The 1918 Flu 1 – A Conspiracy of Silence

"The important and almost incomprehensible fact about the Spanish influenza is that it killed millions upon millions of people in a year or less. Nothing else - no infection, no war, no famine - has ever killed so many in as short a period. And yet it has never inspired awe, not in 1918 and not since…"

So says Alfred Crosby in "A*merica's Forgotten Pandemic*…

- Epidemic diseases have often changed the course of human history
- The death of a world leader, an epidemic before a great battle…
- But few diseases have accomplished it through sheer brute force

- The deadliest epidemic of all times wasn't smallpox, or the Black Death…
- It was the 1918 Flu
- An estimated 50 to 100 million people died, out of a global population of 1.8 billion
- In America alone, 675,000 people died

- More Americans died of the flu in a single year than in World War I, World War II, Korea, and Vietnam combined!
- It was one of the great watershed events in the history of the world
- But it has remained shrouded in a cloud of silence ever since…

- The usual explanation is that World War I took center stage
- But it is also true that flu survivors were so horrified, they didn't want to remember
- During one of the most productive periods in American literature, there are only a few mentions of the flu

- Thomas Wolfe describes the death of his brother in *Look Homeward Angel*
- And Katherine Anne Porter tells of her own brush with mortality, and laments the death of her fiancée in *Pale Horse, Pale Rider*

- If you're upset by the chilling story that I am about to tell, ask yourself this -
- If it was so bad that we can barely stand to hear about it nearly a century later – how much more horrible must it have been for those who actually lived through it?

- So let's go back in time, to a simpler era, before television, and computers, before Ipods, before the Internet…

- In the Summer of 1918, the U.S. was enjoying warm weather, and general prosperity
- For most people, their biggest worry was the War in Europe, World War I, the war to end all wars

- The flu had passed through the previous spring, bringing mild fever and aches, but nothing unusual
- Most of its victims were among the very young or the very old

- This is the typical “U-shaped” curve of flu mortality

- Flu was nothing new…
- The first global flu pandemic may have been in 1580
- It started in Asia and swept across Europe
- 9,000 people died in Rome, and many Spanish cities were virtually depopulated

- From 1700 to 1900 there had been at least sixteen major epidemics of influenza, some of them deadly
- An outbreak in 1729-1730 claimed 1,000 lives a week in Europe

- The last major pandemic was in 1889-1890, the first of what were later called the Asiatic flus - Why do so many flu epidemics start in Asia?
- As we’ll learn later on, it’s probably due to the large numbers of people living in close proximity to large numbers of chickens and ducks

- No one knows exactly where the 1918 Flu began, but evidence points to Haskell County, in Kansas
- Local physician Dr. Loring Miner saw dozens of his patients stricken by an unusually virulent form of flu in January to mid-March of 1918

- Virulence is a measure of the relative severity of a disease, usually determined by its mortality rate

- By the middle of March, the flu had faded away as quickly and as mysteriously as it had appeared
- Dr. Miner was so concerned with its intensity, however, that he reported it to the U.S. Public Health Service, who published his cautionary note, but otherwise ignored it

- And there it might have ended, except for one unalterable fact – we were at war
- Flu victims can spread the disease for up to a week
- In an isolated place like Haskell County, the flu might have quickly died out after being passed back and forth among the local population

- But in wartime, people move between populations more often, and in greater numbers
- So the timing of the epidemic could not have been worse!

- Some 300 miles from Haskell County was Camp Funston, part of the huge Fort Riley military complex
- Camp Funston had a higher population than usual due to wartime training

- Because of the cold winter that year, soldiers were crowded together indoors with insufficient clothes and blankets, jammed closely around the few working stoves
- In early March, soldiers began to report to the infirmary with flu-like symptoms

- Within days, several thousand were stricken, but only 38 of them died – not enough to

quarantine the camp in wartime
- Troop movements soon spread the flu to many other army camps

- 24 of the 36 largest camps reported an outbreak of flu in the Spring of 1918, along with 30 of the country's 50 largest cities
- But it was relatively mild, if highly contagious

- The first wave of the flu was so mild, in fact, that several doctors refused to believe it was even influenza
- British doctors writing in the *Lancet*, for example, didn't think it was the flu because the symptoms were too mild, and "of very short duration and so far absent of relapses or complications."

- Soldiers from Ft. Riley were loaded onto troop ships by the thousands
- In the last six months of World War I, over 1.5 million soldiers crossed the ocean to go to war in Europe

- It was the largest such movement of people in the history of the world
- The troop ships were loaded to capacity with young men who were fated to die in the sausage-grinder of the Western Front

- But many of them were dead before they even reached the shore
- Overcrowded troop ships became terrifying charnel houses, disgorging sick and dying soldiers by the thousands

- Members of the 57th Pioneer Infantry were already ill with the flu
- As they marched from Camp Merritt, New Jersey, to board the troop ship *Leviathan*, they began to drop out of ranks
- Trucks and ambulances scooped up those too ill to continue, but the rest marched on

- By the time they reached the ship, most of them had gone 24 hours without sleep and several hours without food
- The sick and broken soldiers were hurried aboard

- 120 more were taken off the ship before it departed – they turned out to be the lucky ones
- Conditions aboard the troop ship *Leviathan*, were so bad that a detail of soldiers actually mutinied, rather than go below decks!

- Night time was the worst, as one official report describes, with
  - > "scenes which cannot be visualized by anyone who has not actually seen them…The decks became wet and slippery [with blood], groans and cries of the terrified added to the confusion of applicants clamoring for treatment, and altogether a true inferno reigned supreme"

- Of the estimated 2,000 flu victims on board, at least 70 died en route, 31 more the day it docked, and 14 more the following day

- Many of the sick soldiers fled the death ship as soon as their orders allowed, spreading the disease to fresh troops

- Hundreds more died on shore in the days that followed
- The 57th Pioneer Infantry, one of the units aboard the *Leviathan*, recorded 195 flu deaths in the few days after disembarking

- This scene was repeated over and over again throughout England and Europe
- Aboard the troop carrier *Olympic*, for example, 1,947 troops were infected, and over 140 died

- No one was prepared to deal with the thousands of sick and dying men, confined in the living hell that the troop ships became
- The flu soon spread to French and British troops
- Allied soldiers took it home to civilians when they went on leave

- The virus spread rapidly through soldiers, POW's, and civilians, spreading to Germany, Russia, China, India, Southeast Asia, and down into Spain…becoming a true global pandemic
- It was dubbed the "Spanish Flu", but only because the press started to take notice as it happened to be hitting Spain

- The records of the 88th Combat Division in France are typical…
- Total combat casualties (killed, wounded, missing, or captured) = 90 men
- Total deaths from the flu ? = 444!

- Something happened aboard those troopships, or perhaps in the foul and crowded trenches, that turned the flu into a savage killer…
- The second wave of infection was now poised to fall like a hammer blow on an unsuspecting population

- Why had this mild strain of flu suddenly become so virulent?
- Several hypotheses have been proposed:
  - > A new and entirely *different* strain had emerged
  - > Or perhaps a genetic mutation altered the original strain
  - > Or maybe two different viruses had fused together to create a new strain

- We'll briefly consider each of these three explanations
- But before we can do that, we need to take a few minutes to consider how the flu virus actually works

- Viruses are mysterious little creatures
- They generally consist of a core of RNA or DNA, surrounded by a membrane or capsule
- RNA is a single strand of genes, DNA is two complementary strands joined together in a double helix

- Unlike cells, viruses cannot replicate by themselves
- They need to take over the protein synthesis factory in a living cell, and reprogram it to make copies of the virus

- Influenza is an RNA virus, with 8 separate genes enclosed in a membrane covered with spikes
- The virus is very small, about $1/10{,}000^{th}$ of a millimeter
- Move over angels – viruses are so small that an area the size of the head of a pin could hold a *billion* of them!

- There are two kinds of spikes on the outside of the virus, called H spikes and N spikes
  - > The H spikes, hemagglutinin, cause red blood cells to clump together (agglutinate)
  - > The N spikes are a type of enzyme
- An enzyme is a catalyst, a protein that can affect the course of a chemical reaction

- We'll talk more about catalysts later on
- The short version is that it's like putting a puzzle together on a table top
- The table, the enzyme, isn't changed by the act of assembling the puzzle, and can be used over and over to help assemble more puzzles

- The immune system, in its efforts to locate invaders, looks for unique groups of amino acids (little bits of proteins) called epitopes
- Molecules or cells with epitopes in their structure or on their surface are called antigen
- We'll learn more about epitopes and antigens in our lectures on immunity

- Every organism has a different pattern of epitopes sticking out on the surface of its cells
- This is hard to visualize, because we think of cells as smooth little circles - maybe because that's the way we drew them in High School Biology lab

- But, in fact, the outer surfaces of cells are complex surfaces, with lots of little bits of molecules and compounds sticking out
- The immune system can recognize these epitopes, these little projections, as cellular ID tags, and uses them to separate self from non-self

- Both H and N spikes act as antigens, as do two proteins inside the core of the virus
- They can be readily identified by the immune system
- The two core antigens, incidentally, are the same in all type A flu viruses, and are diagnostic for type A flu

- Small changes in antigen structure are called antigenic drift, and they create very similar strains called variants
- Larger changes, called antigenic shifts, create different strains called subtypes
- It is these major antigenic shifts in H and N antigens, these new subtypes, that are responsible for new outbreaks

- When the virus attacks, it sticks to the outside of a cell by its H spikes

- The spikes lock onto a type of sialic acid sugar found on the outside of cells in the lungs and throat – they repeatedly bind to the sialic acid receptors, like a velcro strip, or like tiny pirate grappling hooks…

- And I'm told, that if you listen very carefully with a stethoscope at this stage, you can even hear the little pirate "arrhh's"
- Well, that's why flu is an upper respiratory disease
- It's designed to cling to a molecule that protrudes from cells in the throat and lungs

- Now the virus is stuck onto the outside of the cell
- The virus is absorbed into the cell, through a process of phagocytosis, in which small particles can be surrounded by the cell membrane and drawn inside, leaving the particle wrapped in a tiny bubble of cell membrane called a vesicle

- Many other kinds of viruses fuse themselves to the surface of the cell in order to inject their contents
- This strategy, however, leaves them exposed to discovery by the immune system
- By slipping inside the cell membrane intact, and by wearing the cell membrane like a wolf in sheep's clothing, the flu virus makes itself invisible to the many wandering immune system cells that are scouting the body for trouble

- Once primed inside the cell, the virus sheds its envelope, releasing its RNA genes
- Remember that what we refer to as a gene is simply a series of coded instructions along a length of DNA or RNA that codes for the assembly of a particular protein – proteins are the building blocks of life

- Each strand of RNA or DNA consists of a long series of genes, which are recipes for proteins – each separate gene is a separate recipe
- It's like taking a file card box of recipes and taping them end to end – that's how strands of DNA & RNA are built

- And, while we're on the subject - what we call a chromosome is really just a series of genes on a single very long strand of DNA, all coiled up into a tiny little packag

- Viruses contain relatively few genes – these are usually on a single strand of RNA or DNA
- But the flu virus has multiple strands of RNA, each with only one or two genes

- The RNA genes of influenza, once primed and liberated in the cell, hijack the cellular factory
- They replace some of the host cell's genes, and reprogram the cell to make thousands and thousands of copies of the flu virus

- The flu genes replicate and group together in sets of eight to form a new core, wrap each new core in a fresh membrane, and exit the cell to spread the infection
- Within ten hours of infection, the cell releases 100,000 to a million or more new flu viruses!

- But, theoretically, new viruses should become trapped as soon as they exit the cell, by the very same sialic acid receptors they stuck to on the way in
- That's where the N spikes, the neuraminidase spikes, come into play…

- They have a blunt tip, like a tiny box with four miniature propeller blades
- These "blades" slice through the receptor sites as the virus emerges from the cell, preventing it from being stuck

- Now we can better answer the question we posed earlier - why did this mild strain of flu suddenly become so virulent?
  - > Was it a new and entirely different strain?
  - > Had a genetic mutation altered the original strain?
  - > Or did two different viruses fuse together to create a new strain?

- The fact that survivors of the first wave of the 1918 Flu had some immunity to later waves, tells us that the second wave was not an entirely new strain, but an altered form of the virus that caused the first wave
- The re-energized strain might have experienced a mutation in its new host

- Mutations are alterations in genetic information, changes in the recipes that determine how proteins are put together
- And even a small change in the exterior antigens of a microbe, can cause the immune system to fail to recognize it

- The influenza virus also has an extremely high rate of mutation, making it a real genetic chameleon from the standpoint of the immune system
- DNA has a proofreading mechanism built in, which stops many mutations in their tracks when the DNA is replicated for cell division

- RNA, however, lacks the proofreading mechanism, so mutations of RNA aren't repaired or eliminated
- And that means that an RNA virus, like the flu, has a much higher mutation rate than a DNA virus, thousands and thousands of times higher – what we call hypermutability

- While mutations provide the new variation that is essential for natural selection to work on, they come with a cost
- It's like throwing a hammer into a jet engine – you might get lucky and change it for the better, but more often than not you're going to break it

- That means that as many as 99% of the newly created flu viruses are damaged, and can't infect another cell
- But it also means between 1,000 to 10,000 viruses from each infected cell can not only still infect other cells, but may now be even more lethal than before, and better able to hide from the immune system

- Mutations are thought to be the explanation for antigenic drift, small changes that create new variant forms
- But they can't adequately explain the more dangerous antigenic shifts, where the virus becomes more radically different

- Antigenic shifts, like the change that caused the second wave of the 1918 Flu to be so virulent, could result from the fusion of two different types of flu viruses (hybridization)
- That seems rather a tall order – but the way the flu virus reproduces actually makes it relatively easy

- Remember that the eight genes of the virus are on several separate strands of RNA
- If two subtypes or variants infect the same cell at the same time, each makes thousands of copies of its own eight genes, which are now all mixed up together in the same cell

- When the genes are reassembled in groups of eight to form a new core, and sealed into a fresh viral envelope, the two types can easily mix together
- So the new virus will still have all eight genes, but it will now be a random mixture of the genes of both types of the flu virus

- Only by reconstructing the virus can we determine its origin and test this hybridization hypothesis about its virulence
- We'll talk more about the hybridization hypothesis in our final lecture on the flu

- The virus could also have strengthened through passage from host to host
- It is easy to demonstrate in the lab that as a new virus infects new victims, it seems initially to strengthen with each passage
- It may be that each new passage provides an fresh opportunity for mutation or hybridization

- In the end, we just don't know where the killer flu of 1918 came from
- Perhaps the 1918 flu was born from the war itself, taking advantage of the new ecosystem presented by trench warfare

- John Oxford claims that it first emerged in a massive field hospital complex in Étaples, in north-west France, in the winter of 1915-1916
- The symptoms were like those of the later pandemic, and the area had goose, duck and pig farms that could have harbored the virus, plus 24 varieties of possibly mutagenic chemical warfare gas

- There was little doubt, however, that fall's killer flu was a close relative of the bug that had swept through the previous spring
- Survivors of the first wave of flu were moderately immune to the second wave

- The flu now struck with savage intensity
- Fevers ran so high that doctors often misdiagnosed the flu as malaria
- The usual bone and joint pains were so severe, some doctors thought they were dealing

with dengue fever, also known as breakbone fever

- Symptoms included severe earaches and headaches
- Victims often bled heavily from the nose, mouth, eyes and ears

- Lung damage was so severe that doctors compared it to the damage done by mustard gas
- Pockets of gas bubbled up under the skin from ruptured lungs

- The immune system reactions were so strong that they often created a disastrous feedback loop called a cytokine storm, the immune system version of a nuclear attack

- Cytokine storms can destroy the ability of the lungs to exchange gases
- This severe lung damage led to cyanosis, a blue coloration of the skin caused by the lack of oxygen in the blood

- Victims were stained so darkly in some cases it was hard to tell black men from white
- The extreme cyanosis fueled rumors among the soldiers that the flu was really the Black Death

- Autopsies revealed extensive damage to the lungs, heart, and brain
- Although flu is not normally associated with neurological problems, victims were often left with permanent nerve damage and even psychosis

- The 1918 Flu virus also attached to the cells lining the lungs, not just to cells in the upper respiratory cells, as it usually does (we'll learn why in our last lecture on the flu)
- This left people open to secondary lung infections, and pneumonia in the weakened flu victims was often the bigger killer

- Pneumonia can be caused by bacteria, but it's really a general term for lung damage that can be viral, bacterial, or even chemical
- Casualty figures for Fall of 1918 show the brutal power of the renewed virus in decimating the American, British, and French allied forces…

- In September, October, and November of 1918, American Expeditionary Forces recorded nearly 112,000 military hospital admissions for flu or pneumonia, with over 9,000 deaths
- French forces admitted about 132,000, with over 10,000 deaths - and British force recorded nearly 63,000 admissions with 3,600 deaths

- A total of over 307,000 flu casualties in only three months, with nearly 23,000 dead!
- And we'll never know how many thousands more died where they lay in the endless foxholes and trenches of the front
- The 8.5 million lost in the "war to end all wars" pales beside the more than 50 million lost world wide in our battle with the flu…

- Unlike earlier epidemics, which took their toll on the very young and the very old, this one took full aim at people in the prime of life

- John M. Barry estimates that 5- 10 % of the world's young adults died

- The 1918 Flu was a W curve instead of U (explain…)
- Why did so many young adults die?

- Imagine a group of young girls in 1918, playing jump rope on the sidewalk – if we listened closely, this is what we might have heard:

  > I had a little bird, Its name was Enza
  > I opened up the window and in-flu-enza

- Most authorities think that the American flu mutated into a killer in its new European population
- By late summer, this mutant or hybrid strain was poised and ready to re-enter the US

- Re-entry may have occurred Aug. 12, 1918, from passengers on the Norwegian ship *Bergensfjord*
- The liner entered New York harbor with 200 sick - four had been buried at sea.

- The sick and exposed people were so frightened, they ran down the gang plank as soon as it docked, and scattered into the New York City population

- Ms. Olsen, a passenger on the *Bergensfjor*d, was one of the first to die in America in the second wave of the flu
- Over half a million Americans followed her into the grave…

- This scene was no doubt repeated over and over again, as the flu America had sent overseas returned with a vengeance
- June 1918, the *City of Exeter* arrived from Liverpool, docking in Philadelphia with 28 ill…

- The victims from the *City of Exeter* were rushed into strict quarantine and the city was spared for a while...
- The *Somali*, arriving from India, with 89 sick crewmen, put ashore at Grosse Isle, Canada…

- Port cities and cities with large military installations were the most vulnerable
- Boston was an early target…
- One story is that a group of 106 sailors in Boston called in sick at Commonwealth Pier - 26 died, and the flu spread rapidly from there

- Camp Devens, Boston, was especially hard hit
- Col. Victor Vaughan, former AMA president, was among those sent by the army to Camp Devens to investigate the outbreak

- Vaughan saw:
  > "Hundreds of stalwart young men in the uniform of their country coming into the

> wards of the hospital in groups of ten or more. They are placed on the cots until every bed is full, yet others crowd in. Their faces soon wear a bluish cast; a distressing cough brings up the blood-stained sputum. In the morning the dead bodies are stacked about the morgue like cord wood."

- One of the first cases at Devens was a young soldier from the 42d Infantry
- He ached so badly that he screamed whenever anyone touched him!
- He was misdiagnosed with meningitis, along with several others

- In a single day at Camp Devens 1,543 soldiers reported sick
- The medical staff was soon overwhelmed
- Then the doctors and nurses started to sicken and die

- A doctor at Devens describes it:
  - > One can stand it to see one, two or twenty men die, but to see these poor devils dropping like flies…It takes special trains to carry away the dead. For several days there were no coffins and the bodies piled up something fierce…It beats any sight they ever had in France after a battle."

- From sailors and soldiers in coastal cities, the flu spread inland, following the rivers and railroads
- It ravaged the Great Lakes Naval Training Station near Chicago

- One of the nurses recalls wrapping still-living men in winding sheets and putting tags on their toes, because it saved time and they were utterly exhausted
- In her nightmares she wondered "what it would be like to be that boy who was at the bottom of the cord wood in the morgue."

- Camp Grant, near Rockford, Illinois, was jammed with over 40,000 troops
- Col. Charles Hagadorn, commander of Camp Grant decided to ignore army regulations against overcrowding

- The camp medical staff objected, but were over ruled
- The first soldier reported sick on Sept. 21st, from an infantry training group that included officers from Camp Devens

- Within a week he was joined by 4,102 other soldiers
- 1,810 soldiers reported sick in a single day!
- The same day that the first soldier died of flu at Camp Grant, Hagadorn ordered a crowded troop train to leave Camp Grant for Camp Hancock, near Augusta, Georgia

- He ignored demands for a quarantine of the camp
- Hundreds of men were packed into each car, and the flu spread rapidly on board the overcrowded train

- 2,000 of the 3,108 soldiers on that train got the flu, with a death rate estimated at over 10%

- When the death toll at Camp Hancock passed 450 men, Col. Hagadorn instructed his staff to clear the building, shut himself in his office, and shot himself

- One of the reasons the flu was so terrifying at the time is that no one had any real idea of what caused it

- Researchers followed several bacterial dead ends
- In the wake of the 1889-1890 flu pandemic, Dr. Richard Pfeiffer had isolated a new species of bacterium which he called *Bacterium influenzae*, also known as Pfeiffer's bacillus

- Now known as *Hemophilus influenzae,* the bacterium was thought by many, including the Public Health Service, to be the causative agent
- The bacterium could kill its hosts in the lab, but the symptoms it caused were not quite identical to those of influenza

- Nevertheless, Pfeiffer insisted he had found the culprit, and his sterling reputation and high standing in the scientific community managed to convince many of his colleagues that he was correct

- Despite improved culture techniques, however, the bacterium was not always present in flu victims, and was usually found together with several other pathogens

- By 1919 the bacterial hypothesis had been rejected, and researchers concluded that whatever the cause, it must be viral
- That was a controversial conclusion, because it was based entirely on negative evidence, the gradual elimination of all the alternative hypotheses

- Remember that viruses were still a big mystery in 1918
- The first influenza virus wasn't isolated, and observed, until 1934
- The first flu vaccinations weren't until 1944

- So, was the whole thing a fiendish German plot?!
- Maybe German spies had mined Boston Harbor with "influenza-sprouting germs"
- Maybe it was started by Germans put ashore from U-Boats, setting germs loose in theaters and other public places
- There was no cure - even secondary bacterial infections like bacterial pneumonia were untreatable – sulfa drugs and antibiotics had not yet invented yet
- Medical treatment consisted mostly in comforting, and, whenever possible, isolating the patient – basic nursing

- Treatments included:
    - Bleeding (!), saline or glucose injections, enemas, alcohol, camphor oil, heroin, morphine, mustard plasters, castor oil, sulfur smoke, lard mixed with camphor and chloroform, or lard mixed with turpentine

- Public health responses included:

- > Fumigation of trains, buses, passengers and luggage, urging people to wear gauze masks, campaigns against spitting and sneezing, warnings about public gatherings, and a general prescription of rest, fresh air, and reporting of cases to the authorities

- Folk cures included:
  - > stuffing salt up children's noses, magic charms, wearing goose grease poultices, hanging bags of garlic or onions around your neck, and gargling with disinfectants
- "Snake oil" salesmen were everywhere…

- By mid-October the full, tragic potential of the epidemic had been realized
- Many American cities and towns were hard hit, with unprecedented mortality rates
- Families were devastated, and all public life ground to a halt

- William Sardo, of Washington DC, says:
  - > "People were afraid to kiss one another, to eat with one another, they were afraid to have anything that made contact because that's how you got the flu…You were constantly afraid, you were afraid because you saw so much death around you…It wiped out entire families from the time that the day began in the morning to bedtime at night…There was an aura of constant fear…"

- An Ottawa newspaper writes:
  - > "Street cars rattled down Banks Street with windows open and plenty of room inside. Schools, vaudeville theaters, movie palaces are dark; pool halls and bowling alleys deserted."

- All across America, in the aftermath of the flu, the fate of the survivors became a major problem
- Many families were impoverished, with one or more bread winners sick or dead

- The flu left behind a world filled with widows and orphans – 21,000 orphans in New York City alone!
- The third and final wave followed in late 1918 and into 1919
- The flu seems to have gradually mutated into weaker strains – the third wave was short and sharp, but mild compared to the killer second wave

- The final toll was grim
- Estimates of American dead run to 675,000, out of a population of 105 million!
- Britain lost 228,000 to the flu
- The best global estimate is 50-100 million dead, out of 1.8 billion (from Nobel laureate and flu expert Dr. Macfarlane Burnet)

- Everyone on Earth at one time was probably exposed to virus
- Those who survived the infection formed an immune reaction
- In the end, the virus had no place left to go – it could not maintain itself in the human population

- Fortunately for the flu virus, it doesn't need humanity to sustain itself
- Birds are usually its primary host, and as long as bird populations are healthy, the flu will always find a home

- At the height of the second wave, Victor Vaughan nearly lost hope, writing that
  > "If the epidemic continues its mathematical rate of acceleration, civilization could easily disappear from the face of the earth within a matter of a few more weeks"

- But by late November 1918, the crest of influenza deaths had past
- It was the worst epidemic in the history of mankind…

- What can we do if this killer virus returns?
- In our next lecture we'll wrap ourselves in the cloak of Sherlock Holmes, and follow the trail of one of the most curious detective stories of modern times – the search to recover an intact flu virus, a discovery that could help prevent the next pandemic

- We'll also learn how the 1918 flu may have helped set the stage for WWII, by infecting President Wilson at a critical stage of the peace talks