bats, or for the bats themselves.***
   - ***Remove or relocate the bat population away from the city.***

10. Where you live, what examples are there of human populations being close to wildlife? How might this lead to disease?
    Answers will vary depending on students' past experiences and prior knowledge. For example, they might mention large populations of deer where they live that carry Lyme disease.

CREDITS

Written by Annie Prud'homme-Généreux, University of British Columbia, BC, Canada; J. Phil Gibson, University of Oklahoma, OK
Edited by Laura Bonetta, Aileen O'Hearn, Esther Shyu, HHMI
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