Viruses - General

not living

strict parasites

infectious particles of nucleic acid enclosed in protein layer.

infect virtually every form of life, every kingdom

too small to see with regular microscope: smallest is 20nm – millions could fit on head of pin

symptoms range from very mild (asymptomatic) to lethal

acute to chronic infections

many are childhood diseases, self limiting

others remain a lifetime

**History:**

remained part of the invisible world until late 1800’s

1880’s: Pasteur knew that rabies was caused by something smaller than bacteria

1890’s: viruses were first isolated

viruses crystallized in 1930’s

life doesn’t crystallize, cannot be living organisms

viruses first seen in 1940’s with newly invented electron microscope

most of our knowledge of viruses has come in the last 50 years

**Structural Characteristics**

size: 20 – 14000 nm (0.2 – 14 µm) (bacteria 1-10µm; protists 50-100µm)

viruses contain a single kind of nucleic acid

   can be circular, linear or in several separate segments

genome can be DNA or RNA, never both

only a few genes: smallest have 4, largest 100’s of genes (bacteria E. coli 16
few 1000 to 250,000 pairs of nucleotides
   (E. coli => 4M pairs)

they use the synthesis machinery and enzymes of host cells to reproduce

viruses have few or no enzymes of their own:
   polymerase for syn of nucleic acid
   enzymes to digest host DNA or proteins

capsid or protein shell surrounds the nucleic acid

makes up most of the mass of the virus particles

consists of subunits = capsomeres

usually result in helical or icosahedral shape

many different shapes of capsids: spherical, elongated, icosahedral, lunar lander, etc

some covered with viral envelope – derived from membrane of host cell

layer of host cell membrane “buds off” when viruses emerge

original host proteins are replaced with viral proteins

envelope may or not be covered with spikes (CHO-Protein complexes)
   for attachment
   cause clumping of RBC’s = hemagglutination

Isolation, Cultivation and Identification

difficult to propagate

can only be grown with host cells – difficult to study

need tissue cultures or whole organisms

   tissue culture – produce “plaques”
   brain, blood, muscle, skin, etc
   often use “continuous cell lines”=cancer cells
   must be kept free of contamination

   embryonated eggs
animals: mice, rats, hamsters, rabbits, primates,
inverts: mosquitoes

many difficulties:
HIV infects some animals but doesn’t produce symptoms of disease

can genetically engineer animal to be human model
eg. mouse with human T-cells & gamma globulin

Life Cycle

Two basic reproductive cycles: lytic & lysogenic

1. attachment
   onto specific host cell

2. penetration
   either by injection of nucleic acid
   injection can be by
     a. hypodermic like
     b. enzymes may dissolve a hole in cell membrane of host
     c. entire virus particle gets taken in by phagocytosis triggered by virus

3. biosynthesis
   of virus parts and construction of virus particles
   host protein synthesis is stopped
   then virus has host make proteins to:
     seal cell puncture wound
     copy viral genome
     make capsid proteins
     produce enzymes for lysis of host
   almost all viral genes code for enzymes needed to replicate and produce
   viral nucleic acids and proteins
   enzymes needed for protein synthesis, ribosomes, energy production are
   supplied by host cell

4. Assembly (Maturation)
   the complete virus particle (=virion) is put together

5. lysis
   or release of virus and death of host cell
   sometimes uses lysozyme produced by host cell
   a single virus can give rise to up to 1000 new virus particles from on host cell
   (average = 50-200 (=burst size))

duration of viral life cycle in host cell (=burst time)
averages 20-40 minutes

eg. polio: 6-8hrs
eg. herpes: 12-30min

some viruses remain dormant for a time in host cell and become part of the hosts genome temporarily (lysogenic life cycle)

**Origin of viruses**

since they are intracellular parasites they must have evolved after the first cells

some believe them to be highly degenerate bacteria

or may have originated from pieces of genome of host cells

a viral genome usually has more in common with genome of its host than the genome of viruses infecting other hosts

most likely candidates for source of viral genomes: plasmids and transposons

all three are mobile genetic elements

**Examples of Viruses**

1. **Rabies**

   animal disease = zoonosis

   long incubation time, can be vaccinated after exposure

   travels along nerves

   symptoms: first: mild then muscle spasms
   esp in face and neck; final – extensive

   brain damage and death

2. **Herpes**

   lifetime infection

   very high infection rate – 90% infected in US

   two major forms cold sores and genital herpes
both can occur in either area
relative of chicken pox and epstein barr viruses
humans are only host
symptoms alternate with latency when virus “hides” in nerves
symptoms often exhibit during stress, less frequent with age
especially dangerous for pregnant women

3. HIV/AIDS

first recognized in US in early 80’s
originated in central Africa
mutated from common primate virus
10’s of millions worldwide are infected
in past couple of years incidence and death rate has decreased in US, but still a
very deadly disease in the rest of the world
Its virulence is due to the fact that it infects the T-cells of the immune system –
these are the cells that control the entire system, if they are knocked out the immune system fails
Requires direct contact with body fluids; sexually transmitted, needles, mothers milk
Can’t get it from kissing, touching, sharing utensils, etc
Incubation period lasts years before AIDS symptoms appear
symptoms begin with flu-like symptoms, then fever, fatigue, swollen glands, etc
eventually the immune system is immobilized and various infections and cancers set in
4. Some viruses cause cancer

~100’s different kinds of cancer

numerous causes: genetic, chemicals, viruses

viral causes – not contagious

eg. Epstein Barr virus: mononucleosus → lymphatic cancer
   90% of US carry latent stage of this virus in WBC’s with no signs of disease

eg. Hepatitis B virus → implicated in liver cancers

eg. HTLV 1&2 → leukemia

5. Bacteriophages (bacteria viruses)
   are being looked at as a way to treat some bacterial infections without the use of antibiotics, to which many bacterial are becoming resistant.
Prions and Viroids

even viruses are not the smallest infectious particles around.

viroids $\rightarrow$ naked RNA molecules
  - no capsid
  - no coatings
  $\{ =$ disease causing molecules

prions $\rightarrow$ pieces of proteins
  - no nucleic acids involved

Viroids

so far only infect plants:
  - tomatoes, potatoes, cucumbers, citrus trees, chrysanthemums
  eg. killed 12 million coconut trees in Philippines
  eg. in 50’s killed most of the chrysanthemums in US

about a dozen known viroids

0.1$^{th}$ the genetic material of the smallest virus (350 bases)

  eg. if bases were 1 mm wide:
    - human sperm $\rightarrow$ 1800 miles
    - T2 virus $\rightarrow$ 2 football fields
    - viroids $\rightarrow$ 1 foot long

too small to encode for even a single enzyme

don’t know how they work
  $\rightarrow$ may affect editing or control molecules

no one has been able to isolate an animal viroid

but some think they may be involved in animal diseases like:
  - arthritis
  - encephalopathies
  - cancerous lymphomas

Prions

“slow viruses”
  $\rightarrow$ long term but typically fatal
not really virus $\rightarrow$ protein fragments

cause 8 known animal diseases

all 8 are neurological diseases:
cause mental derangement
loss of muscle control
progressive and fatal

eg. kuru
    New Guinea – eat brain to spread disease

eg. Creutzfeldt-Jakob disease (= Mad Cow Disease)
    spread cow to cow in animal feed that contains ground brains
        from infected animals
    spread to humans in infected meat (hamburger)

eg. scrapie
    in sheep

eg. Gerstmann-Straussler syndrome