Influenza: Swine and Avian Flu Lecture Notes
Biol 100 – K. Marr

- Reading assignments in Essential Biology
  - Chapter 10: Viruses (pp. 189 – 195)
- Optional Reading
  - Novel H1N1 Flu Situation Update: http://www.cdc.gov/H1N1flu/update.htm
  - Questions & Answers: H1N1 Flu (Swine Flu) and You: http://www.cdc.gov/H1N1flu/qa.htm

- Genetic material (DNA or RNA) surrounded by a protein coat
- No cellular structure
- No cell organelles
- Exhibit some but not all characteristics of living organisms
- Can’t carry out metabolism or reproduce by itself
- Can only reproduce inside a host cell

What is a virus?

- Viruses — genes in packages!
  - Very small — about the size of a ribosome
  - Millions could fit on the head of a pin
- Viruses sit on the fence between life and nonlife

Importance of Viruses

1. Cause many diseases in plants, animals & humans
   - Some viruses are easily controlled with a vaccine — Why?
     - Mumps, Measles, Smallpox, Polio
   - Some viruses are difficult to control with a vaccine — Why?
     - Common cold, Influenza (Flu), HIV

2. Used as vectors in biotechnology
   - Used to insert therapeutic genes into a host cell chromosome
   - Use viruses with provirus in life cycle

Herpes (DNA Virus)
- Cold sores
- Herpes virus may rest inactive inside host cells for long periods

Adenovirus (DNA Virus)
- Adenoviruses cause various respiratory diseases
- Electron micrograph of Human Adenovirus (27,000x)

Polio Virus (ssRNA serves as mRNA)
- Polio is easily prevented with a vaccine — Why?
Measles (ssRNA template for mRNA synthesis)

Measles: a childhood disease that can be prevented with a vaccine—why?

Couple at AIDS quilt (HIV: ssRNA \(\rightarrow\) dsDNA)

HIV is very difficult to control with a vaccine—why?

1918 Influenza epidemic (ssRNA template for mRNA synthesis)

Influenza Today

- 250,000 to 500,000 deaths globally/yr.
- 36,000 deaths and >200,000 hospitalizations/yr. in U.S.
- $37.5 billion in economic costs/yr. in U.S. related to influenza and pneumonia.
- Ever-present threat of pandemic influenza.

Sources: CDC, WHO, Am. Lung. Assoc.

Flu pandemics occurred in 1889, 1900, 1918, 1957, 1968, and 1977

- Pandemics occur every 10–50 years
- From 20 to 40% of population is infected
- Projections for the next pandemic in USA:
  - 207,000 deaths, 734,000 hospitalizations, 42 million outpatient visits
- Estimated economic impact: $70-170 billion

Now enter ...
H5NI: the avian flu virus
H1N1: the swine flu virus

What is H1N1 (swine flu)?

Source: http://www.cdc.gov/H1N1flu/qa.htm (accessed 5/28/09)

- A new virus causing illness in people
  - 1st detected in people in the U.S. in April 2009
- Other countries, including Mexico and Canada, have reported people sick with this new virus.
- Spreading from person-to-person
  - probably in the same way as the seasonal influenza virus
  - Not known how easily the virus spreads between people
  - Not known at this time how severe this new H1N1 flu virus will be in the general population
- As of May 27, 2009: 11 deaths out of 7927 confirmed cases in the U.S.

(Source: http://www.cdc.gov/h1n1flu/update.htm)
Why is this new H1N1 virus sometimes called “swine flu”?

Source: http://www.cdc.gov/H1N1flu/qa.htm (accessed 5/28/09)

• Because many of its genes are similar to influenza viruses found in pigs. But…
  – this new virus is very different from the normal virus found in North American pigs.

• The new virus has…
  – two genes from flu viruses found in pigs in Europe and Asia, avian genes and human genes.
  • Scientists call this a “quadruple reassortant” virus.

Why do new strains of influenza and bird flu usually arise in Asia?

Generation of a Pandemic Influenza Strain

Antigenic shift is due to genome reassortment within intermediate hosts drives flu epidemics and pandemics

Source: www.cdc.gov/eid Vol. 12, No. 1, Jan. 2006

Background: Influenza Virus Structure

1. Flu viruses are named by the type of surface proteins
   a. Hemagglutinin
      • Helps virus enter cell
      • Type A infects humans, birds and pigs
      • Type A has ~20 different subtypes

Flu Viruses Currently infecting...
   • Humans: H1N1, H1N2, and H3N2
   • Avian Flu Virus: H5N1

2. Named for the type of surface proteins
   a. Neuraminidase
      • Helps virus exit cell
      • 9 subtypes

   b. Currently infecting Humans: H1N1, H1N2, and H3N2

3. Influenza viral genome
   • ssRNA
   • 8 segments (pieces)
   • One gene per segment

Avian Flu Virus: H5N1
   • Transmitted from birds to humans
   • No evidence of human to human transmission
   • Antiviral drugs: Tamiflu
      – a neuraminidase inhibitor
      – Consequences of its action?
Genetic Changes in Influenza Viruses

1. **Antigenic drift** – due to errors in replication and lack of repair mechanism (i.e. no proofreading) to correct errors
   - Results in ____________ changes

2. **Antigenic shift** - reassortment of genetic materials when concurrent infection of different strains occurs
   - Results in ____________ changes

Emergence of New Influenza Subtypes

**Antigenic shift** is due to genome reassortment within intermediate hosts drives flu epidemics and pandemics

Where do the “new flu” viruses come from?

**Antigenic Drift**: mutations result in changes to the Hemagglutinin (HA) molecules

- RNA replication is error prone
- New HA types are created frequently
- Requires new vaccine every “season”
- What is a vaccine?

Vaccines: Protection against viruses

1. **What is a vaccine?**
   - Made of a weakened or killed pathogen (e.g. bacterium or virus) or a portion of the pathogen’s structure
   - Stimulates antibody production or cellular immunity against the pathogen

2. **Vaccines stimulate the production of memory cells**
   - Give long-term protection against a specific antigen

3. **Why are vaccines ineffective against the flu virus?**
   - Why will this year’s flu vaccine be ineffective next year?

4. **Why are vaccines effective against DNA viruses?**
   - e.g. small pox

Smallpox

(dsDNA → dsDNA)

Smallpox has been irradiated worldwide due to a very successful vaccine

Why are vaccines for DNA viruses so successful?