The Bubonic Plague:

Medieval Scourge Finds Modern Victims

A Retrospective of the Bubonic Plague and its Presence in Contemporary Society

Khushbu Aggarwal

"Those infected felt themselves penetrated by a pain throughout their whole bodies and, so to say, undermined. Then there developed on the thighs or upper arms a boil about the size of a lentil, which the people called 'burn boil.' This infected the whole body, and penetrated it so that the patient violently vomited blood. This vomiting of blood continued without intermission for three days, there being no means of healing it, and then the patient expired."

This excerpt, written in Messina in 1357, is from the first account of the bubonic plague, or Black Death, a disease that many believed would be the end of mankind, and not without good reason (Loude 2009). The first pandemic is believed to have started in Africa, as a text dating from 1500 BC identifies a disease that "has produced a bubo" responsible for 100 million deaths (Loude 2009; National Geographic News 2004). In the Middle Ages, the plague claimed one fourth of Europe's population, and in the early twentieth century, the plague accounted for 10 million deaths in India (WebMD 2006). In addition to the human death toll, oxen, mules, goats, pigs, and chickens also succumbed to the bubonic plague. Historian Henry of Knighton described a field with 5,000 dead sheep so ravaged by the disease that even hungry wolves "as if alarmed by some invisible warning, turned and fled back into the wilderness" (Adrian Empire).

But, the bubonic plague is not only a historical disease, as commonly believed; it is the subject of research and public health concern, as it is still present today to a more limited degree, though a pandemic rivaling those seen in history is not impossible and could have severe global consequences.

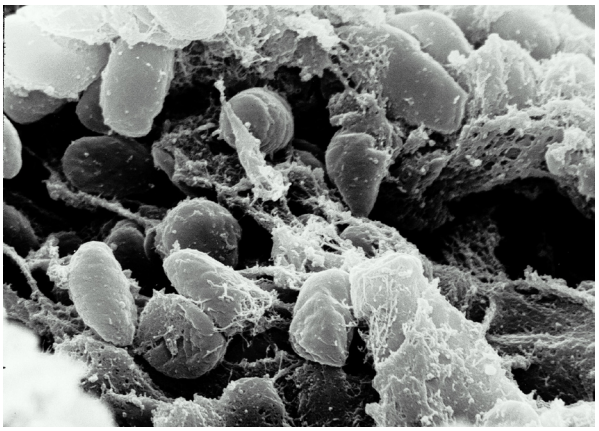

Figure 1. An electron scanning micrograph of *Yersinia Pestis*, the rod-shaped bacteria reponsible for the Bubonic Plague in 14th century Europe.

"This vomiting of blood contiued without intermission for three days, there being no means of healing it, and then the patient expired."

During the Middle Ages, the plague spread rapidly, primarily as a result of poor living conditions. Flea-infested rats were so commonplace in human homes and work places due to lack of hygiene that nobody suspected them of being the vectors of the disease. In fact, rotten food was routinely dumped into the streets, which further encouraged the rats to live in human proximity (Adrian Empire, Rich East High School 1997). Overcrowded living conditions, especially amongst the poor, facilitated rapid human to human infection, as did trade (since rats and fleas often made home in the cargo of ships) (Joshua ISD, Adrian Empire). The bubonic plague was even spread through its use as a biological weapon. When the plague struck Crimea in 1346, thousands of Muslim Tartars died. The survivors blamed these deaths on the Christian Genoese and sent an army to attack Caffa, where the Genoese were taking shelter. As Tartar soldiers died from the plague, the Tarters catapulted the bodies of these plague victims over the walls of Caffa to infect the city, and so the Genoese set sail for Italy, bringing rats and fleas with them (Adrian Empire).

Anyone who seemed immune to the disease was suspected of witchcraft. Jews were especially vulnerable, as they practiced good hygiene and so limited the population of fleas and rats in their living quarters. Similarly, any individual having a cat (the natural predator of the rat) was accused of associating with the devil and put to death (General Board of Global Ministries). In fact, the Mayor of London himself ordered that all cats be destroyed (which only worsened the condition by aiding the multiplication of rats) (GlobalSecurity.org 2007). Often times, the church and state looked the other way as these falsely accused individuals became the victims of mob violence (General Board of Global Ministries) (Adrian Empire, GlobalSecurity.org 2007). In such instances, general panic overshadowed any form of reasoning, thus preventing the true vectors of the disease from being discovered.

Instead, even the most educated individuals of society attributed the disease to a variety of superstitious causes, ranging from the result of a punishment from God to the conjunction of Saturn, Jupiter, and Mars in 1345, which caused hot and moist conditions that promoted the exhalation of poisonous vapors by Earth (Adrian Empire, GlobalSecurity.org 2007). Perhaps the latter explanation came from the fact that, due to the stench of death in the air and especially near the cemeteries (where mass graves were commonplace), many came to believe that the disease was transmitted by air. Thus, they turned to the use of scents, including juniper, laurel, pine, beech, lemon leaves, rosemary, camphor, and sulfur (Adrian Empire).

Some said that "no man should think of death" but

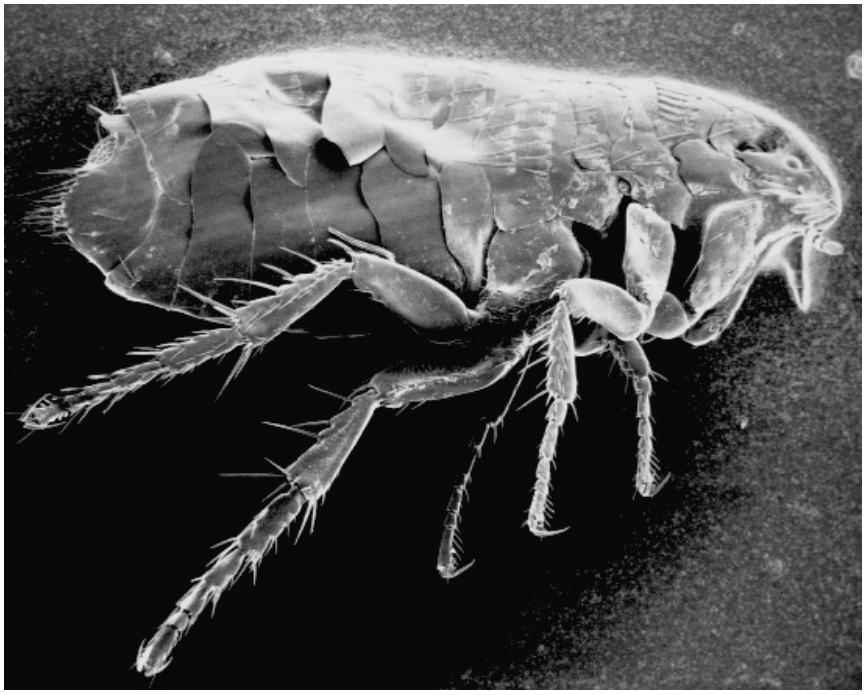

Figure 2. Scanning electron micrograph of *Xenopsylla cheopis* or rat flea. These organisms acted as the primary vectors for the spread of Black Death.

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instead "beautiful landscapes, fine gardens should be visited . . . listening to beautiful, melodious songs is wholesome" (Adrian Empire, GlobalSecurity.org 2007). Home remedies included drinking mixtures of ground eggshells and marigold flowers. So-called "beak doctors" (who employed an elongated, artificial 'nose' and lenses for protection against the disease) treated the sick, prescribing herbs, special diets, bleeding, new postures for sleeping, and even medicines of gold and pearls for the rich. But, people soon realized that the disease did not discriminate between the rich and poor and so it would be commonplace to see "houses of deceased . . . open with all their valuables, gold, and jewels" (Adrian Empire).

"From the time of the onset of symptoms to rupture of the swollen lymph nodes to death spans only three to four days, with mortality being up to 50% without treatment."

But, alongside these treatments that had no effect on the diseased was sound advice for prevention of the bubonic plague, including sanitation, proper disposal of the dead, quarantining, and marking houses to show where the disease had struck (Adrian Empire, GlobalSecurity.org 2007). Perhaps these measures, alongside antibiotics in the future, aided in the eventual decline of the bubonic plague.

But, the social repercussions resonate even today. The high mortality rate in Europe resulted in labor shortage, which fueled demands for higher wages, ultimately facilitating the end of feudalism and the rise of the middle class, as the atmosphere of panic facilitated peasant revolts (GlobalSecurity.org 2007). At the same time, the oversupply of goods (due to a lack of consumers) caused prices to drop, which increased the standard of living (Center for Disease Control and Prevention 2009). Besides the socioeconomic consequences, the tomb sculptures and paintings of the time period reveal a general brutality and grotesqueness that serves as a reminder for this dark period of human history (Adrian Empire).

The Present

Though the symptoms of the plague were accurately described in primary accounts throughout history, it was not until 1894 that Alexander Yersin isolated the responsible bacterium, Yersinia pestis (Center for Disease Control and Prevention 2009, WebMD 2006). When a rat flea, such as Xenopsylla chepois, ingests blood from an infected animal (such as a rat, squirrel, rabbit, or prairie dog), a coagulase in Yersinia pestis causes blood clotting in the foregut of the flea, blocking the gut and causing regurgitation of bacteria while the flea is feeding on another host (Bard College 2009). The bacteria are inoculated into the host of the skin, from where they migrate via

Figure 3. Photoportrait of Alexandre Yersin (1863-1943) who discovered the Bubonic Plague causing bacteria in 1894 and prepared the first combatitive serum in 1895.

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lymphatic vessels to lymph nodes, which are dilations of lymphatic tissue that serve an important function in the immune system. (Merck 2008, SIGBIO). From the lymph nodes, bacteria may be released into the bloodstream through macrophages that act as protective micro-environments, producing severe illness referred to as plague septicemia, and then may spread to the lungs, resulting in plague pneumonia (A.T. Still University 2004, Center for Disease Control and Prevention 2009, Enteropathogen Resource Integration Center, PBS 2002).

Humans become ill when bitten by the rat flea (or possibly by ticks and lice), by handling infected animals, or by inhaling the droplets from the cough of an infected animal or human infected with plague pneumonia (Adrian Empire, Center for Disease Control and Prevention 2009, WedMD 2006). Two to seven days after being infected, the symptoms begin: swollen, discolored, hot-to-the-touch lymph nodes called bubos (thus giving rise to the names of the disease: the bubonic plague and Black Death), fever, and exhaustion. From the time of the onset of symptoms to rupture of the swollen lymph nodes to death spans only three to four days, with mortality being up to 50% without treatment (Adrian Empire, Center for Disease Control and Prevention 2009).

Successful treatment depends on the timely administration of specific antibiotics, which may be hindered by a doctor misinterpreting the flu-like symptoms of the plague (for example, penicillin has no effect on the plague). The antibiotics streptomyocin, aureomycin, or chloramphenicol in conjunction with tetracycline are most effective if administered in early stages of the disease. In instances of pneumonic plague, antibiotics are only effective twenty-four hours after onset. If these antibiotics are not available, sulfadiazine is prescribed instead, though it is more commonly used to enhance the effectiveness of antibiotics or as a preventive measure for individuals exposed to the plague who have not yet shown any symptoms (University of North Carolina 2002).

Figure 3. Dr. Stephen O'Brien investigating the town of Eyam England for genetic resistance to *Yersinia pestis*.

Interestingly, studies by Dr. Stephen O'Brien of the National Institutes of Health in 1996 have revealed that resistance to the plague may have been, and continues to be, genetic. The CCR5 gene, which normally encodes a chemokine-receptor that functions as a coreceptor allowing HIV virus entry into cells, is mutated in HIV-resistant individuals (Carrington et al., 1997). The mutated form, referred to as delta 32, may also confer resistance to the plague by preventing entry of Yersinia pestis into the host's white blood cells. One copy of the mutation is believed to facilitate recovery after a period of illness, while two copies confer complete resistance (University of North Carolina 2002). Dr. O'Brien studied the town of Eyam in England, which survived the plague epidemic. He reasoned that, since this population was relatively isolated, their gene frequencies were replicated for several generations without much combination from the outside, thus providing a pool of survivor-descendents who possibly inherited the trait for resistance. DNA was harvested from these individuals and tested for the presence of delta 32, found at an incidence of 14%. Then, an international team of scientists was employed to test for the presence of delta 32 in different ethnic groups: native Africans, East Asians, and Indians had a 0% incidence, while

regions of Europe affected by the plague and America (which was settled by survivors from Europe) had the same incidence as that in Eyam, thus supporting Dr. O'Brien's conclusions (PBS 2002).

The relevance of such studies is that, even today, the bubonic plague has not been completely eradicated: outbreaks still occur in both rural areas and in cities due to infected fleas and rats, at 1,000 to 3,000 cases per year. In the United States, the last urban plague epidemic occurred not a hundred years ago, in Los Angeles from 1924 to 1925. Subsequent cases, at 10 to 15 cases per year, occur in rural areas in the western states, in New Mexico, Colorado, Arizona, and California. Most of these cases occur in people under the age of 20, with a mortality rate of 15% (Center for Disease Control and Prevention 2009). The plague vaccine is no longer commercially available in the United States, even though the Center for Disease Control and Prevention has specified Yersinia pestis as a prime candidate for use in bioterrorism (Adrian Empire, WebMD 2006). Instead, the vaccine is only recommended for persons who reside in rural areas with unavoidable flea and rat populations and laboratory personnel working with the bacterium (Department of Health and Human Services 1998).

The Future

But, even though laboratories today still study the plague, there is a scant chance that missing infected mice (which prompt fear in the general public) can cause an epidemic to the extent that history has witnessed (msnbc 2005). What is more likely is the evolution of an antibiotic-resistant strain: in 1995, a sixteen-year-old boy in Madagascar (which sees 500 to 2,000 new cases per year) was found to have a strain resistant to eight drugs, including streptomycin, tetracycline, and spectinomycin (National Geographic News 2004, University of North Carolina 2002). Though he was saved with an antimicrobial drug containing sulpha, this case serves as a warning that another pandemic is not impossible, or in the words of those studying the case, "such a clinically ominous event may occur again" (University of North Carolina 2002).

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