

Activity 1: Emerging Diseases: Causes and Effects

Based on video content

15 minutes (10 minutes before and 5 minutes after the video)

Setup

This unit is about emerging infectious diseases, but what exactly does that mean? What makes an infectious disease “emerging”? What makes a disease reappear as a “re-emerging” disease? Warm up before watching the video by making group lists of your ideas about these questions. At the end of this session, you’ll review the lists as part of a summary discussion.

Materials

- One copy of the Instructions per person (master copy provided)
- Tips and Suggested Answers

Instructions

1. Come up with a group list of any and all diseases that might qualify as an emerging or re-emerging infectious disease. At this point, just brainstorm. You'll sort out the ideas later. (The session facilitator can write them down on a board or transparency.)
2. When all ideas are on the board or transparency, go through the list more carefully, reasoning through why some should be included and some might not.
3. Do the same exercise of brainstorming and then going carefully through your list, but this time name factors that make an infectious disease emerging or re-emerging. What contributes to the introduction and spread of a disease into the general population?
4. Compare the list of diseases made by the group and the list of factors. Do the diseases you thought of fit your list of criteria?
5. After the video, look at your lists again.
6. Keep a copy of your lists! After watching the entire video and doing some of the activities, you'll compare your list against new information from the video and activities.

Emerging Diseases: Causes and Effects

Definitions of “emerging infectious diseases” might include:

- any that have recently been introduced into the human population
- diseases that have gone from localized to global in the past few years or decades
- diseases that have recently escalated their threat to humans, for example, because of antibiotic resistance

Diseases might include:

- SARS
- HIV
- antibiotic or drug-resistant diseases, like tuberculosis and malaria
- Hantavirus
- West Nile virus
- Ebola and other hemorrhagic fevers
- Dengue fever
- cholera
- Lyme disease
- new strains of influenza
- anthrax, smallpox, or other bioterrorism possibilities

Causes and contributing factors might include:

- rapid urbanization so humans live in close contact with each other
- poor sewage and water systems
- lack of hospital facilities
- penetration of remote areas and new habitats to expose humans to new pathogens
- global distribution of food
- drug or antibiotic resistance
- human contact with animal reservoirs
- rapid global transportation

Activity 2: Lifecycles of the Infectious and Famous

Based on video and online text content

30 minutes

Setup

Finding a treatment for an infectious disease requires detailed knowledge about the cause of the disease. Developing a prevention or eradication plan requires detailed knowledge about how the disease is maintained in hosts or carriers, and how it is transmitted. For some infectious diseases, this task is complicated by a complex replication cycle and multiple hosts or reservoirs.

In this exercise, work in pairs to sort out the replication steps of the cause of four complicated infectious diseases: influenza, malaria, Lyme disease, and West Nile virus. Each team should take one set of papers with the steps of the replication cycles of the diseases. Take a few minutes to arrange the steps into the proper cycles for the disease agents. Then, using the diagrams you've made, go over the discussion questions in teams or as a group.

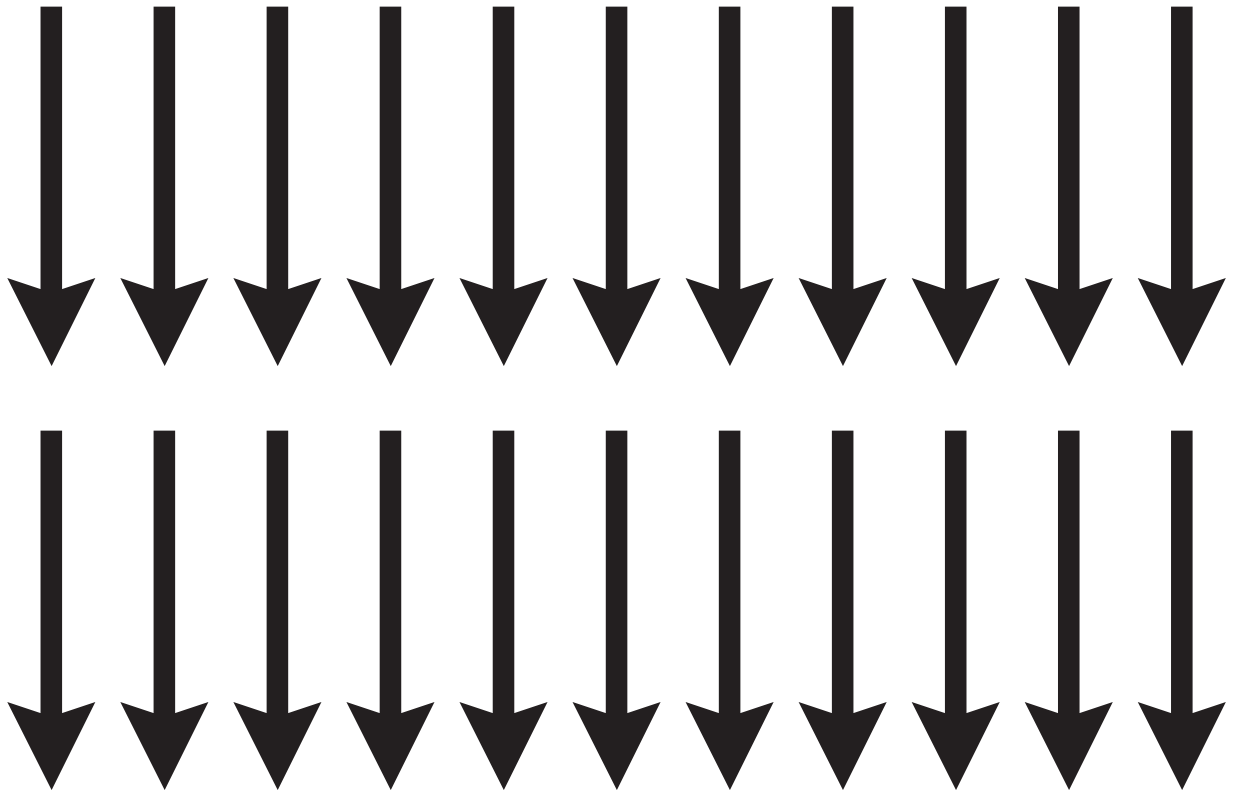
Materials

- One set of Replication Cycle Steps and Arrows per two people (master copy provided; to make a set, cut out the arrows to separate them, cut on the dotted lines of the lifecycle steps and scramble them)
- One set of Discussion Questions per person (master copy provided)
- One copy of the Emerging Infectious Diseases online text chapter per two people (available online at <http://www.learner.org/channel/courses/biology>)
- Tips and Suggested Answers

Replication Cycle Steps and Arrows

After copying, cut to separate the arrows. Then cut on the dotted lines to separate the lifecycle steps, and scramble them.

See the Tips and Suggested Answers for Replication Cycle answers.



Parasite sexual cycle occurs in mosquito gut.

Occasionally, a mosquito vector transmits the virus to an animal or a human.

A mosquito carrying the parasite bites a human. The parasites (as sporozoites) enter the blood.

In humans, the virus undergoes small mutations to create new viral strains (antigenic drift).

A tick that is infected or uninfected mates and lays uninfected eggs.

Uninfected tick larvae feed on a bacterially infected animal.

A pig is infected with multiple viruses. (e.g. a combination of human, swine or avian viruses).

Parasite form that can infect humans (sporozoites) migrates from the mosquito gut to the salivary glands.

Mosquito vector acquires the virus by biting an infected bird.

Infected tick transmits bacteria to human, deer, mice, or birds.

Gametocyte form is taken up by a mosquito that feeds on an infected human.

New viral subtype infects humans.

Viral genes from different sources (human, avian or swine) mix to create a new virus subtype (antigenic shift).

Human viruses might infect pigs.

Blood cells are infected, and undergo cycles of bursting, release and infection of new cells. Some gametocyte forms are released.

Parasites enter the liver, where they change form and are released as a form (merozoites) that can infect blood cells.

A bird is infected by a mosquito vector that is carrying the virus.

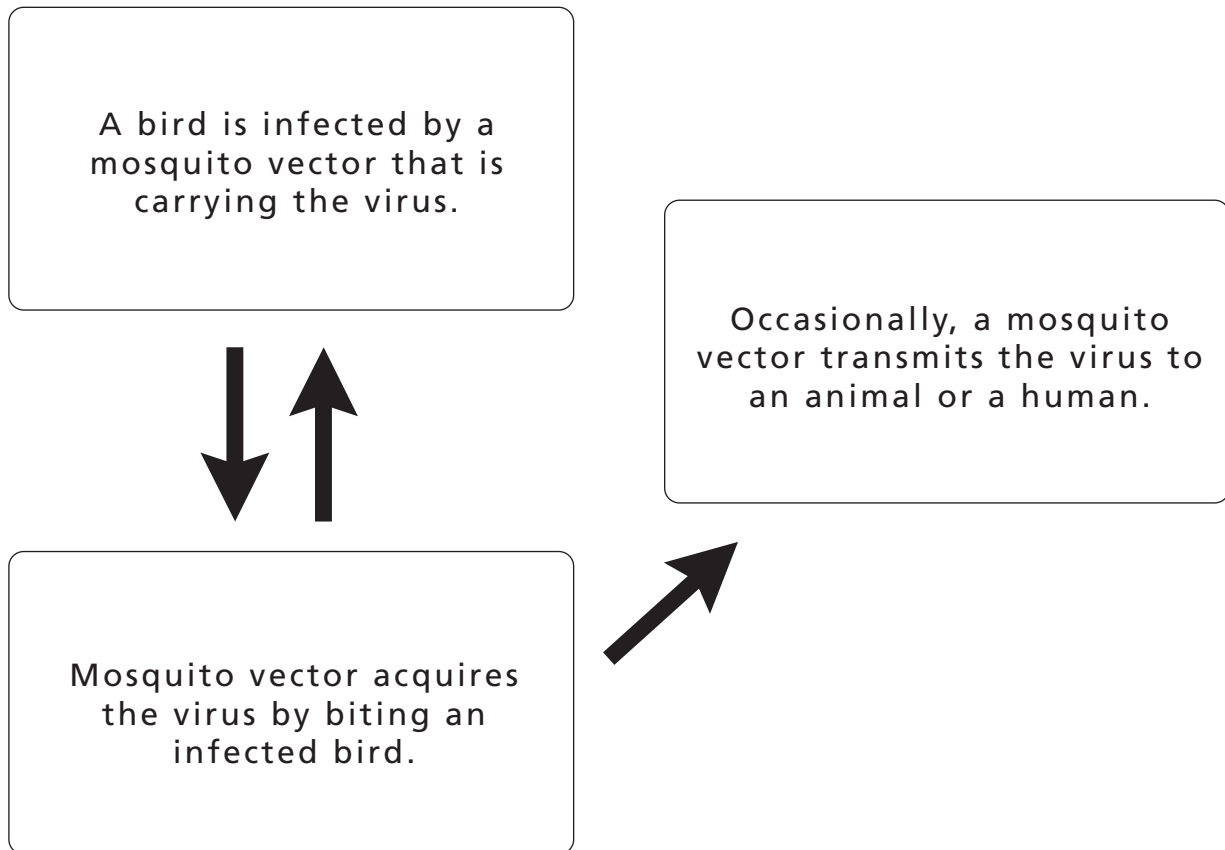
Discussion Questions

See the Tips and Suggested Answers for possible answers.

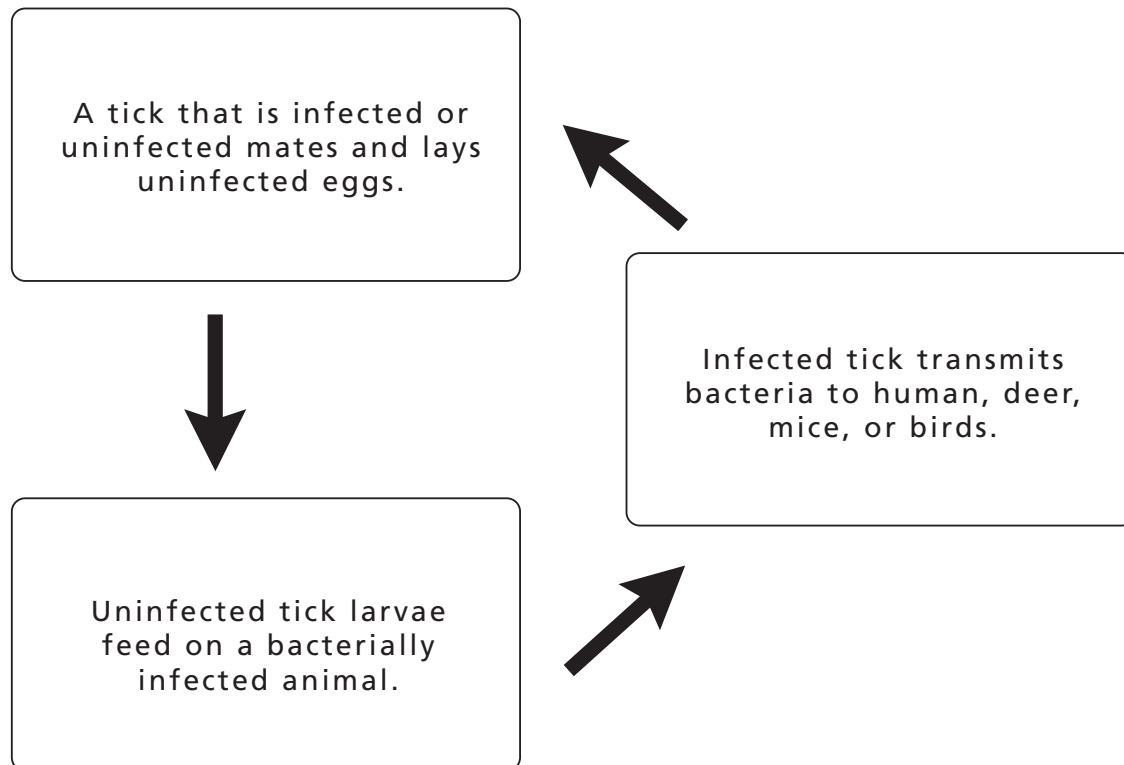
1. What are the direct causative agents of influenza, malaria, Lyme disease, and West Nile virus: a virus, a bacterium, or a eukaryotic organism?
2. Are antibiotics like penicillin or tetracycline effective against any of these diseases? Why or why not?
3. Is there a vaccine against influenza? malaria? Lyme disease? West Nile virus?
4. What treatments or strategies are used to treat or control each disease?
5. What is the role of animal or insect vectors and reservoirs in the replication cycles of these pathogens? Can the microbe exist solely in humans?
6. For each of these diseases, is transmission directly from human to human, or from human to animal?

Replication Cycles

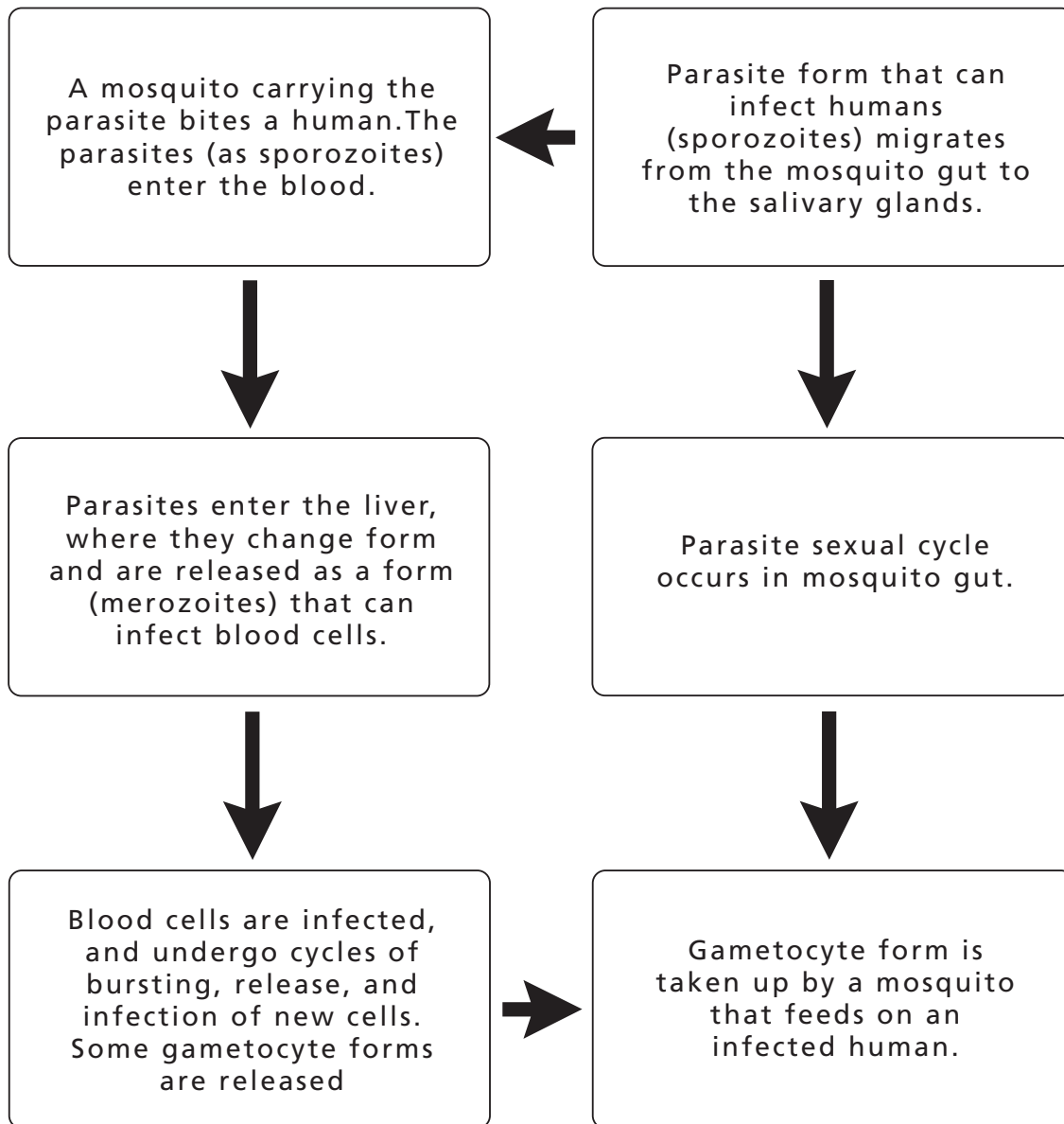
West Nile Virus



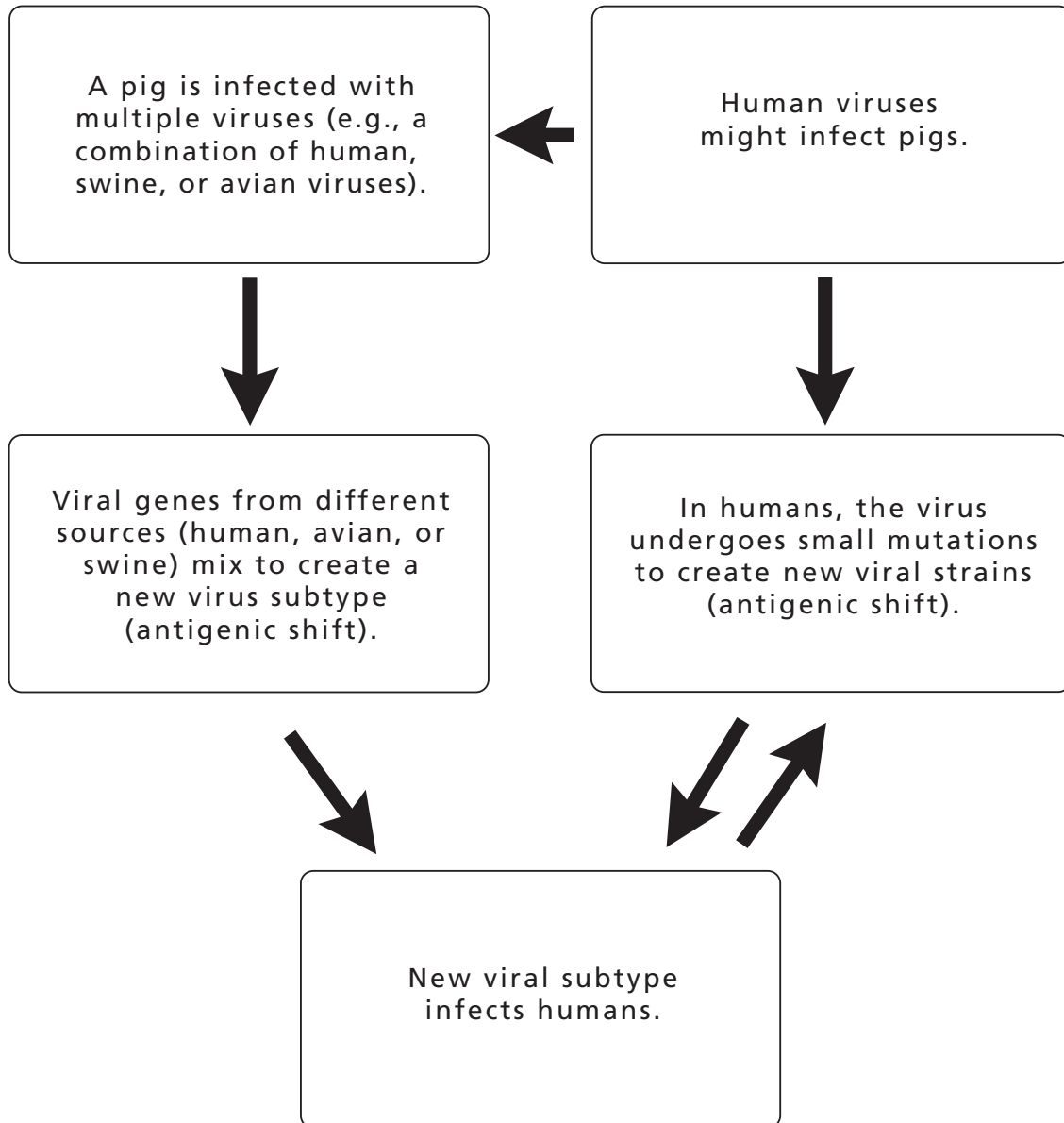
Lyme Disease



Malaria



Influenza A



Discussion Questions

1. What are the direct causative agents of influenza, malaria, Lyme disease, and West Nile virus: a virus, a bacterium, or a eukaryotic organism?
influenza: virus; malaria: eukaryotic microbe in the *Plasmodium* genus; Lyme disease: Spirochete bacterium; West Nile: virus
2. Are antibiotics like penicillin or tetracycline effective against any of these diseases? Why or why not?
Antibiotics like penicillin and tetracycline are effective only against bacteria, so antibiotics can be prescribed for the early stages of Lyme disease. Antiviral and anti-eukaryotic drugs can be prescribed for influenza, malaria, or West Nile virus, although they are less common than antibacterial drugs and often have more severe side effects. This is because antibacterial drugs can target structures or processes unique to bacterial cells. There are fewer unique targets when developing drugs to combat infections of viral and eukaryotic pathogens.
3. Is there a vaccine against influenza? malaria? Lyme disease? West Nile virus?
There is a vaccine against influenza A and B, but it must be administered every year because of antigenic drifts and shifts in the virus. As of 2003, vaccines for malaria are currently in development. There is a vaccine against Lyme disease but prevention by minimizing exposure to ticks, is more common. There is a West Nile virus vaccine for livestock, and human vaccines are in development.
4. What treatments or strategies are used to treat or control each disease?
Antiviral drugs can be used for serious influenza cases. Otherwise, we usually just treat the symptoms of fever, aches, chills, and nausea. Currently, quinine, chloroquine, and a few other drugs are used as anti-malarial therapy; mosquito eradication is used to control it. Lyme disease can be treated with antibiotics; control of ticks and prevention of tick bites is the primary means of prevention. West Nile virus is monitored through infected birds; vector control and animal vaccines prevent transmission.
5. What is the role of animal or insect vectors and reservoirs in the replication cycles of these pathogens? Can the microbe exist solely in humans?
Influenza B exists only in humans; influenza A is harbored by animal reservoirs and undergoes genetic exchange in them to generate new forms. Part of the lifecycle and a specific developmental stage of malaria occurs only in mosquitoes, so the microbe cannot exist without mosquitoes. The mosquitoes also act as the vector for transmission to humans. The Lyme disease bacterium is found in deer and mice reservoirs; it is acquired by the larvae of the tick vector, which transmits the bacterium to other animals and to humans. Birds appear to be the reservoirs for West Nile virus, with transmission from bird to bird through the mosquito vector. Transmission to other animals and to humans is only incidental.
6. For each of these diseases, is transmission directly from human to human, or from human to animal?
Influenza is transmitted directly from human to human and, rarely, from animal to human. Malaria, Lyme disease, and West Nile virus are all transmitted through mosquito or tick vectors and are not transmitted from human to human.

Activity 3: Koch's Postulates

Based on video and online text content

30 minutes

Setup

In the late 1800s, Robert Koch formulated a set of four criteria that must be met in order to prove that a particular type of bacterium is responsible for a disease. In 1937, T. M. Rivers expanded "Koch's postulates" to six criteria to determine if a particular *virus* is the cause of a disease.

An emerging infectious disease whose cause was determined relatively quickly was severe acute respiratory syndrome, or SARS. Koch's and Rivers's postulates were followed to establish a virus called SCV (SARS-associated coronavirus) as the cause of SARS. In this exercise, follow the instructions to go through the logic of Koch's postulates.

Materials

- One copy of the Instructions and Discussion Questions per person (master copy provided)
- One transparency of Koch's and Rivers's Postulates (master copy provided)
- One transparency of Experimental Results for SARS and SCV (master copy provided)
- Tips and Suggested Answers

Instructions and Discussion Questions

1. Individually, take a few minutes to write down how YOU would test if a particular virus caused a disease, and what criteria or tests you would perform to prove that a virus was the cause of a disease. Then, as a group, use the individual lists to make a group list of criteria that would prove that a particular virus was the cause of a disease. If anyone in the group knows Koch's and Rivers's postulates, see if the group's list matches the "official" list.
2. Check your list against the one on the transparency. Is there anything that your group missed? Is there anything that your group thought of that would strengthen the list of criteria?
3. Look at a list of results from fulfilling Koch's and Rivers's postulates for SARS. Compare the list to the postulates and match each result with the postulate that it fulfills. (See the Tips and Suggested Answers.) Do you find the evidence convincing, or is it possible that another infectious agent is responsible for SARS?
4. Talk about these discussion questions as a group. (See the Tips and Suggested Answers.)
If any of the following situations occurred, would it be sufficient to reject SCV (SARS-associated coronavirus) as the cause of SARS? Explain your answer.
 - a. The virus can be isolated from healthy individuals.
 - b. When introduced into animals that normally can be infected with the same disease as humans (e.g., macaques), the animals do not get sick.
 - c. When introduced into hosts, the isolated virus gives them the same symptoms as the disease in humans, but a test for anti-SCV antibodies is negative after three months.
 - d. In one study, evidence for the virus is not found in all tested patients.

Koch's and Rivers's Postulates

Koch's and Rivers's postulates for establishing a virus as the cause of a disease.

1. The specific virus is present and can be isolated from all diseased hosts, and is not present in healthy individuals.
2. The virus isolated from diseased individuals can be cultivated in host cells in the laboratory.
3. Proof of filterability (helps establish that the infectious agent is the size expected of a virus)
4. When an original host species or a related species is inoculated with the virus isolated from diseased hosts, it develops a comparable disease.
5. The virus can be re-isolated from the inoculated hosts.
6. A specific immune response can be detected in the inoculated hosts.

Experimental Results for SARS and SCV

Results that fulfilled Koch's and Rivers's postulates for SARS. Match each result to a specific postulate.

- a. Of 96 individuals in Hong Kong who met the World Health Organization's definition of SARS, 90 percent tested positive in a lab test for SCV infection.
- b. A PCR (polymerase chain reaction) test for SCV DNA was performed on nasal secretions from macaques infected with SCV. Two out of two infected macaques were positive for SCV DNA.
- c. Macaques that were negative in a test for anti-SCV antibodies became positive for anti-SCV antibodies after infection with SCV isolated from a SARS patient.
- d. Viruses isolated from macaques infected with SCV from a SARS patient secreted viruses that were identical, by electron microscopy, to the original infecting virus.
- e. Blood, serum, nasal secretions, and tissue samples from SARS patients were used to inoculate cultured cell lines. The cell lines that showed cytotoxic, cell-damaging effects were producing the SCV coronavirus.
- f. Two macaques were inoculated with SCV. Three to four days later, they became lethargic and developed skin rashes and respiratory distress. Autopsies on the animals showed pneumonia-like tissue damage in the lungs.
- g. Mice were infected with blood, serum, nasal secretions, or tissue samples from SARS patients. When tissue extracts from sick or dead mice were filtered, they yielded viruses that could be cultured in cultured cell lines.
- h. Of 19 patients with SARS, 19 tested positive for presence of the SCV virus, evidence of viral DNA in their tissue samples, or production of antibodies against the SCV virus.

Sources: *Nature* (2003) 423:240; *N. Eng. J. Med.* (2003) 348:1953

Experimental Results for SARS and SCV

- a. fulfills postulate 1
- b. fulfills postulate 5
- c. fulfills postulate 6
- d. fulfills postulate 5
- e. fulfills postulate 2
- f. fulfills postulate 4
- g. fulfills postulates 3 (also 4 and 5)
- h. fulfills postulate 1 (also 6, partially)

Discussion Questions

4. If any of the following situations occurred, would it be sufficient to reject SCV (SARS-associated coronavirus) as the cause of SARS? Explain your answer.
- a. The virus can be isolated from healthy individuals.
- Yes, it could be a reason to reject SCV as the cause of SARS. If people with no symptoms have the disease, it breaks the correlation between infection with the virus and symptoms of the disease.
- No, it should not be a reason to reject SCV as the cause of SARS. Perhaps these people had or have the disease in a mild form. Some people may be a “asymptomatic carriers”: there might be a form of the disease that has a long incubation period, so these people might not be showing symptoms yet.
- b. When introduced into animals that normally can be infected with the same disease as humans (e.g., macaques), the animals do not get sick.
- Yes, it could be a reason to reject SCV as the cause of SARS, especially because it seems that SARS originated from animals.
- No, it should not be a reason to reject SCV as the cause of SARS. Not all diseases infect both humans and macaques and, even if infection occurs, the symptoms are not always the same.
- c. When introduced into hosts, the isolated virus gives them the same symptoms as the disease in humans, but a test for anti-SCV antibodies is negative after three months.
- Yes, it could be a reason to reject SCV as the cause of SARS. Perhaps another virus is being isolated—undetected—with SCV, and that virus is the one that causes the disease and immune response. Perhaps the SCV isolation is not successful and the hosts are getting sick for some other reason.
- No, it should not be a reason to reject SCV as the cause of SARS. Perhaps a more sensitive test for immune response is needed, or the SCV antibodies will not be detectable for another few months.
- d. In one study, evidence for the virus is not found in all tested patients.
- Yes, it could be a reason to reject SCV as the cause of SARS, because if the virus is really not present in some people with the disease, it can't be responsible for the disease.
- No, it should not be a reason to reject SCV as the cause of SARS. The test might not be 100 percent accurate and give false negatives. The test might be accurate but detects the presence of virus only when administered at a particular point in the disease progress. If the accuracy of the test is unknown, then negative test results in some patients might not be a reason to reject the virus as the cause of the disease. For example, the actual symptoms might appear after the virus is no longer present or is present at very low levels.

Activity 4: Shifting Antigens

Based on video and online text content

30 minutes

Setup

In 1918–19, 20 million–50 million people died of the Spanish flu, including approximately half a million in the U.S. This deadly flu pandemic was caused by a particularly virulent type of influenza A that “goes around” every winter. How did this version of influenza suddenly appear? Could this type of pandemic occur again? This exercise will provide some explanation.

The influenza virus changes continuously, so health organizations need to monitor it constantly. They do this by piecing together information on which types of flu virus are present in the population, and which are likely to appear next. In this exercise, you will also piece together bits of information to come up with a model of how the influenza virus changes and why some pandemics like the Spanish flu are so deadly.

The session facilitator has a set of clues to the influenza puzzle to distribute. Each person should have at least one clue. Begin by reading the “starter” questions. Then, read your clue if it seems to contribute to the answer to the question. When all the questions have been read, try to put together a model of influenza virus that explains how it changes continuously, what this means for vaccination programs, and how a particularly deadly version could appear without warning.

Materials

- One set of Clues to distribute to the group (master copy provided; after copying, cut to separate the clues)
- One transparency of the List of Questions to start the discussion of how influenza pandemics occur (master copy provided)

Clues

Cut into separate slips of paper and pass around until they are all distributed.

The Spanish flu was influenza A(H1N1).

A person who has antibodies against one type of influenza A, for example A(H1N1), may not be protected against another type of influenza A, for example A(H3N2).

The deadly Hong Kong influenza pandemic was caused by influenza A(H3N2).

A person who has never encountered an influenza A subtype that has a unique combination of hemagglutinin and neuraminidase will not have antibodies against it.

All types of influenza (A, B, and C) undergo "antigenic drift," in which small changes occur to viral genes. This results in small changes to the viral proteins, including hemagglutinin and neuraminidase.

Influenza A undergoes "antigenic shift." This occurs when influenza A viruses from different species (e.g., bird and human) co-infect a pig. Viral genes mix and re-assort in the pig cells, resulting in a new virus with a mixture of human and, possibly, avian or pig genes.

There are three types of influenza: A, B, and C.

Influenza C does not cause pandemics and is not included in the vaccine.

Hemagglutinin and neuraminidase are proteins on the surface of influenza that are recognized by the immune system.

Influenza A virus can be found in humans, ducks, chickens, pigs, whales, horses, and seals.

The current subtypes of influenza A in humans are A(H1N1) and A(H3N2).

Influenza B passes only from human to human, but it is possible for influenza A to pass from animals to humans.

In subtyping influenza A, "H" stands for the type of hemagglutinin and "N" stands for the type of neuraminidase.

When antibodies against hemagglutinin and neuraminidase bind to these proteins, the virus is neutralized and cannot infect cells.

Pigs can be infected by avian, human, and pig influenza viruses.

The genes for 15 different hemagglutinins and 9 different neuraminidases can be found in the influenza A viruses of wild birds.

List of Questions

1. An influenza vaccine stimulates production of antibodies against the Influenza subtypes that are expected to be common in the next flu season. How do they protect against the flu?
2. Why do we need to get an influenza shot every year in order to be protected?
3. When influenza viruses are identified as A(H1N1), what do the H and N stand for?
4. Why are some flus called “swine flu” or “bird flu”?
5. When flu scares occur—for example, swine flu in 1976 in New Jersey, or avian flu in 1997 in Hong Kong—why do health authorities impose large-scale vaccination programs or large-scale animal extermination programs?
6. How were the great influenza pandemics (worldwide epidemics) like the Spanish flu and Hong Kong flu different from the flu that goes around every year?
7. Was the Spanish flu so deadly because there were no antibiotics? If it occurred today, could we prevent it by treating everyone with an antibiotic like penicillin?

Source: <http://www.cdc.gov/ncidod/diseases/flu/viruses.htm>

Activity 5: Wrapping It Up

Based on video and online text content

15 minutes

Setup

In the first activity, the group generated lists of diseases that could be considered emerging or re-emerging infectious diseases, and a list of factors that cause this phenomenon. Take a look at your lists again now that you have thought about this issue a little bit and discuss the provided questions.

Materials

- The lists made by the group in Activity 1 (List 1: Diseases that might be considered emerging or re-emerging infectious diseases; List 2: Factors that affect the emergence or re-emergence of a disease)
- One copy of the Discussion Questions per person (master copy provided)
- One transparency of the Factors That Affect the Emergence of Disease (master copy provided)

Discussion Questions

1. Look at the list you made of factors that contribute to the emergence or re-emergence of an infectious disease. The transparency shows a table from Smolinski et al. (from the online text for this unit) with the same type of list. Compare the table to your list. Is there anything your list doesn't have? Are there additional factors that you would add to Smolinski's list?
2. Look at the list of diseases you thought might be considered emerging or re-emerging. Is there anything that you now think doesn't fit the definition? Is there any disease that you would add, either from the video or that you have thought of since starting this unit?
3. Was anyone surprised by any of the diseases that the scientists in the video considered emerging infectious diseases? If so, why? What is our perspective, in industrialized countries, on the threat of these diseases? Do we get enough information about diseases that might become a threat in the future?
4. Should diseases that might be used as bioterrorism weapons be treated as re-emerging? How much attention, research, and prevention should we devote to this category of diseases? For example, in December 2002, President George W. Bush announced a smallpox vaccination plan, with military and first responders vaccinated first, and a vaccination available to all Americans by 2004. Is this an appropriate response to the possible re-emergence of smallpox as a bioterrorism weapon?
5. If a disease is occurring on the other side of the world, sometimes it is difficult to imagine its impact and seriousness. When teaching high school students about emerging infectious diseases like cholera or malaria, what are some successful strategies for describing the seriousness of a disease that they might have no direct experience with?
6. On the other hand, if we suddenly hear a great deal of alarming information about a previously unknown disease, it can cause a fear that is not in proportion to the actual risk to the population; think of some of the reactions in the U.S. to mad cow disease, Ebola, and SARS, for example. When teaching high school students about these diseases, what are some successful strategies for providing information, while giving a balanced perspective on the risks?

Factors That Affect the Emergence of Disease

Factors that affect the emergence of disease (Smolinski et al.)

Human behavior and demographics

Microbial adaptation and change

International travel and commerce

Human susceptibility to infection

Technology and industry

Changing ecosystems

Climate and weather

Breakdown of public health measures

Poverty and social inequality

Economic development and land use

War and famine

Lack of political will

Intent to harm

Activity 6: A Picture's Worth a Thousand Words

Based on video and online text content

15 minutes

Setup

You might have played charades before, in which one person makes his or her partner say the name of a person, place, thing, or title by wordlessly acting out clues. In a variation of this game, the clues are not acted, but drawn with pencil and paper.

We'll play the game in which clues are drawn; however, in this version, the items to draw are diseases that might be considered "emerging." The game is played in teams of two. For each round of the game, one person from each team will see the term and will have 60 seconds to get the other person on the team to say the word by drawing key elements of the disease. Suggested clues to draw are the disease symptoms, the vector (carrier) of the infectious agent, area of origin, mechanism of transmission, or any other hint that suggests the disease. No words or letters are allowed!

When one of the team members guesses the disease from his or her partner's drawings, the round is over. For the next round, the team members switch the drawing and guessing roles.

Materials

- Clock with second hand or stopwatch
- One set of the List of Items to Draw (master copy provided; to make a set, cut on the dotted lines after copying)

List of Items to Draw

Hantavirus	malaria	spongiform encephalopathies
SARS	influenza	tuberculosis
Dengue fever	anthrax	antibiotic resistance
HIV	smallpox	bioterrorism
Legionella	cholera	West Nile virus
Lyme disease	hemorrhagic fevers	

Notes
