Virus

An infectious particle composed of a small chromosome surrounded by a capsid (protein coat)

• The chromosome can be DNA or RNA, double-stranded or singled-stranded

• In some viruses, the capsid is surrounded by a membrane (called the envelope)

Viral reproduction

Viruses have no metabolism, no organelles, and no method of reproducing by themselves. They reproduce only by entering a cell and the cell making copies of the virus.

• The virus attaches to membrane proteins on the host cell

√ The "lock and key" specificity of the attachment limits the host range of the virus (the different types of cells it can infect) to certain species and/or tissues

√ For some viruses, only the chromosome enters the host cell

√ For other viruses, the entire virus enters by endocytosis

• Once inside the cell, the virus can reproduce by two pathways: The lytic cycle or the lysogenic cycle

The lytic cycle

A viral reproductive pathway where the cell actively reproduces the virus, usually to such an extent that the cell bursts

• For viruses with DNA chromosomes, enzymes from the host cell expresses the viral genes and replicate the viral chromosome

√ Example viral genes: Capsid proteins

• For viruses with RNA chromosomes, the virus must provide enzymes to help the cell host cell expresses the viral genes and to replicate the viral chromosome

√ Example: Some RNA viruses provide an enzyme that makes a complementary RNA from the RNA chromosome.

- This complementary RNA serves as mRNA for viral genes and as a template to replicate the viral chromosome

√ Example: Some RNA viruses (called Retroviruses) provide an enzyme called reverse transcriptase that makes a complementary DNA from the RNA chromosome.

- This cDNA moves into the host nucleus and inserts itself into the host chromosome. The host enzymes make cRNAs that serve as mRNAs for viral proteins and as copies of the viral chromosome

The lysogenic cycle (latency)

A viral reproductive pathway where the viral chromosome inserts itself into the host cell chromosome then enters a period of little or no activity (little if any gene expression, few if any viruses exit the cell).

• The viral genes are replicated with the host's chromosomes whenever the host cell divides

√ Only retroviruses and certain DNA viruses can reproduce in this way

• The cell remains alive and functioning

√ The virus can remain inactive for years

√ The viral DNA is called a provirus or a prophage

• Certain conditions can cause the virus to begin actively reproducing again (to become lytic)

√ Ex: Radiation, certain chemicals, stress on the host

Prokaryotes (bacteria and archaea)

Organisms that lack a nucleus around their DNA

- All are unicellular and have a single circular chromosome
- The first life forms on earth
- The most numerous life forms
- The most diverse in habitat and metabolism
- Capable of rapid reproduction by binary fission (cell division immediately after DNA replication)
  - √ They do not have sexual reproduction

Archaea

Prokaryotes that have cells walls and cell membranes that made of different molecules than those of bacteria

Most archaea live in extreme environments

• Thermophiles =Archaea that live at high temperatures

• Acidophiles = Archaea that live at acidic pH

• Halophiles = Archaea that live in high salt environments

• Methanogens = Archaea that live only in anaerobic environments (places without oxygen)

√ Methanogens make methane, a flammable gas, by decomposing plant and animal wastes

Bacteria

Prokaryotes that have cells walls and cell membranes that made of different molecules than those of archaea

• Bacteria are found in almost all environments

• The cell wall of bacteria is made of peptidoglycan (chains of sugars cross-linked by short polypeptides).

√ The cell wall thickness is used as a classification method for bacteria

√ Thick wall = Stained purple by Grams stain (Gram positive bacteria)

√ Thin wall = Stained pink by Grams stain (Gram negative bacteria)

• Although all bacteria are unicellular, some are filamentous (linked into long strands)

• Many bacteria are beneficial:

- Cyanobacteria = Perform photosynthesis
- Decomposers = Break down dead matter to recycle nutrients in ecosystems
- N_2 fixing bacteria = Convert nitrogen gas in air into a form plants can use to make proteins and DNA

Some bacteria are pathogenic (disease causing)

- Cholera (in water contaminated with animal wastes)
- Salmonella (on some raw meats)
- Pneumonia (infects the lungs)

Bacteria have a single circular chromosome

- A typical bacteria has a few thousand genes on its chromosome

  √ A bacteria may also have plasmids (small circular pieces of DNA with fewer than 100 genes)

- Bacteria reproduce by binary fission (The chromosome duplicates, then the cell divides)

  √ This is asexual reproduction (daughter cells have same genes as mother cells)

- Genes can pass from one bacteria to another

  √ There are three methods of gene transfer between bacteria: Transformation, Transduction, and Conjugation

Transformation

When a bacteria takes in naked foreign DNA and incorporates it into its chromosome

- Many bacteria have membrane transport proteins to bring in foreign DNA

Transduction

When a bacteriophage virus transfers genes between bacterial cells

- Occasionally a bacteriophage in a cell will accidentally package host cell DNA into a capsid

- When the abnormal bacteriophage infects another cell, that bacteria will receive the genes from the old bacteria

Conjugation

When one bacteria transfers DNA to another bacteria by making a sex pilus (a temporary structure that links the two cells together and establishes a bridge between their cytoplasms)

• F factor = The group of genes enable a bacteria to form a sex pilus and the transfer the F factor DNA to another bacteria

√ Bacteria with the F factor are called “F+” or “hfr”. Bacteria without the F actor are called “F-“.

• The F factor can be located on a bacteria’s chromosome or on one of its plasmids

• The F+ bacteria uses its sex pilus to link to an F- bacteria and transfer DNA to the F- bacteria. The transferred DNA always includes the F factor, so the F- bacteria becomes F+.

√ If the F factor is on the chromosome, genes located near the F factor on the chromosome can be transferred along with the F factor

Operon

A region of the bacterial chromosome that contains several genes (usually for the same metabolic pathway), a promoter, and an operator

- When RNA Polymerase binds to the promoter, an mRNA containing all the genes in the operon is transcribed
- Transcription of the operon can be shut down by a repressor protein
    - √ The repressor protein binds to a sequence in the promoter called the operator
    - √ Once bound, the repressor protein stops transcription by blocking RNA Polymerase from attaching to the promoter

Repressor protein

A protein that stops transcription by blocking RNA Polymerase from attaching to the promoter

- Repressor proteins have a binding site for the operator (a sequence within the promoter)

  √ When the repressor is bound to the operator, transcription is off

  √ When the repressor is not bound to the operator, transcription is on

- The repressor's ability to bind the operator can be changed by small molecules that are allosteric regulators of the repressor

- Some repressors are unable to bind the operator unless they are allosterically activated by a co-repressor

  √ Co-repressor = A small molecule (usually the end product of the operon's metabolic pathway) that activates the repressor

  √ Example: The amino acid Tryptophan is a co-repressor that activates the repressor protein of the Trp operon (the operon that makes tryptophan)

- Some repressors bind the operator unless they are allosterically inhibited by an inducer

  √ Inducer = A small molecule (usually the beginning substrate of the operon's metabolic pathway) that inhibits the repressor

  √ Example: The disaccharide Lactose is an inducer that inhibits the repressor protein of the Lac operon (the operon that allows bacteria to use lactose as an energy source)

Activator protein

A protein that increases transcription by helping RNA Polymerase attach to the promoter

- Activator proteins have a binding site for the promoter
  - √ When the activator is bound to the promoter, transcription is on
  - √ When the activator is not bound to the promoter, transcription is off
  - √ Example: The CAP protein is an activator protein of the Lac operon.
- The activator's ability to bind the promoter can be changed by small molecules that are allosteric activators of the activator protein
  - √ Example: The CAP protein is activated by cAMP, a small molecule that is only present when the cell is starving for glucose