BIOLOGICAL DIVERSITY
CHAPTER 27: VIRUSES (text)
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27.1 The Nature of Viruses

- all viruses have the same basic structure
  - core of nucleic acid (RNA or DNA) surrounded by a protein
  - no cytoplasm, NOT a cell
- viruses are classified by the nature of their genomes
  - RNA viruses
  - DNA viruses
  - retroviruses

Viruses are strands of nucleic acids encased in a protein coat

- capsid: a protein sheath around the nucleic acid core (composed of one to a few different protein molecules repeated many times
  - capsomeres: repeating protein molecules
- in some viruses, special enzymes are stored with the nucleic acid inside of the capsid (ex. reverse transcriptase)
- many viruses have an envelope surrounding the capsid that is rich in proteins, lipids, and glycoproteins
  - lipids found in envelope are derived from host cell
  - proteins found in viral envelope are virally encoded

Viral hosts include virtually every kind of organism

- viruses infect everything (fungal cells, bacterial cells, protists, and cells of plants and animals)
  - however, viruses can replicate in only a very limited number of cell types
- host range: suitable cells for a particular virus
- tissue tropism: once inside a multicellular host, viruses will only target a specific set of ells
- viruses remain dormant until specific environmental trigger causes their expression

Viruses replicate by taking over host machinery

- viruses can only reproduce inside of a host cell
  - when they are outside of the cell, they are referred as "virions"
- viruses lack the necessary parts for replication on their own
  - no ribosomes or enzymes for protein synthesis
  - mostly no enzymes for nucleic acid reproduction
- viruses hijack a host cell's transcription and translation systems to produce viral proteins

Most viruses come in two simple shapes

- icosahedron: structure with 20 equilateral triangular facets
  - most animal viruses are icosahedral
- helical: rod-like or thread-like appearance
- some envelope viruses are polymorphic (without definite shape)

Viral genomes exhibit great variation

- genomes vary in nucleic acid carried and the number of strands
- RNA viruses
    - single stranded
    - replicated and assembled in the cytosol of infected eukaryotic cells
    - replication is error-prone
        - high rates of mutation*
    - difficult targets for immune systems, vaccines, and antiviral drugs
    - retroviruses have reverse transcriptase
        - reverse transcriptase: enzyme that reverse transcribes RNA genome into DNA
            - this DNA is integrated into the host's chromosomal DNA
            - ex. HIV (human immunodeficiency virus)
- DNA viruses
    - mostly double stranded
    - DNA is replicated in the nucleus of eukaryotic host cells

27.2 Bacteriophage: Bacterial Viruses

- bacteriophage: virus that infect bacteria
    - structurally and functionally diverse
    - bacterial hosts
    - DNA viruses

Archaeal viruses have diverse morphologies

- DNA genomes
- unrelated to bacteriophages
- found in extreme conditions with extreme archaea

Bacterial viruses exhibit two reproductive cycles

- during infection, one whisker or tail fiber contacts the protein of bacterial cell wall
- other whiskers set bacteriophage perpendicular to the host cell and then bring the base plate into contact with the bacterium's surface
- Contact with the host
    - different bacteriophages target different parts of the surface of bacteria
    - **first step** is attachment (bacteriophage attaches to the host bacterium)
    - **second**, DNA is injected into the bacterium cytoplasm
    - once inside of the cell, (**third step**) synthesis occurs; a bacteriophage may take over the replication and protein synthesis enzymes in order to synthesize viral parts
    - **fourth**, during assembly, the components that were made are put together
    - finally (**fifth stage**) the virus particles are released through enzymes that lyse the cell or budding through host cell wall
- The lytic cycle
    - similar to the above steps, but the cell is ruptured, or lysed, at the end of the process
    - ends with cell death
    - these types of bacteriophages are called virulent or lytic
- The lysogenic cycle
    - some bacteriophages do not immediately kill the cells they infect
        - called lysogenic, temperate
    - integration of nucleic acid into genome of host bacterium

        - advantage because virus will replicate as long as host cell is replicating
        - DNA segment that is integrated into the genome is called a prophage
        - resulting cell is called a lysogen
    - after penetration and the DNA is injected into the bacterial host, there is integration of the DNA into the host genome
    - propagation occurs when prophage is replicated along with the host genome
        - reproduction of lysogenic bacteria
    - cell stress (such as starvation) can push a prophage into induction
        - when lysogenic prophage leaves the lysogenic cycle and goes into the lytic cycle
            - requires turning on the gene expression required for the lytic cycle
            - induction takes advantage of host proteins that respond to stress into producing protease: enzyme that destroys the repressor protein that is keeping the viral genome silent (the repressor protein that controls DNA repair genes)

Bacteriophage can contribute genes to the host genome

- during integration, some viral genes may be expressed while host genes are being expressed
- phage conversion: when phenotype or characteristics of lysogenic bacterium is changed by the prophage integration

27.3 Human Immunodeficiency Virus (HIV)

HIV infection compromises the host immune system

- HIV specifically targets macrophages and CD4+ cells (type of helper T-lymphocyte cell)
    - without these cells, body cannot fight off infections
        - ultimately leads to death

HIV infects key immune-system cells

- viral glycoprotein gp120 fits on the cell-surface marker protein CD4+ on macrophages and T cells
    - HIV attaches to the two receptors (CD4+ and CCR5
    - receptor-mediated endocytosis is activated
    - HIV particle enters cell
- inside of cell, protective coat is shed and viral RNA and reverse transcriptase are released into the cytoplasm
    - reverse transcriptase makes double stranded DNA that compliments the viral RNA
        - this may be incorporated into the host genome as a provirus
- replicated viruses are budded off the cell by exocytosis
- HIV has a high mutation rate because reverse transcriptase is much less accurate than DNA polymerases
    - mutations lead to altered glycoprotein gp120 that now binds to CXCR4 receptor only found on CD4+ cells
        - rapid decline in T cells and immune response

AIDS treatment targets different phases of the HIV life cycle

- drugs work to target reverse transcriptase, viral entry, and integration of the genome
    - most approved drugs are reverse transcriptase and protease inhibitors

Vaccine development for HIV has been unsuccessful

- attempts against HIV subunits have failed