Viruses and Vaccines

- Modern medicine has developed **vaccines**, harmless variants or derivatives of pathogenic microbes, that stimulate the immune system to mount defenses against the actual pathogen.

- The first vaccine was developed in the late 1700s by Edward Jenner to fight smallpox.

  - Jenner learned from his patients that milkmaids who had contracted cowpox, a milder disease that usually infects cows, were resistant to smallpox.

  - In his famous experiment in 1796, Jenner infected a farmboy with cowpox, acquired from the sore of a milkmaid with the disease.

  - When exposed to smallpox, the boy resisted the disease.

  - Because of their similarities, vaccination with the cowpox virus sensitizes the immune system to react vigorously if exposed to actual smallpox virus.

- Effective vaccines against many other viruses exist.

- Vaccines can help prevent viral infections, but they can do little to cure most viral infection once they occur.

- Antibiotics which can kill bacteria by inhibiting enzymes or processes specific to bacteria are powerless against viruses, which have few or no enzymes of their own.

- Some recently-developed drugs do combat some viruses, mostly by interfering with viral nucleic acid synthesis.

  - AZT interferes with reverse transcriptase of HIV.

- In recent years, several very dangerous "***emergent viruses***" have risen to prominence.

  - HIV, the AIDS virus, seemed to appear suddenly in the early 1980s.

  - Each year new strains of influenza virus cause millions to miss work or class, and deaths are not uncommon.

  - The deadly Ebola virus has caused hemorrhagic fevers in central Africa periodically since 1976.

  - The emergence of these new viral diseases is due to three processes: mutation, spread of existing viruses from one species to another, and dissemination of a viral disease from a small, isolated population.

- Mutation of existing viruses is a major source of new viral diseases.
  - RNA viruses tend to have high mutation rates because replication of their nucleic acid lacks proofreading.
  - Some mutations create new viral strains with sufficient genetic differences from earlier strains that they can infect individuals who had acquired immunity to these earlier strains.
    - This is the case in flu epidemics.
- Another source of new viral diseases is the spread of existing viruses from one host species to another.
- It is estimated that about three-quarters of new human diseases have originated in other animals.
  - For example, hantavirus, which killed dozens of people in 1993, normally infects rodents, especially deer mice.
  - That year unusually wet weather in the southwestern U.S. increased the mice's food, exploding its populations.
  - Humans acquired hantavirus when they inhaled dust containing traces of urine and feces from infected mice.
- Finally, a viral disease can spread from a small, isolated population to a widespread epidemic.
  - For example, AIDS went unnamed and virtually unnoticed for decades before spreading around the world.

Viruses and Cancer

- Since 1911, when Peyton Rous discovered that a virus causes cancer in chickens, scientists have recognized that some viruses cause animal cancers.
- These *tumor viruses* include retrovirus, papovavirus, adenovirus, and herpesvirus types.
- Viruses appear to cause certain human cancers.
  - The hepatitis B virus is associated with liver cancer.
  - The Epstein-Barr virus, which causes infectious mononucleosis, has been linked to several types of cancer in parts of Africa, notably Burkitt's lymphoma.
  - Papilloma viruses are associated with cervical cancers.
  - The HTLV-1 retrovirus causes a type of adult leukemia.
- All tumor viruses transform cells into cancer cells after integration of the viral nucleic acid into host DNA.
  - Viruses may carry genes that are directly involved in triggering cancerous characteristics in cells. These genes are called *oncogenes.*
  - These oncogenes are often versions of *proto-oncogenes* that influence the cell cycle in normal cells.
  - Proto-oncogenes generally code for growth factors or proteins involved in growth factor function.
  - In other cases, a tumor virus transforms a cell by turning on or increasing the expression of proto-oncogenes.
- It is likely that most tumor viruses cause cancer only in combination with other mutagenic events (exposure to mutagens, mistakes in DNA replication or repair).

Viroids and prions are infectious agents even simpler than viruses

- **Viroids**, smaller and simpler than even viruses, consist of tiny molecules of naked circular RNA that infect plants.
- Their several hundred nucleotides do not encode for proteins but can be replicated by the host's cellular enzymes.
- These RNA molecules can disrupt plant metabolism and stunt plant growth, perhaps by causing errors in the regulatory systems that control plant growth.
- **Prions** are infectious *proteins* that spread a disease.
  - They appear to cause several degenerative brain diseases including scrapie in sheep, "mad cow disease", and Creutzfeldt-Jacob disease in humans.
- According to the leading hypothesis, a prion is a misfolded form of a normal brain protein.
- It can then convert a normal protein into the prion version, creating a chain reaction that increases their numbers.

Viruses may have evolved from other mobile genetic elements

- Viruses are caught up in the definition between life and nonlife.
- An isolated virus is biologically inert and yet it has a genetic program written in the universal language of life.
- Although viruses are obligate intracellular parasites that cannot reproduce independently, it is hard to deny their evolutionary connection to the living world.
- Because viruses depend on cells for their own propagation, it is reasonable to assume that they evolved *after* the first cells appeared.
- Most molecular biologists favor the hypothesis that viruses originated from fragments of cellular nucleic acids that could move from one cell to another.
- Candidates for the original sources of viral genomes include plasmids and transposons.
  - Plasmids are small, circular DNA molecules that are separate from chromosomes.
  - Plasmids, found in bacteria and in the eukaryote yeast, can replicate independently of the rest of the cell and are occasionally be transferred between cells.
  - Transposons are DNA segments that can move from one location to another within a cell's genome.
- Both plasmids and transposons are mobile genetic elements.