Chapter 2:
Diversity: From simple to complex
Learning Goals

• Describe and compare the characteristics of viruses, prokaryotes (bacteria and archaea) and protists

• Examine important relationships between organisms, the environment and human health

• Explain how viruses cause disease

• Explain key steps in the evolution of eukaryotes

• Classify and draw biological drawings of micro-organisms
Viruses

http://www.youtube.com/watch?v=e2QAGVMlns4&feature=related
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What are Viruses?

- *Virulentus* (poisonous)
- small, infectious, non-living, non-cellular particles
- contain no cytoplasm
- cannot grow or reproduce on their own
- do not produce or use energy
- do not create waste
- packages of genetic instructions that can enter and take control of cells (cell eventually makes copies of virus)
- Antibiotics do not work against viral infection, only antivirals or vaccines
Classifying Viruses

• Since viruses are not cellular, they’re not formally considered to be organisms

• Not included in classification of life but...

• Contain genetic material and reproduce
Size of Viruses

- less than 0.1 μm in diameter

- Hundreds of thousands can fit inside a typical human cell.
Basic Structure of a Virion (a virus particle)

- **Genetic material** – RNA (ss) or DNA (ds) core
- **Capsid (or head)** – protein coat that surrounds and protects the genetic material

**Note**: Some viruses are surrounded by an envelope, which is created when a virus leaves a host cell and part of the host cell membrane wraps around the virus. (See Fig. 2.2B on pg. 54)
Diagrams of Viruses

(a) Tobacco mosaic virus
(b) Adenovirus
(c) Influenza virus
(d) T-even bacteriophage
RNA or DNA?

Viruses with RNA (higher mutation rate)
- Human immunodeficiency virus (HIV)
- Influenza viruses
- Rabies
- Measles, mumps, pneumonia, polio, common cold
- SARS

Viruses with DNA (usually stable/constant, vaccines effective)
- Chickenpox, cold sores, genital herpes
- Mononucleosis
- Hepatitis
- Respiratory infections, tumours
Virus Shapes

1) **Helical** – rod-like with capsid proteins winding around the core in a spiral

Ex. Tobacco Mosaic Virus
Virus Shapes cont’d:

2) Polyhedral/Icosahedral
   - has many sides
   - most polyhedral capsids have 20 sides and 12 corners
Virus Shapes cont’d:

3) Complex - Polyhedral capsid *attached* to a helical tail

- The *tail* is made of protein, which aids in binding to host cells.
- This is the typical structure of *Bacteriophages* (viruses that attack bacteria).
2 methods of Viral replication: (also called Infectious Cycles)

1) **Lytic Cycle** – the virus enters the cell, replicates itself hundreds of times, and then bursts out of the cell destroying it

1. Attachment
2. Injection/Entry
3. Replication
4. Assembly
5. Release

(lysis = breaking open)

http://www.youtube.com/watch?v=wVkCyU5aeeU&feature=related
http://www.youtube.com/watch?v=rzdWfwuVWUU&feature=related
2) **Lysogenic Cycle**

- the virus enters the cell, viral DNA integrates with the host DNA and becomes inactive, the host functions normally
- an environmental change may then cause the virus to enter the Lytic Cycle

1. Attachment
2. Injection/Entry
3. Integration into host cell’s DNA
4. Dormancy/Normal cell functions
5. Triggering of viral DNA to be released and then Lytic cycle begins

**Draw and explain Fig. 2.3 on page 55**

http://www.youtube.com/watch?v=_J9-xKitsd0&feature=related
The lambda phage which infects *E. coli* demonstrates the cycles of a temperate phage.

**LYTIC CYCLE**
- Phage DNA
- Bacterial chromosome
- Phage attaches to host cell and injects DNA.
- Occasional prophage exits the bacterial chromosome, initiating a lytic cycle.
- Many cell divisions produce a colony of bacteria infected with prophage.
- Cell lyses, releasing phages.
- New phage DNA and proteins are synthesized and assembled into phages.

**LYSOGENIC CYCLE**
- Phage DNA circularizes
- Phage DNA integrates into the bacterial chromosome, becoming a prophage.
- Bacterium reproduces normally, copying the prophage and transmitting it to daughter cells.
- Prophage

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Differences Between Lytic and Lysogenic Cycles

In the Lytic Cycle:
- Viral DNA destroys Cell DNA, takes over cell functions and destroys the cell.
- The virus replicates and produces progeny phages.
- There are symptoms of viral infection.

In the Lysogenic Cycle:
- Viral DNA merges with cell DNA and does not destroy the cell.
- The virus does not produce progeny.
- There are no symptoms of viral infection.

Viruses and Disease

• In viruses that undergo lysogenic cycle, effects on host might not be immediate (HIV)

• HIV is a retrovirus (what is retro?)

• Retroviruses have an enzyme called reverse transcriptase (RNA → DNA)

• Viral DNA enters host chromosome, becoming a provirus

• Certain triggers will cause provirus to become lytic

http://www.youtube.com/watch?v=dn1tNlrMPRk&feature=related
3 ways Viruses enter living cells:

1) enter bacterial cells by punching a hole in the cell wall and injecting its DNA
Viruses Enter Living Cells cont’d:

2) enter plant cells through *tiny rips in the cell wall*

3) enter animal cells by *endocytosis*
Viruses are host cell specific

- can usually infect one type of host or even an organ, tissue or cell type (called its HOST RANGE)
- a protein on the surface of the virus has a shape that matches a molecule in the plasma membrane of its host, allowing the virus to lock onto the host cell (like a key fits in a lock)

Examples:
- a plant virus can only attack a plant cell and not an animal cell
- HIV (human immunodeficiency virus) infects only certain immune system cells

- some viruses can infect many species

Examples:
- rabies (rhabdovirus) – infects all birds and mammals
- swine flu virus can infect swine or humans
How are viruses spread?

- **VECTORS** - carry the virus from one host to another

  - Vectors include:
    - Insects (yellow fever – mosquitos)
    - Animals (rabies)
    - Water (polio)
    - Air (influenza, common cold, chicken pox)
    - Humans (influenza, hepatitis, HIV)

http://www.youtube.com/watch?v=Rpj0emEGShQ
The Origin of the Virus

- The origin of the modern virus is unclear.
- Two hypotheses exist:
  1) They could be runaway stretches of nucleic acid from a larger organism that detached and became active, therefore new viruses are forming frequently and many do not have ancestors.
  2) Viruses once lived outside of host cells, but over time due to their parasitic lifestyle, they lost the genes necessary to live outside the host.
The Prokaryotes: Bacteria and Archaea
### Table 2.1 Two Types of Cells

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Bacteria Introduction

• Bacteria are unicellular micro-organisms ranging in length from a few micrometers to half a millimeter.

• They come in a variety of different shapes (cocci, bacilli and spirilli).

• Bacteria can be found in almost every ecosystem on Earth. They are an estimated $5 \times 10^{30}$ bacteria on Earth!
Bacteria Introduction

- Bacteria are important to many nutrient cycles and are important decomposers of organic material.

- Bacteria are found all over the human body, however the majority are harmless or even beneficial.

- Some bacteria are pathogenic and cause disease.
Bacteria History

• Bacteria were first observed by Anton Van Leeuwenhoek in 1676.

• The term ‘bacteria’, Greek for ‘small stuff’ was first used in 1838.
Bacterial History

- Robert Koch and Louis Pasteur were the first to discover that bacteria caused many diseases (mid 19th century)

- The first antibiotic used to treat bacterial disease was made by Paul Ehrlich in 1910. It was used to treat syphilis.
The Evolution of Bacteria

• Bacteria are thought (by some) to be the first forms of life, about 4 billion years ago.

• It is believed that both the Domain Archaea and the Domain Eukarya evolved from bacteria.

• Due to a poor fossil record, scientists are unable to determine from what bacteria evolved.
Characteristics of Bacteria
Prokaryotic Cells:

- unicellular (single-celled)
- no nuclear membrane or other membranes around organelles
- small—less than 2 µm
- only 1 circular chromosome
Morphology

- Prokaryotic, lacking a nucleus and complex organelles.

- They have a cell membrane and a cell wall made up of peptidoglycan which is a combo of protein and carbohydrate, making it different from the cell walls of Archaea and Eukaryotes such as plants or fungi.
Two Types of Bacterial Cell Walls

**Gram Positive**
Thick Cell Wall (Less Common)

**Gram Negative**
Thin Cell Wall with lipoproteins (More Common)
Morphology Continued

• Bacteria use flagella or pili for movement and interaction with the environment.

• Shapes:
  - bacillus – rod
  - coccus – sphere
  - spirillus – spiral
  - vibrio – boomerang
  - spirochaetes – tight coils
Morphology Continued

• Prefixes are added to the shapes to indicate the living arrangement of the bacteria.

• Prefixes:
  
  **Strepto** – chain of bacteria
  
  **Staphylo** – grape like cluster
• Describe the two populations of bacteria in this stain.

• Why might gram staining be helpful?
Bacteria and Metabolism

- Autotrophs
- Heterotrophs
Autotrophs

• make their own energy
• use solar energy (or other chemical compounds) to ‘fix’ carbon dioxide
• eg. Cyanobacteria uses photosynthesis to make glucose
Example: Cyanobacteria

- Photosynthetic bacterium
- Bluish-greenish color
- Contain membranes that carry out the process of photosynthesis
- Do not contain the same type of chloroplasts as plants do
- This bluish-greenish algae can be found nearly everywhere on earth.
- Can survive in extremely hot environments and even extremely cold environments
Why are Cyanobacteria not in the **Plant Kingdom**??

- Can exist unicellularly
- Prokaryotic (no nucleus and membrane-bound organelles)
Heterotrophs

- Obtain energy from eating other organisms
- Eg. *E. coli*
Bacterial Reproduction

• Binary Fission
• Conjugation
• Spore Formation
Bacterial Reproduction

• Bacteria usually reproduce asexually using the process of binary fission (p. 62 in your text).
Sexual Reproduction???

- Some bacteria reproduce sexually by exchanging some of their DNA through a conjugation tube to another bacterium.
- Usually plasmid DNA, not genomic DNA.
Spore Formation: Endospore

- A type of dormant cell (sometimes for years)
- Exhibit no signs of life
- Highly resistant structure that forms around the chromosome when cell is under some sort of environmental stress such as:
  - High temperatures
  - Irradiation
  - Strong acids
  - Disinfectants
Archaea

- Lack important carbohydrate found in cell walls (Gram -)
- Have different lipids in their cell membrane
- Different types of ribosomes
- Very different gene sequences
- Do not cause disease
- Archaebacteria can live in extremely harsh environments
- They do not require oxygen (anaerobic) and can live in extremely salty (halophiles) environments, as well as extremely hot (thermophiles) or cold (psychrophiles) environments.
Kingdom Eubacteria

- Make up the larger of the two prokaryote kingdoms
- Generally are surrounded by a cell wall composed of complex carbohydrates
- Gram + and –
- Can cause disease
- Live nearly everywhere
Bacterial Interactions

• **Mutualism**: an interaction where all parties benefit.

• Examples are nitrogen fixing bacteria in the soil as well as the naturally occurring bacteria in our gut.
Bacterial Interactions

• **Parasitism**: An interaction where one party benefits and the other is negatively affected.

• Bacteria cause disease in many organisms. These bacteria are said to be pathogenic.
Treatment of Bacterial Diseases

- Antibiotics are used to treat bacterial diseases.

- Antibiotics work by punching holes in the cell walls of bacteria to allow the body’s natural defenses to be more effective OR they prevent the bacteria from reproducing.
Antibiotic Resistance

• Many bacteria are resistant to antibiotics due to their overuse for treatment of things not caused by bacteria, patients not following their prescriptions properly or just by natural selection.

• This has created what is known as a ‘superbug’, which is a term for a bacterium that cannot be destroyed by antibiotics.

It was on a short-cut through the hospital kitchens that Albert was first approached by a member of the Antibiotic Resistance.
Bacteria and Technology

1) **Food Preparation**: 
*Lactobacillus* is used in making pickles, soy sauce, cheese, wine, yoghurt, etc…

2) **Bioremediation**: Cleaning up toxic chemicals in the environment by breaking them down into less toxic products

3) **Bioengineering**: Used to reproduce specific genes quickly to mass produce their protein products (i.e. insulin).
Kingdom Archaeabacteria

Prokaryotic Team Extreme
Introduction

- Archaea are prokaryotic, single-celled organisms.

- They are similar to bacteria since they are prokaryotic, but their genes and the metabolic pathways they use are more similar to eukaryotes, hence why they have their own Domain and Kingdom.
Introduction

- They were only thought to live in ‘extreme’ environments

- Have been found in more milder environments (Mesophile) and may contribute up to 20% of the Earth’s total biomass!
Evolution

- Archaea are thought to have been one of the earliest forms of life to evolve on our planet.

- Fossilized remains of Archaea have been dated to 3.5 billion years ago!
Morphology

- microscopic, ranging in size from 0.1 to 15 µm.

- Come in many shapes such as spheres (cocci), rods (bacilli), spirals (spirilli) and plates.

- The majority have pili and flagella
Reproduction

- Asexual reproducers
- They use binary fission, budding or fragmentation to propagate.
Nutrition of Archaea: Methanogens

• Chemotroph

• Methane producing archaea that live in oxygen free environments.

• They use nitrogen, carbon dioxide or hydrogen sulfide to get energy and produce methane as a waste product.
3 main types of Extremophilic Archaea

- phile means “loving”
- Thermophile
- Acidicophile
- halophile
Thermophiles

• All grow best above 80°C and most grow well above the boiling point of water!

• Most have been discovered in geothermically heated waters, such as hot springs or black smokers (right).
Acidophiles

• Live in waters with a low (acidic) pH, usually containing strong sulfuric acid.

• No eukaryotic or bacteria species are this extreme.

http://www.youtube.com/watch?v=U3145eB_DCU
Halophiles

- Live in places with a high salt concentration, like the Dead Sea or Great Salt Lake.
Halophiles

• They were the first archaea to be studied, 110 years ago when salt was the primary preservation agent.

• Virtually all halophiles can live at the saturation point of salt, 32% or 5.5 M NaCl. The oceans are not salty enough for these guys.

• Kingdom Protista (Dunaliella) and Kingdom Bacteria (purple sulfur bacteria) also have halophilic species.
Archaea and Space???

• NASA is interested in salt deposits on Mars and one of Jupiter’s moons, Europa, because they have huge salt formations that some scientists believe could hold archaea.

• May suggest life started elsewhere…
Archaea and Biotechnology

- Archaea were deemed very useful for scientists because they contain enzymes that work under harsh conditions.

- Scientists isolated and purified these enzymes and now use them in a variety of processes.
Archaea and Biotechnology

- Archaean enzymes are used in DNA analysis, disease analysis, toxic waste removal and PCR, which is a technique used to make DNA fingerprints.