

MEDMYST MAGAZINE

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1.4

ZOONOSES

How do infectious agents move from animals to people?
Why are zoonotic diseases on the rise?



The health of animals and humans are tied together. Over 60% of known diseases are ones that are transmitted from animals to humans. Nearly all emerging diseases of the past 10 years have involved zoonotic infectious agents.

Acknowledgements

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Movement of pathogens from animals to people

There are a variety of **Transmission Pathways**—some obvious and some are more subtle.

- **Direct Contact** – when people and animals touch
 - Petting, cleaning, or physically moving an animal
 - Receiving an animal bite or scratch
 - Through feces, urine, saliva, or blood
 - Breathing airborne microbes from an animal
- **Food** – when people eat contaminated animal products
 - Diseased meat
 - Undercooked eggs
 - Untreated raw milk
- **Vector-borne** – when an insect, such as a mosquito or tick, carries the disease from an animal to a person

Getting the words straight

The word ZONOSIS, meaning a disease transmitted from animals to humans, comes from two Latin and Greek words

ZO (animal) + NOSOS (diseases)

The plural form is ZONOSSES.

The adjective is ZONOTIC.

Can you determine what ENZOOTIC means?



What are some zoonotic diseases that you are familiar with? Have you heard of Q-Fever, Chikungunya or Tularemia?

ZONOSSES ARE ON THE RISE – HERE'S WHY

- **INCREASED POPULATION DENSITY**
 - Urbanization – As cities and suburbs spread, animals are forced to move out of their remote habitats and live closer to humans.
 - Reforestation – Some areas, such as the Northeastern United States, have undertaken efforts to re-grow the forests that had been removed in earlier centuries. As a result, some animal populations, such as deer, have grown, increasing the spread of illnesses like Lyme disease.

- **GLOBALIZATION/ RAPID AIR TRAVEL**

- Business and pleasure take more and more people to more and more places around the world where they are exposed to new diseases
- Vectors that carry an infectious agent, such as mosquitoes, can hitch a ride and show up in new spots across the world.
- The exotic pet industry in the United States has reached \$1 billion per year. Exotic pets travel long distances to find homes in North America, live in close proximity with dogs, cats, and people, and bring exotic diseases along.

- **CHANGING ECO-SYSTEMS**

- Rainforests are shrinking and wilderness areas are becoming cultivated fields and gardens. Humans are encroaching on areas that were once reserved for animals. Droughts and extended rainy seasons occur in new locations. As a result, animal populations, and their pathogens, are on the move.

- **BIOTERRORISM AND WAR**

- People have been known to spread illnesses on purpose for hundreds of years. For example, in the eighteenth-century British troops reportedly gave small-pox-infected blankets to the Pontiac Indians to subdue them.
- Newer technologies have enabled people to suspend pathogens in liquid or gas particles that can be spread through the air – a potential tool for terrorists.

- **MICROBIAL EVOLUTION**

- Unlike the slow pace we think of with human evolution, microorganisms evolve or mutate on a fast track. For example, within weeks, a population of bacteria can virtually reinvent itself.
- With the use of antibiotics, different types of bacteria have evolved antibiotic resistance making it harder to defeat disease.



Transmission Pathways

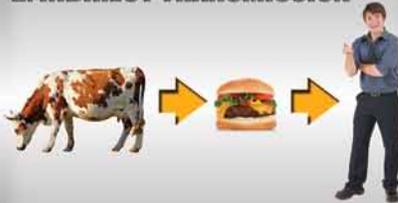
1. DIRECT TRANSMISSION



Direct – transmitted from animals to humans by bites, scratches, inhalation.

Examples: Rabies, Cat Scratch Disease, Anthrax

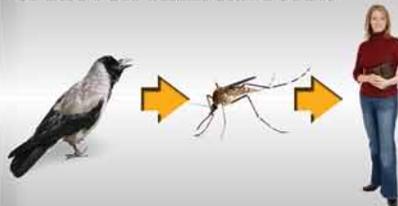
2. INDIRECT TRANSMISSION



Indirect – transmitted from animals to humans through contamination of food or water

Examples: BSE/variant Creutzfeldt-Jakob Disease, Escherichia coli 0157 strain

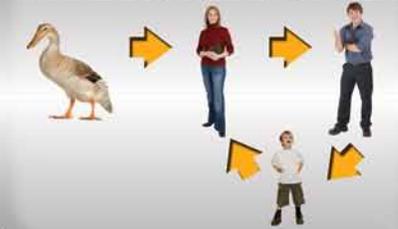
3. VECTOR TRANSMISSION



Vector – transmitted from animals to humans via another organism

Examples: Lyme disease, West Nile virus

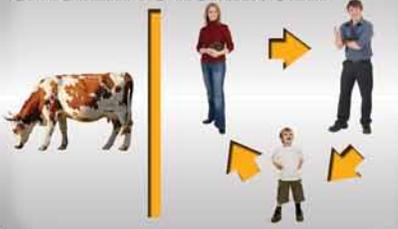
4. ANIMAL TO HUMAN TO HUMAN



Animal to Human to Human – transmitted from animals to humans, but also from humans to humans

Examples: Influenza, SARS

5. HUMAN TO HUMAN ONLY



Human to Human Only ("species jumping") – once transmitted from animals to humans, but now transmitted between people only

Examples: Measles, AIDS, Typhoid Fever

INTERVIEW WITH *Kimberly Schuenke, PH.D.*

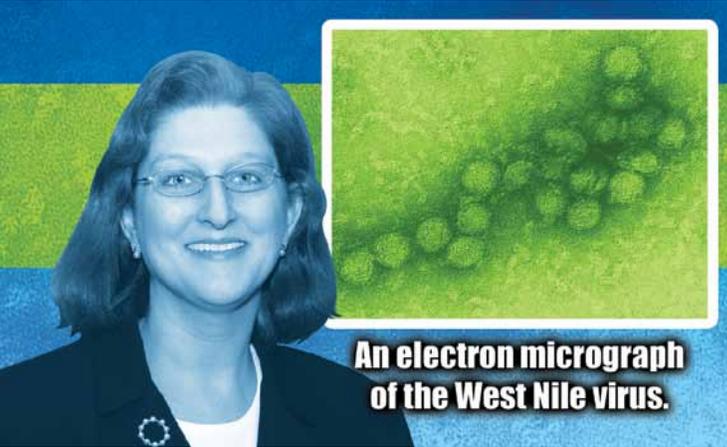
WHERE DO YOU WORK?

I am currently the associate director for the **Center for Biodefense and Emerging Infectious Diseases**, located at the University of Texas Medical Branch in Galveston. I am also the program administrator for a major grant that funds research on infectious diseases, called the **Western Regional Center of Excellence for Biodefense and Emerging Infectious Diseases Research (WRCE)**. The WRCE is one of 10 such Centers across the country. The Centers are developing vaccines, drugs, and diagnostics for diseases caused by "priority pathogens" such as the **plague bacillus** and **viral hemorrhagic fever viruses**.



Thumb with skin ulcer of tularemia.

Image courtesy of Emory U. Dr. J. Sellers



An electron micrograph of the West Nile virus.

DOES THE WRCE STUDY ZONOTIC DISEASES?

Yes, most of the diseases we study, especially ones that are emerging and cause disease outbreaks in humans and domestic animals, are transmitted by insects or animals.

CAN YOU GIVE US SOME EXAMPLES OF PROJECTS?

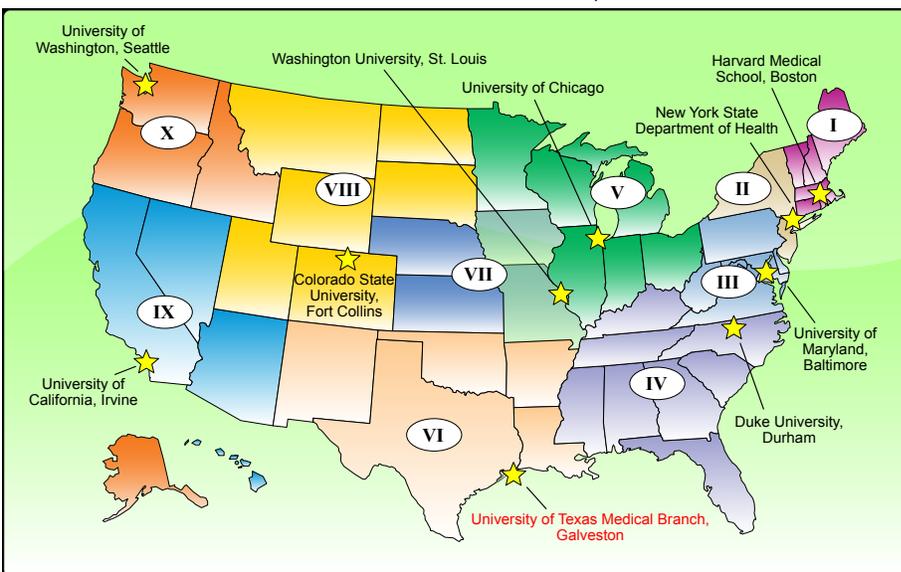
We have over 30 scientific projects, and they range from diseases you may have heard of (**tularemia, anthrax, influenza, SARS**) to more exotic diseases that rarely occur in the continental US (like **Venezuelan equine encephalitis, Omsk hemorrhagic fever, and brucellosis**). The WRCE funds research on over 17 different infectious agents, and many of these must be studied in specially designed high containment laboratories called BSL-4 labs.

CAN YOU PREDICT WHEN AN OUTBREAK OF A ZONOTIC DISEASE WILL OCCUR?

We can't, but we can take steps to be prepared to respond quickly. To deal with emerging zoonoses, scientists have adopted an approach called the "**discovery-to-control continuum**". A continuum is a progression of events. The idea is that scientists build upon the knowledge they collect (like discovering that a new disease is occurring in a new area), share this information with a wide variety of colleagues (including **veterinarians, researchers, public health officials, physicians, and epidemiologists**), and formulate a plan to stop the spread of a disease.

"With a science background you can do so many things—such as field research (all over the world!), computer modeling, science education, examining legal issues for things like bioterrorism, and developing science policy for our country."

RCE Biodefense Network funded by NIAID/NIH



WHAT DO YOU LIKE BEST ABOUT YOUR WORK?

I love science, and even though I am no longer in the laboratory, I interact with scientists and get to be a part of cutting-edge research. I was encouraged to enter science fairs by my high school biology teacher, and she also inspired me to consider a career in science.

I was trained as an experimental pathologist, and studied how to make a better vaccine for a tick-borne disease called **Mediterranean spotted fever**. Although there were not many women in the biological sciences when I went to graduate school, I think this is changing and there are many opportunities for both men and women. Not everyone who has an interest in science needs to work in a laboratory or hospital.



DR. MURPHY AND THE SPAGHETTI NOODLE VIRUSES

PUT YOURSELF IN THE SHOES OF DR. FRED MURPHY AS HE TELLS HIS STORY:

October, 1976

I remember it clearly. I was head of the Viral Pathology Branch at the Centers for Disease Control (called the CDC) in Atlanta. At that time my Branch included the "hot lab," the lab for work on the most dangerous viruses. The call came. Doctors in a small missionary hospital in Zaire, Africa, (now the Democratic Republic of the Congo) needed our help. People with the same symptoms were arriving daily at the clinic for help. The staff treated the patients as best they could, but many of them died.

The doctors described the disease as starting with a headache that became intense, along with a high fever. Body aches and blood shot eyes were often present. Bouts of diarrhea and vomiting drained the patients' strength away. Often the vomit was mixed with blood, and the dry heaves followed.

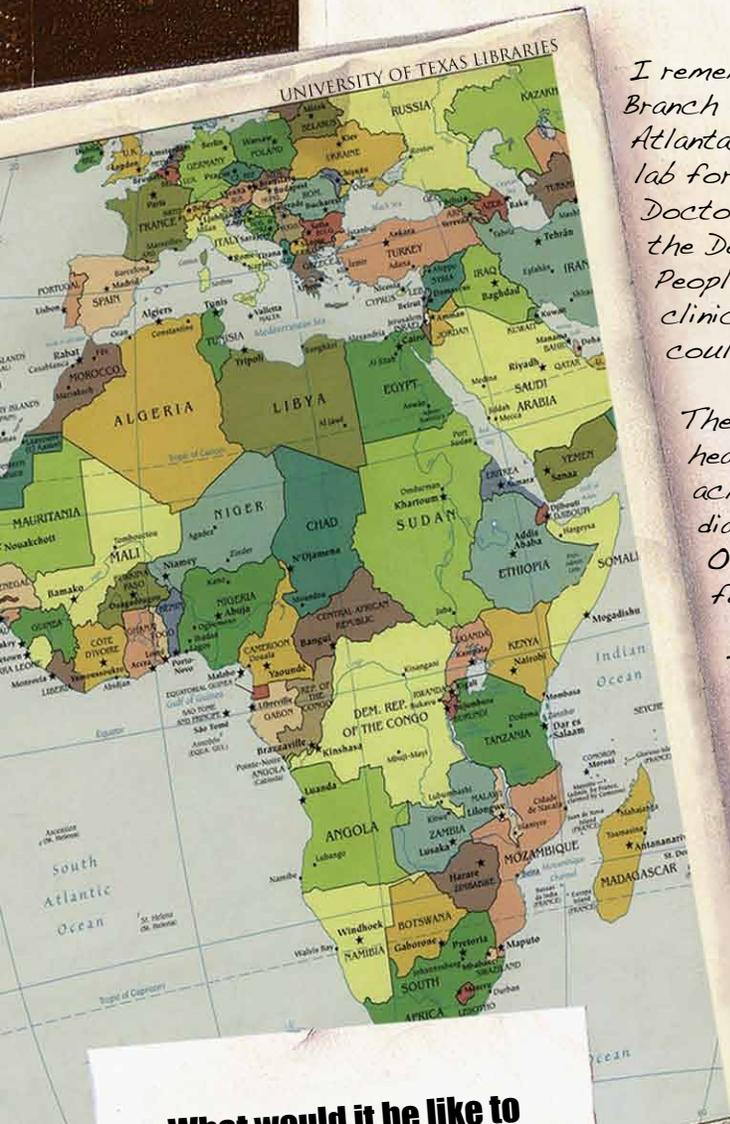
The disease destroyed the immune system, weakened the blood vessels causing bleeding (hemorrhaging) under the skin. In the last stages, there was bleeding from all the organs, from the mouth, eyes, and ears as the disease ravaged the body. Sounded like it might be an outbreak of a hemorrhagic fever—maybe the deadly Marburg virus—that had been identified in 1967.

What was this dreadful disease, how far would it spread, and how many more people would die?

These questions needed answers fast.

A box of clinical specimens arrived from Zaire. Opening the package, my colleague, Patricia Webb, found the glass tubes containing human blood specimens were broken.

Should we destroy the mess to avoid contamination?



What would it be like to identify a new and deadly virus...particularly one that was killing people in strange ways in Africa?



Never! We'll just be very, very careful (and with lots of experience we really knew what we were doing!). Dr. Webb, put on a mask, gloves and a gown, and she squeezed a few drops of fluid out of the cotton surrounding the broken tubes. I prepared those few drops for the electron microscope. I ran back to the preparation area and wiped everything with Clorox to prevent any contamination. I threw all the preparation materials in the sterilizing machine to destroy

them.

Under the electron microscope what we saw was a new virus to humans, the Ebola virus, which proved even more deadly than the Marburg virus.

I was struck by the resemblance both viruses had to spaghetti noodles so I named this new family of viruses, *Filoviridae*. This comes from the Latin word, *filo*, meaning "threadlike." Marburg and Ebola are the two *filoviridae* viruses identified so far. There are no known treatments, but scientists, working in extremely secure and safe (BSL-4) laboratories are working on answers.

The same day that I first saw Ebola virus in the electron microscope, the director of CDC joined in with the World Health Organization (the WHO) to send a team of doctors and scientists to Africa, most importantly to help save the lives of infected patients and to prevent the spread of infection of others both in the hospital and in the villages nearby.

IS EBOLA A ZONOTIC DISEASE?

While Ebola has caused hundreds of human deaths in Africa, Ebola has killed over 5,000 gorillas and an unknown number of chimpanzees.

How the first person became infected during previous outbreaks has never been determined; however, based on the available information, scientists believe that the Ebola virus normally lives in an animal host in Africa--perhaps the gorillas or chimpanzees.

Since the natural reservoir of Ebola has not been precisely identified, the prevention of Ebola is a challenge. Until scientists discover more information, Ebola is a "suspected" zoonosis and an ongoing Medical Mystery.



Belgian missionary hospital staff members who died at the Yambuku Hospital

Electron micrograph of the Ebola Zaire virus. This was the first photo ever taken of the virus by Dr. Murphy while at the CDC.



10/13/1976

Frederick A. Murphy, D.V.M., Ph.D.
University of Texas Medical Branch - Galveston

Dr. Frederick Murphy trained as a veterinarian and as an infectious disease scientist. He has had a productive and exciting career studying emerging diseases. About seventy percent of emerging diseases have been identified as zoonotic.

Be **RABID** about **RABIES** prevention!



WHAT MAKES THE ZOO NOTIC DISEASE, **RABIES**, SO DEADLY?

When a person is bitten, the saliva with the virus enters the body. During the incubation period the virus multiplies in the body. After about a month the virus migrates to the brain. The rabies virus attacks the central nervous system (brain and spinal cord) causing confusion, anxiety, hypersalivation, hydrophobia (fear of water), coma and death.

HOW DO YOU **PREVENT** **RABIES**?

Rabies kills if it is not prevented. Once signs of the disease appear in an animal or a human, they usually die within 10 days. Animals should get vaccinated against rabies. People can also get anti-rabies shots to fight off the disease. Rabies shots for humans need to be given as soon as possible after a bite has occurred, before symptoms appear. The vaccination consists of a series of six shots given over 30 days.

WHAT IS IT LIKE FOR **HUMANS** TO GET THE **RABIES** VACCINE IF THEY HAVE BEEN **BITTEN**?

Thanks to modern science, we no longer have to dread a series of very painful injections in the stomach. No one gets those anymore. With the current rabies vaccine, one shot is given around the area of the bite. The rest are given in the arm. The rabies shots produce an immune response that creates antibodies which helps the body fight off the virus.

WHAT ARE THE **BEST** WAYS TO **PREVENT** **RABIES**?

- Vaccinate dogs, cats, ferrets, and livestock.
- Supervise pets outdoors.
- Don't leave pet food or exposed garbage outside to attract wild animals.
- Don't mess with animals you do not know.
- If you see a wild animal acting strangely, report it.
- Bat proof your home.
- Wash any bite immediately and seek medical help



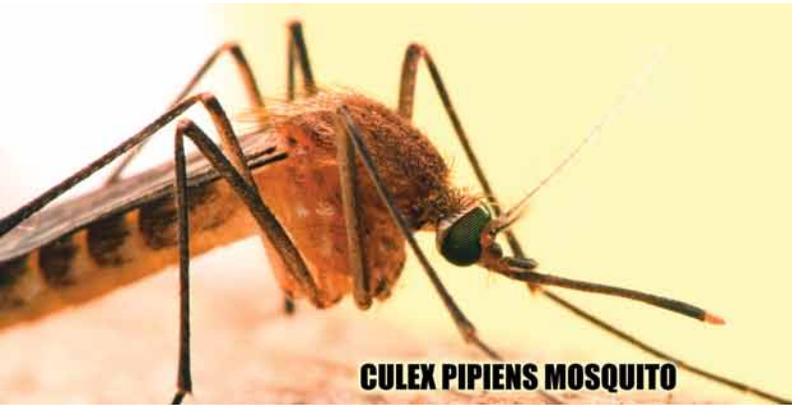
WHAT **ANIMALS** TRANSMIT **RABIES**?

In the USA, people and pets get rabies from wild animals primarily from bats, but also from raccoons, skunks, foxes, coyotes. The sneaky thing about bat bites is that sometimes people don't realize that they have been bitten. Rabies is spread in Asia, Africa, and parts of Latin America mostly by dogs. Only mammals can get or transmit rabies.



Did you know that bats are the only mammals that can fly?

Can you find out how many species of bats there are?



CULEX PAPIENS MOSQUITO

WEST NILE VIRUS IS A WORLD TRAVELER

BIRDS to MOSQUITOS to HUMANS and other animals

The West Nile Virus (WNV) was originally discovered in the African nation of Uganda in 1937. The virus is carried by birds and transmitted by mosquitoes. A human being or animal is infected with the disease when they are bitten by a mosquito, specifically the *Culex pipiens* mosquito, that is also infected.

SYMPTOMS

People who contract WNV usually have no symptoms or mild symptoms. Those with symptoms may have a fever, headache, body aches, skin rash or swollen lymph glands.

If West Nile virus enters the brain, however, it can be deadly. It may cause inflammation of the brain, called **encephalitis**, or inflammation of the tissue that surrounds the brain and spinal cord, called **meningitis**. The most severe cases of WNV have been found in people over the age of 50.

IT TAKES A TEAM

It wasn't until 1999 that this emerging infectious disease appeared in the United States. In New York City crows, then flamingos and pheasants at the Bronx Zoo, began dying. Horses in the region also began to die, and several people were admitted to hospitals with symptoms. A team of **epidemiologists, pathologists, veterinarians, and public health workers** put together the clues that revealed a disease never before found in North America—WNV!

- How do you suppose West Nile Virus got to the United States?
- Is the West Nile Virus in your community?



SURVEILLANCE PROGRAM

In 1999, the Centers for Disease Control put into place an enhanced human and animal infection surveillance program for states affected by West Nile virus.

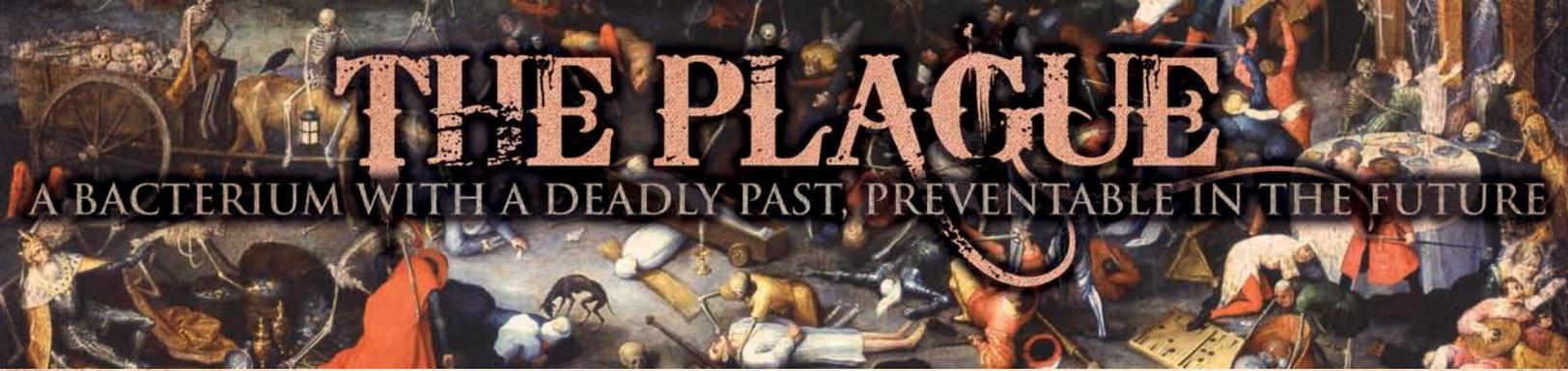
Want to know about the history of WNV?

West Nile Story

by
Dickson Despommier

1. Kids are in the most danger of getting sick from West Nile virus.
(True or False)
2. Insect repellents containing DEET are not safe.
(True or False)
3. As long as my area has a mosquito control program, I don't have to worry about using repellent.
(True or False)
4. There is a lot that I, personally, can do to reduce my chance of West Nile virus infection.
(True or False)
5. If I see a dead bird, I should pick it up and take it home.
(True or False)

1. False Most of the reported deaths due to WNV were in people over 50.
2. False As long as you use according to manufacturers instructions, repellents with DEET should be safe.
3. False Personal protection is still important.
4. False There are many actions you can take such as emptying containers with standing water and "right the blues" of mosquitoes.
5. False Check with your local or state health department for instructions on reporting and disposing of a dead bird. If you need to pick up a dead bird, or local authorities tell you to simply dispose of it. Avoid bare-handed contact with any dead animals, and use gloves or an inverted plastic bag to place the bird carcass in a garbage bag and dispose of it with your routine trash.



THE PLAGUE

A BACTERIUM WITH A DEADLY PAST, PREVENTABLE IN THE FUTURE

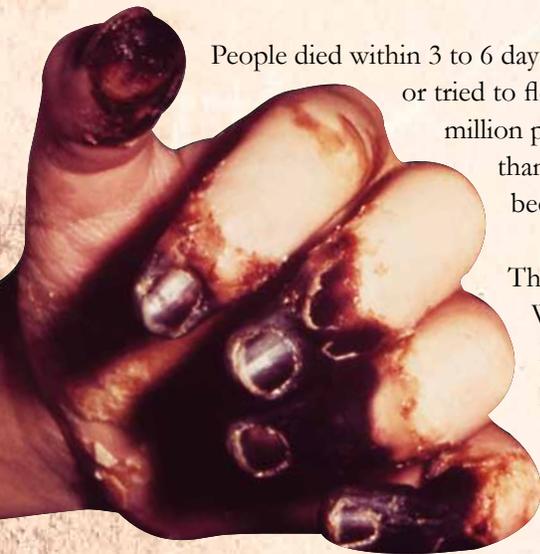


ould this ever describe your neighborhood?

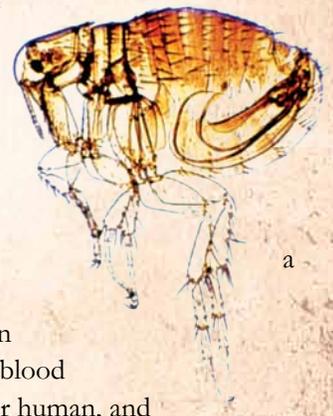
“THEY SICKENED BY THE THOUSANDS DAILY, AND DIED UNATTENDED AND WITHOUT HELP. MANY DIED IN THE OPEN STREET, OTHERS DYING IN THEIR HOUSES, MADE IT KNOWN BY THE STENCH OF THEIR ROTTING BODIES.”

In 1348 for Giovanni Boccaccio, this was his world during the bubonic plague epidemic. The people had fevers, then swollen lymph glands called “buboes” - large, purple-black discolorations formed under the skin, giving the disease its name – **the Black Death**.

People died within 3 to 6 days. Households and towns were decimated as more people died or tried to flee the devastation. The plague eventually caused over 20 million people in Europe to die by 1350. This number is more than died in both World War I and World War II. And all because of *Yersinia pestis*.



The plague bacteria, *Yersinia pestis*, lives in wild animals. When a flea bites an infected animal and then bites human, the bacteria are spread. The interesting thing about plague and the flea is that the bacteria multiply exponentially in the flea’s gut, which effectively blocks passage of subsequent blood meals for the flea. The starving flea then bites the next rat or human, and regurgitates (or throws up) the bacteria into the bloodstream of the new host, setting up the infection.



Forms of Plague

Bubonic strikes the lymph nodes in the groin, armpit or neck, which become swollen and painful. Symptoms generally develop within two or three day of contact with an infected animal or flea bite and include high fever, chills, weakness, headache and muscle ache.

Septicemic plague, occurs when the bacteria go directly into the blood. There are no swollen lymph nodes, just fever and flu-like symptoms.

Pneumonic plague develops when the bacteria invade the lungs. It can spread to other people through coughs and sneezes.

Even though plague is not the scourge it once was, the disease still occurs throughout the world and if left untreated is fatal in over 50% of cases. Delays in seeking treatment and misdiagnosis are also problems, and the plague bacillus could potentially be used as a biological weapon. For these reasons, The National Institute of Allergy and Infectious Diseases (NIAID) conducts and supports research to develop a vaccine, a rapid diagnostic test for the inhaled form of the disease, and promising drugs to treat and prevent plague infection. Scientists are even examining how *Yersinia pestis* infects the digestive tract of fleas so they can better understand how the bacteria are transferred to humans!

Read excerpts from the story of a woman as told by Ben Swan, a reporter for the Santa Fe New Mexican newspaper. Reprinted with permission.

THE SANTA FE NEW MEXICAN

AUGUST 19, 2007

SUNDAY

ONE DOLLAR

Living with Plague By Ben Swan

Cindy Roper survives bout with deadly disease persistent in Northern New Mexico.

"I'm part of an exclusive club," Roper said. "When you hear the word plague, you think you're going to die, or you're going to be really, really sick for a very long time, or something horrific is going to happen to you. But that is not (always) the case if you're aware it's out there, and you recognize the symptoms and get treated."

veterinarian. One theory is that the mix of juniper and piñons in the region helps maintain a high diversity among rodent populations. That diversity allows plague, a **bacterial disease**, to survive through what health department officials call **susceptible** and **maintenance animals**.

Maintenance animals, such as **deer mice**, are resistant to plague. The bacteria spread to susceptible animals, such as **prairie dogs**, **rock squirrels** and **wood rats**, through infected flea bites. The bacteria kill those animals rather rapidly. Ettestad said, but the hungry fleas then search for other blood hosts, such as humans and their pets.

Enzootic disease

Plague is **enzootic** in New Mexico, meaning it's established in the rodent and flea population. It might wax and wane and seem to disappear for a while, but a long-term study in Eldorado (NM) indicates that the plague simmers in an area and never really goes away.

In Roper's case, health officials speculate that infected fleas either jumped on Roper while she was working in the yard or traveled to her through one of her dogs. Surviving the plague has given Roper immunity for up to a year, doctors have told her. But the illness has taught her not to take life for granted.

It was the headache that finally forced Cindy Roper to call an ambulance. The upset stomach and the nausea could be controlled along with the fluctuating temperature. But the headache would not ease its grip.

Roper's illness initially stumped the doctors. After many tests, an infectious disease specialist confirmed what had been a growing suspicion. Roper had contracted the plague. She became another statistic, the fourth confirmed human plague case this year in New Mexico, a place that racks up more than half the nation's cases every year.

Unlike the bubonic form of plague, **septicemic** plague - which Roper contracted - occurs when the bacteria go directly into the blood. There are no swollen lymph nodes, just fever and flu-like symptoms.

Plague sources

No one knows precisely why plague remains persistent in Northern New Mexico, said Dr. Paul Ettestad, the state Health Department's public health



Slide shows unblocked anterior portion of flea's digestive track. A blocked flea is unable to ingest its blood meal because a mass of bacteria is preventing passage of blood from the esophagus to the stomach.

