**The Cell: The Basic Unit of Life**

  
**The above photograph demonstrates the size of bacterial cells in relation to a pinpoint.**

The cell is the basic unit of life - the smallest structure capable of basic life processes, such as taking in nutrients, getting rid of waste, and reproducing. All living things are made of cells.

**Cell Components**

Cells are made up of molecules - nonliving structures formed by the joining of atoms. Small molecules serve as building blocks for larger molecules.

The four major molecules that underlie cell structure and participate in cell functions are:

* [**Proteins**](https://phtc-online.org/learning/courses/MB/glossary/glossary.cfm?searchGlossary=protein)
* **Nucleic acids**
  + **DNA** - contains the hereditary information for cells.
  + **RNA** - works with DNA to build the thousands of proteins the cell needs.
* [**Carbohydrates**](https://phtc-online.org/learning/courses/MB/glossary/glossary.cfm?searchGlossary=carbohydrate)
* [**Lipids**](https://phtc-online.org/learning/courses/MB/glossary/glossary.cfm?searchGlossary=lipid) (include fats and oils)

All cells have at least three things in common:

* [**Cell membrane**](https://phtc-online.org/learning/courses/MB/unit01/lesson01_intro/topic02/_pg03TE.cfm)
* [**Cytoplasm**](https://phtc-online.org/learning/courses/MB/unit01/lesson01_intro/topic02/_pg03TE.cfm)
* [**Genetic Material**](https://phtc-online.org/learning/courses/MB/unit01/lesson01_intro/topic02/_pg03TE.cfm)

**Prokaryotes and Eukaryotes**

There are two general classes of cells, both of which clearly affect human health and are essential for maintaining life as we know it:

[**Prokaryotes**](https://phtc-online.org/learning/courses/MB/unit01/lesson01_intro/topic03/_pg01.cfm) **and** [**Eukaryotes**](https://phtc-online.org/learning/courses/MB/unit01/lesson01_intro/topic03/_pg01.cfm)

**Prokaryotes and Eukaryotes: Key Differences**

The most important difference between prokaryotes and eukaryotes is that eukaryotes have:

* [**A true nucleus**](https://phtc-online.org/learning/courses/MB/unit01/lesson01_intro/topic03/_pg02.cfm)
* [**Membrane-bound organelles**](https://phtc-online.org/learning/courses/MB/unit01/lesson01_intro/topic03/_pg02.cfm)

**Prokaryotes and Eukaryotes: Additional Differences**

Additional differences between prokaryotes and eukaryotes include:

* [**Size**](https://phtc-online.org/learning/courses/MB/unit01/lesson01_intro/topic03/_pg03.cfm)
* [**DNA composition and length**](https://phtc-online.org/learning/courses/MB/unit01/lesson01_intro/topic03/_pg03.cfm)
* [**Cell Wall**](https://phtc-online.org/learning/courses/MB/unit01/lesson01_intro/topic03/_pg03.cfm)

|  |  |
| --- | --- |
| Usually smaller | Usually larger |
| More simple | More complex |
| Either unicellular or colonia | Exist in multicellular forms |
| Lack tru nucleus | Has membrane bound nucleus |
| Lacks organelles | Has organelles |
| Has a cell wall made of peptidoglycan |  |

**Pathogenic Microorganisms**

Not all microorganisms are pathogenic or capable of causing diseases or infections. There are 5 microbial groups that are of concern to the public health worker:

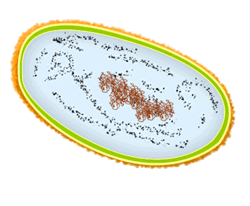
* Bacteria
* Fungi
* Protozoa
* Helminths (Worms)
* Viruses

**Pathogenic Microorganisms: Structural Classification**

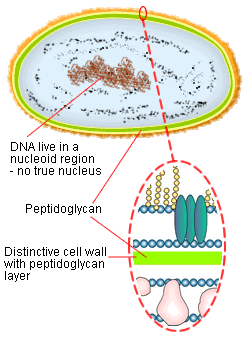
|  |  |  |  |
| --- | --- | --- | --- |
| **Below is a structural classification chart of the microbial groups:** | | | |
| **Microorganism** | **Prokaryote** | **Eukaryote** | **Acellular** |
| Bacteria | \*\*\* |  |  |
| Fungi |  | \*\*\* |  |
| Protozoa |  | \*\*\* |  |
| Helminths |  | \*\*\* |  |
| Virus |  |  | \*\*\* |

* Notice there is only one prokaryote: bacteria
* Notice that a virus is **not** a cell

**PROKARYOTES**



**Characteristics of a Prokaryote**



Prokaryotes have the following characteristics:

* No true nucleus - instead of a nucleus, they have a nucleoid region to organize DNA
* Distinct cell walls that contain a [peptidoglycan](https://phtc-online.org/learning/courses/MB/glossary/glossary.cfm?searchGlossary=peptidoglycan) layer (some exceptions)
* No [organelles](https://phtc-online.org/learning/courses/MB/glossary/glossary.cfm?searchGlossary=organelle) with internal membranes
* Single-celled organisms
* Cells are smaller
* Simpler structure

### Prokaryotes and Public Health

In public health, we are only concerned with bacteria.

**Bacteria**

Did you know that bacteria cause the following threats to public health?

* [**Anthrax (*Bacillus anthracis*)**](https://phtc-online.org/learning/courses/MB/unit01/lesson03_bac/topic01/_pg01.cfm)
* [**Syphillis (*Treponema pallidum*)**](https://phtc-online.org/learning/courses/MB/unit01/lesson03_bac/topic01/_pg01.cfm)
* [**Strep throat (*Streptococcus*)**](https://phtc-online.org/learning/courses/MB/unit01/lesson03_bac/topic01/_pg01.cfm)
* [**Botulism (*Clostridium botulinum*)**](https://phtc-online.org/learning/courses/MB/unit01/lesson03_bac/topic01/_pg01.cfm)
* [**Skin boils (*Staphyloccus*)**](https://phtc-online.org/learning/courses/MB/unit01/lesson03_bac/topic01/_pg01.cfm)

# Bacteria: The Basics

Bacteria are prokaryotic cells, the simplest of microbial cells. In essence, they consist of cell protoplasm contained within a retaining structure or cell envelope.

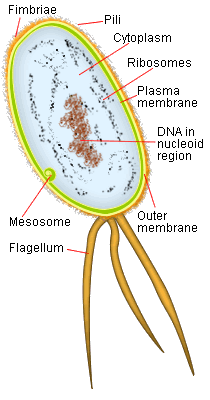
### Basic Characteristics:

* Prokaryotic
* Simplest of all microbial cells
* Single-celled organisms
* Distinctive cell walls, or unique cell envelopes, which contain a peptidoglycan layer
* Tiny; measured in units called [micrometers](https://phtc-online.org/learning/courses/MB/glossary/glossary.cfm?searchGlossary=micrometers) (µm)
* Lack a true nucleus; instead, have a region called the ‘nucleoid region' (i.e., DNA)
* DNA is free floating
* May have additional DNA which is not associated with this nucleoid region (called a plasmid)

### Other Characteristics:

* Rapid growth and cell division (binary fission) under favorable conditions
* Mutants that arise from bacteria can become extremely resilient organisms because bacteria can:
  + Grow and reproduce cells quickly
  + Adapt quickly to changing environments
* [Plasmids](https://phtc-online.org/learning/courses/MB/glossary/glossary.cfm?searchGlossary=plasmid) impart additional resistant characteristics to bacteria via cell-to-cell transfer of this extra DNA material
* Capable of colonizing in almost any environment
* Extremely diverse and numerous in soils or waters

**Basic Bacteria**



|  |  |  |
| --- | --- | --- |
| **Constituents of bacterial cell components** | | |
| **Cell Appendages** | **Cell Envelope** | **Cell Protoplasm (Plasma membrane)** |
| [Flagella](https://phtc-online.org/learning/courses/MB/glossary/glossary.cfm?searchGlossary=flagellum) | [Glycocalyx](https://phtc-online.org/learning/courses/MB/glossary/glossary.cfm?searchGlossary=glycocalyx) | Ribosomes |
| [Pili](https://phtc-online.org/learning/courses/MB/glossary/glossary.cfm?searchGlossary=pilus) | Cell wall | Mesosomes |
| [Fimbriae](https://phtc-online.org/learning/courses/MB/glossary/glossary.cfm?searchGlossary=fimbriae) | Cell membrane | Granules |
|  |  | Nucleoid |

|  |  |
| --- | --- |
| **All bacterial cells have a:** | **Not all bacterial cells have:** |
| * Cell envelope * Protoplasm that contains:   + Cell membrane   + Cytoplasm (cell pool)   + Ribosomes   + Nucleoid | * Cell wall (most have them) * Flagella * Pili |

**Classifying Bacteria**

Understanding this simple classification method can lead to a better comprehension of the Bergey's Manual.

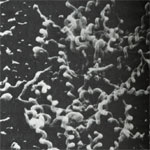
We can classify bacteria according to:

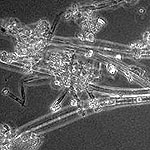
* Shape
* Cell wall structure and the Gram Stain
* Cellular respiration
* Growth factors: *Energy Source and Nutrient Source*

# Classifying Bacteria by Shape

  
**Coccus**

  
**Bacilli (rods)**

  
**Spirillum**

  
**Filamentous**

Bacteria cells vary in shape:

* Cocci – spherical
* Bacilli – rods, or cylindrical
* Spirillum – spiral, or helical
* Filamentous – complex forms, like ‘jellybeans in a straw'

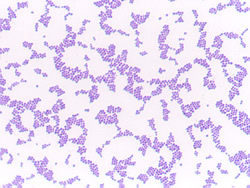
The shape of a cell affects its survival and activity in the environment. For example, cocci have less surface area per volume than bacilli or spirillum, and thus can survive more severe desiccation or dehydration. Bacilli, however, have a greater surface area to volume ratio and can take up nutrients from dilute solutions more efficiently. Shape also affects motility. For instance, spirillum are spiral cells, move with a corkscrew motion, and meet less resistance from surrounding water.

### Examples of Bacteria Classified by Shape:

* **Cocci:**
  + *Streptococcus*
  + *Staphylococcus*
* **Bacilli:**
  + *Bacillus anthracis*
  + *Clostridium*
* **Spirillum:**
  + *Treponema pallidum*
* **Filamentous:**
  + *Leptothrix, Crenothrix*

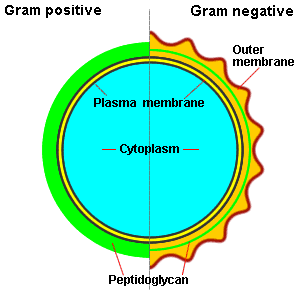
**Classifying Bacteria by Cell Wall Structure: The Gram Stain**

Another way to classify bacteria is based on differences in the composition of cell walls. The difference becomes clear by means of a technique called the **Gram stain,** which identifies bacteria as either **Gram positive**or **Gram negative.** After staining, Gram positive bacteria hold the dye and appear purple, while Gram negative bacteria release the first dye used and appear red from the second (counter) dye. Gram positive bacteria have thicker cell walls than Gram negative bacteria. Knowing whether a disease-causing bacterium is Gram positive or Gram negative helps a physician to prescribe the appropriate antibiotic. The stain is named for H. C. J. Gram, a Danish physician who invented it in 1884.

  
**Gram stain of Gram positive Staphylococcus cell**

  
**Gram stain of Gram negative E. coli cell**

# Distinctive Cell Walls: Peptidoglycan



Both Gram positive and Gram negative organisms have more than one layer protecting their [cytoplasm](https://phtc-online.org/learning/courses/MB/glossary/glossary.cfm?searchGlossary=cytoplasm) and nucleus from the outer environment. This is different from animal cells, which have only a single cytoplasmic membrane, made of a phospholipid bilayer. The layer just outside the bacterial cytoplasmic or plasma membrane is called the **peptidoglycan layer**. The peptidoglycan is what gives both cell wall types their rigid and protective qualities.

# Gram Positives and Gram Negatives: Key Differences

Gram positive bacteria have simpler, but thicker walls, with a relatively large amount of peptidoglycan. The walls of Gram negative bacteria are thinner and have less peptidoglycan but are more complex in structure. An outer membrane on the Gram negative cell wall contains **lipopolysaccharides** (LPS.) These are toxic substances responsible for making Gram negative organisms more threatening than Gram positives. Even the LPS of dead organisms are a potential threat.

# Gram Positives

The Gram positive cell envelope has two layers:

An outer cell wall – thick peptidoglycan layer, composed of complex cross-linked peptidoglycan, [teichoic acid](https://phtc-online.org/learning/courses/MB/glossary/glossary.cfm?searchGlossary=teichoic%20acid), polysaccharides and other proteins

Cytoplasmic membrane - contains proteins that span the lipid bilayer

### Special Components of Gram Positive Bacteria

The special components of Gram positives are:

* Teichoic Acids
* Polysaccharides

The teichoic acids anchor the outer cell wall to the cytoplasmic membrane by attaching to glycolipids. Teichoic acids also act as [antigenic](https://phtc-online.org/learning/courses/MB/glossary/glossary.cfm?searchGlossary=antigenic) determinants, so they are important for the serologic identification of many Gram positive organisms.

Examples of Gram positive Bacteria:

* *Streptococcus pyogenes -*causes [strep throat](https://phtc-online.org/learning/courses/MB/glossary/glossary.cfm?searchGlossary=strep%20throat)
* *Staphylococcus aureus -*causes skin infections and may be responsible for boils

# Gram Negatives

The Gram negative cell envelope has 3 layers (not including the periplasmic space):

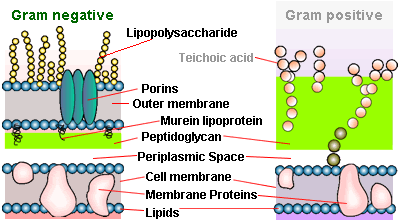
* A unique outer membrane
* A thin peptidoglycan layer
* Cytoplasmic membrane

### Special Components of Gram negative Bacteria

The special components of Gram negatives are:

* Outer membrane
* Murein lipoprotein
* [Lipopolysaccharide](https://phtc-online.org/learning/courses/MB/glossary/glossary.cfm?searchGlossary=Lipopolysaccharides) (LPS) – has toxic properties

Unlike Gram positives, Gram negative cell envelopes have **a complex outer membrane**, which likely explains the resulting difference in the gram-stain process. Unlike Gram positives, the thin peptidoglycan layer does not contain a teichoic acid, but it does have a small, helical lipoprotein called **murein lipoprotein**. This lipoprotein is important because it starts in the peptidoglycan layer and extends outward to bind the unique third outer membrane. Another factor that adds to the complexity of the outer membrane is the presence of **lipopolysaccharides (LPS)**. Lipopolysaccharides are the major toxins of pathogenic Gram negative bacteria. When the cell dies, LPS are released and can cause problems with organs or tissues.



### Examples of Gram Negative Bacteria:

* *Treponema pallidum*- causes [syphilis](https://phtc-online.org/learning/courses/MB/glossary/glossary.cfm?searchGlossary=syphilis)
* *Escherichia coli -*may cause severe gastrointestinal problems

# Classifying Bacteria by Cellular Respiration

We can also classify bacteria according to whether or not they need oxygen to survive.

* **Aerobic bacteria,** or **strict aerobes**- require oxygen
* **Anaerobic bacteria,** or **strict anaerobes**- cannot tolerate oxygen
* **Facultative anaerobics –**are generally aerobes, but have the capacity to grow in the absence of oxygen

### Examples of Bacteria Classified by Cellular Respiration:

* **Aerobic:**
  + *Bacillus cereus*
* **Anaerobic:**
  + *Clostridium*spp. ( [botulism](https://phtc-online.org/learning/courses/MB/glossary/glossary.cfm?searchGlossary=botulism), tetanus)
* **Facultative anaerobes:**
  + *Staphylococcus*spp.

# Classifying Bacteria by Growth Factors

Bacteria can further be classified according to how they grow and metabolize. Under this scheme, they are generally classified according to:

* Energy source
* Nutrient source

### Energy Source

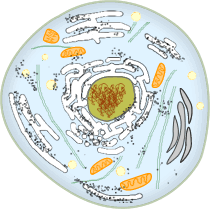
* **Chemotroph**– chemical compounds as an energy source (most pathogenic bacteria are chemotrophs.)
* **Phototroph**- light as energy source

### Nutrient Source

* **Heterotroph**– derive carbon from preformed organic nutrients such as sugar (most pathogenic bacteria are heterotrophs.)
* **Autotroph**– derive carbon from inorganic sources such as carbon dioxide

**Eukaryotic:**

**Characteristics of a Eukaryote**



Eukaryotes are complex organisms whose cells contain a membrane-bound nucleus holding hereditary materials or DNA. The presence of a nucleus distinguishes eukaryotes from prokaryotes. The organelles of eukaryotes allow them to exhibit much higher levels of intracellular division of labor than is possible in prokaryotic cells.

Eukaryotes have the following characteristics:

* Complex structure
* May be [unicellular](https://phtc-online.org/learning/courses/MB/glossary/glossary.cfm?searchGlossary=unicellular) or [multicellular](https://phtc-online.org/learning/courses/MB/glossary/glossary.cfm?searchGlossary=multicellular)
* May or may not have cell walls
* Extensive membrane-bound organelles
* Membrane-bound nucleus to organize DNA
* Cells are larger

**Pathogenic Eukaryotes**

There are three types of pathogenic microorganism groups that are classified as eukaryotes:

* Fungi
* Protozoa
* Helminths (Worms)

FUNGI:

Did you know that fungi causes the following threats to public health?

* [**Aspergillosis *(Aspergillus fumigatus)***](https://phtc-online.org/learning/courses/MB/unit01/lesson05_fun/topic01/_pg01.cfm)
* [**Meningoencephalitis (*Cryptococcus neoformans*)**](https://phtc-online.org/learning/courses/MB/unit01/lesson05_fun/topic01/_pg01.cfm)
* [**Oral Thrush (*Candida albicans*)**](https://phtc-online.org/learning/courses/MB/unit01/lesson05_fun/topic01/_pg01.cfm)
* [**Mold (*Stachybotrys*)**](https://phtc-online.org/learning/courses/MB/unit01/lesson05_fun/topic01/_pg01.cfm)

# Fungi: The Basics

Fungi are eukaryotic cells that are widespread in the environment and critically affect human health and welfare.

### Basic Characteristics:

* Eukaryotic
* Non-vascular organisms
* Reproduce by means of spores, usually wind-spread
* Both sexual (meiotic) and asexual (mitotic) spores may be produced, depending on the species and conditions
* Typically not capable of movement
* Like plants, fungi have an alternation of generations

### Other Characteristics

* Vegetative body may be unicellular (yeasts) or composed of microscopic threads called hyphae
* Cell walls similar in structure to plants but differ in chemical composition; fungi cell walls are composed mostly of [chitin](https://phtc-online.org/learning/courses/MB/glossary/glossary.cfm?searchGlossary=chitin); plant cell walls are composed mostly of [cellulose](https://phtc-online.org/learning/courses/MB/glossary/glossary.cfm?searchGlossary=cellulose) (plus lignin in secondary walls)
* Cytoplasmic ultra-structure is broadly similar to plants cells, but differs significantly in kinds of organelles and structures

**Fungal Forms**

**Some fungi can grow into two major fungal forms:**

* **Yeasts**– primarily unicellular growth form of fungi; reproduce [asexually](https://phtc-online.org/learning/courses/MB/glossary/glossary.cfm?searchGlossary=asexual%20reproduction) through budding
* **Molds or Mycelia**– characterized by having long, filamentous structures known as **hyphae**(long threadlike structures that entwine together into a mass known as a mycelium)

**Other fungal forms are:**

* **Spores –**reproducing bodies of molds
* **Dimorphic Fungi**– fungi that can grow as either yeast or mold depending on environmental conditions and temperatures; *[Blastomyces dermatitidis](https://phtc-online.org/learning/courses/MB/glossary/glossary.cfm?searchGlossary=blastomycosis)* is an example of a dimorphic fungi (mycelial forms at 25°C, and grow into yeast form at 37°C).

**Classifying Fungi**

The formal classification scheme for fungi is not essential for the scope of this course. Briefly, fungi are formally classified according to their growth and reproduction process. The three groups or divisions are:

* [**Zygomycota**](https://phtc-online.org/learning/courses/MB/unit01/lesson05_fun/topic04/_pg01TE.cfm)
* [**Ascomycetes**](https://phtc-online.org/learning/courses/MB/unit01/lesson05_fun/topic04/_pg01TE.cfm)
* [**Basidiomycetes**](https://phtc-online.org/learning/courses/MB/unit01/lesson05_fun/topic04/_pg01TE.cfm)

**Pathogenic Fungi**

Fungal pathogens adversely affect human health. Fungal infections develop slowly but recur more frequently than bacterial infections and do not produce a lasting immunity in the body. Infections can be generalized in one of two groups, depending on the part of the body that is infected.

* [**Dermatomycosis**](https://phtc-online.org/learning/courses/MB/unit01/lesson05_fun/topic05/_pg01.cfm) - infecting the skin, hair, or nails
* [**Systemic mycosis**](https://phtc-online.org/learning/courses/MB/unit01/lesson05_fun/topic05/_pg01.cfm) - infecting the entire body

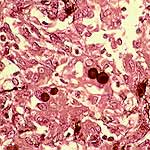
Fungal infections are typically spread by spores that enter the body through breathing or through an opening in the skin. Some infections are passed from animals to humans or between humans.

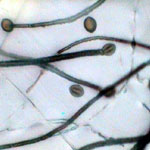
# Pathogenic Fungi: Examples of Pathogenic Fungi

### Examples of Pathogenic Fungi

* [***Aspergillus fumigatus***](https://phtc-online.org/learning/courses/MB/unit01/lesson05_fun/topic05/_pg02.cfm)
* [***Blastomyces dermatitidis***](https://phtc-online.org/learning/courses/MB/unit01/lesson05_fun/topic05/_pg02.cfm)
* [***Stachybotrys atra***](https://phtc-online.org/learning/courses/MB/unit01/lesson05_fun/topic05/_pg02.cfm)

  
***Aspergillus fumigatus***

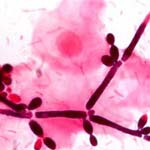
  
***Blastomyces dermatitidis***

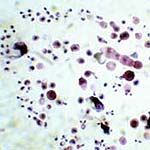
  
***Stachybotrys atra***

# Pathogenic Fungi: Examples of Pathogenic Yeasts

### Examples of Pathogenic Yeasts

* [***Candida albicans***](https://phtc-online.org/learning/courses/MB/unit01/lesson05_fun/topic05/_pg03TE.cfm)
* [***Cryptococcus neoformans***](https://phtc-online.org/learning/courses/MB/unit01/lesson05_fun/topic05/_pg03TE.cfm)

  
***Candida albicans***

  
***Cryptococcus neoformans***

**Protozoa**

Did you know that protozoa causes the following threats to public health?

* [**Cryptosporidiosis (*Cryptosporidium*)**](https://phtc-online.org/learning/courses/MB/unit01/lesson06_zoa/topic01/_pg01.cfm)
* [**Giardiasis (*Giardia lamblia*)**](https://phtc-online.org/learning/courses/MB/unit01/lesson06_zoa/topic01/_pg01.cfm)
* [**Encephalitis**](https://phtc-online.org/learning/courses/MB/unit01/lesson06_zoa/topic01/_pg01.cfm)

**Protozoa: The Basics**

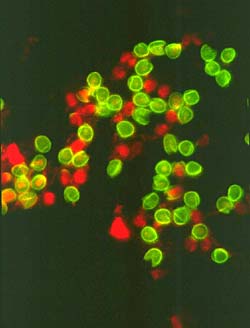
Protozoa are unicellular eukaryotes, meaning that they have characteristic organelles. They are relatively large and some are visible with the naked eye. They occupy a vast array of habitats and niches and have organelles similar to those found in other eukaryotic cells as well as specialized organelles. Protozoa usually reproduce asexually by binary fission.

* Eukaryotic
* Can be both free-living (can live outside of a host) or parasitic (colonize host cell tissues)
* Usually single-celled organisms
* Divided into seven phyla
* Large - some are visible with the naked eye
* May have one or more nuclei
* Typically lack cell walls
* Complex life cycles and diverse. There are approximately 65,000 known protozoa. By way of comparison, only about 4,500 bacteria are known.
* May have both sexual and asexual reproductive phases
* Found in nearly all terrestrial and aquatic or moist environments and are thought to play a valuable role in ecological cycles
* Many are able to exist in extreme environments, from polar regions to hot springs and desert soils
* [*Giardia*](https://phtc-online.org/learning/courses/MB/glossary/glossary.cfm?searchGlossary=giardia), [*Cryptosporidium*](https://phtc-online.org/learning/courses/MB/glossary/glossary.cfm?searchGlossary=cryptosporidium) and *Microsporidium*have become major concerns in the drinking water industry

The traditional four phyla classification, based largely on movement, includes the following groups:

* [**Flagellates**](https://phtc-online.org/learning/courses/MB/unit01/lesson06_zoa/topic02/_pg01.cfm)– use flagella
* [**Amoebae**](https://phtc-online.org/learning/courses/MB/unit01/lesson06_zoa/topic02/_pg01.cfm) – uses [pseudopodial](https://phtc-online.org/learning/courses/MB/glossary/glossary.cfm?searchGlossary=pseudopod) structures, flowing cytoplasm
* [**Sporozoans**](https://phtc-online.org/learning/courses/MB/unit01/lesson06_zoa/topic02/_pg01.cfm) – bending, creeping or gliding
* [**Ciliates**](https://phtc-online.org/learning/courses/MB/unit01/lesson06_zoa/topic02/_pg01.cfm)**–**use cilia

**Oocysts**

  
**Oocysts of *Cryptosporidium* parvum**

Oocysts are encapsulated [zygotes](https://phtc-online.org/learning/courses/MB/glossary/glossary.cfm?searchGlossary=zygote) of sporozoan protozoa, occurring as a life-cycle stage. Further development in an oocyst stage produces small individual infective organisms called sporozoites.

**Sporozoites**, products of meiotic division of zygotes in parasitic protozoa, are infective cells that invade the host and undergo asexual reproduction.

**Pathogenic Protozoa**

Not all protozoa are of concern to public health. Within the seven-phyla classification, there are only four that are pathogens:

|  |  |
| --- | --- |
| **Phylum** | **Pathogenic** |
| Apicomplexa | Yes |
| Sarcomastigophora | Yes |
| Microspora | Yes |
| Ciliophora | Yes |
| Acetospora | No |
| Myxospora | No |
| Labyrinthomorpha | No |

We will briefly discuss each of the pathogenic protozoa in the next few pages.

***Apicomplexa***

*Apicomplexa* are characterized by the presence of complex apical organelles generally consisting of a conoid that aids in penetrating host cells, [rhoptries](https://phtc-online.org/learning/courses/MB/glossary/glossary.cfm?searchGlossary=rhoptry) that possibly secrete a [proteolytic](https://phtc-online.org/learning/courses/MB/glossary/glossary.cfm?searchGlossary=proteolysis) enzyme, and[subpellicular microtubules](https://phtc-online.org/learning/courses/MB/glossary/glossary.cfm?searchGlossary=subpellicular%20microtubules) that may be related to motility.

* All species parasitic
* No organelles for movement
* Characteristic apical complex
* Reproduction by spores and cysts

**Examples:**

* [*Toxoplasma*](https://phtc-online.org/learning/courses/MB/glossary/glossary.cfm?searchGlossary=toxoplasma)
* [*Cryptosporidium*](https://phtc-online.org/learning/courses/MB/glossary/glossary.cfm?searchGlossary=Cryptosporidium)

*****Toxoplasma***

*****Cryptosporidium***

**Apicomplexa: Coccidians**

The coccidia are classified as members of the phylum *Apicomplexa*, class *Sporozoae*, and subclass *coccidia*.

Six genera of coccidia infect humans:

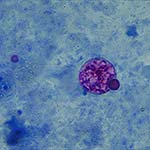
* *Toxoplasma*
* *Isospora*
* *Cryptosporidium*
* *Cyclospora*
* *Sarcocystis*
* *Plasmodium*

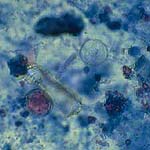
The six coccidians have some features in common, but also differ markedly. The infective stage for all coccidia is a [sporozoite](https://phtc-online.org/learning/courses/MB/glossary/glossary.cfm?searchGlossary=sporozoite), which is very similar in form and function among all coccidians. All produce an [oocyst](https://phtc-online.org/learning/courses/MB/glossary/glossary.cfm?searchGlossary=oocyst) stage following the sexual cycle, and this environmentally hardy oocyst stage is excreted in the stool.

**Important Coccidians: *Cyclospora***

***Cyclospora*** can cause watery diarrhea, nausea, vomiting, and fever. *Cyclospora* is spread by ingestion of water or food that was contaminated with infected stool. For example, outbreaks of cyclosporiasis have been linked to various types of fresh produce. *Cyclospora* needs time (days or weeks) after being passed in a bowel movement to become infectious. Therefore, it is unlikely that *Cyclospora* is passed directly from one person to another. It is unknown whether animals can be infected and pass infection to people.

*Cyclospora* is ingested as an oocyst that contains two sporocysts with two [sporozoites](https://phtc-online.org/learning/courses/MB/glossary/glossary.cfm?searchGlossary=sporozoite).

  
**Modified acid-fast smears - oocysts stain from a light pink to a deep red**

  
**There are two oocysts of*Cyclospora* in this field, one shows the typical acid fast reaction and the other is a ghost**

**Important Coccidians: *Isospora***

***Isospora belli***(*I. Belli*) causes human [coccidiosis](https://phtc-online.org/learning/courses/MB/glossary/glossary.cfm?searchGlossary=coccidiosis) or [isosporiasis](https://phtc-online.org/learning/courses/MB/glossary/glossary.cfm?searchGlossary=isosporiasis) and is one of the four intestinal coccidia that parasitize humans. It is spread by the fecal-oral route. *Isospora belli* infects the mucosal epithelium of the small intestine and can cause diarrhea that may last for only a few days or a chronic infection that may persist for months. It can be life threatening to patients with weak immune systems. Although infection with *I. Belli* occurs worldwide, it tends to be a very uncommon infection.

*Isospora* is ingested as a mature oocyst that contains two sporocysts each with four nucleated sporozoites.

  
**Immature *Isospora* oocyst with one sporocyst**

  
**Infective stage - mature*Isospora* oocyst with 2 sporocysts**

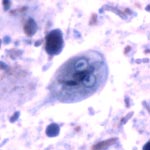
***Sarcomastigophora***

*Sarcomastigophora* is characterized by a single-type nucleus and movement by flagella, pseudopodia, or both. It comprises the subphyla *mastigophora*, *opalinata*, and *sarcodina*.

* Locomotory organelles are pseudopodia and flagella
* Only one type of nucleus

**Examples:**

* [*Giardia*](https://phtc-online.org/learning/courses/MB/glossary/glossary.cfm?searchGlossary=giardia)
* [*Cryptobia*](https://phtc-online.org/learning/courses/MB/glossary/glossary.cfm?searchGlossary=Cryptobia%20spp) spp.

  
***Giardia***

  
***Cryptobia* spp**

***Ciliophora***

*Ciliophora* is characterized by the presence of [cilia](https://phtc-online.org/learning/courses/MB/glossary/glossary.cfm?searchGlossary=cilia) at some time during the life cycle.

**Examples:**

* [*Paramecium*](https://phtc-online.org/learning/courses/MB/glossary/glossary.cfm?searchGlossary=paramecium)
* [*Tetrahymena*](https://phtc-online.org/learning/courses/MB/glossary/glossary.cfm?searchGlossary=tetrahymena)

  
***Paramecium***

  
***Tetrahymena***

**Virus**

Did you know that viruses cause the following threats to public health?

* [**Herpes**](https://phtc-online.org/learning/courses/MB/unit01/lesson08_vir/topic01/_pg01.cfm)
* [**Chickenpox**](https://phtc-online.org/learning/courses/MB/unit01/lesson08_vir/topic01/_pg01.cfm)
* [**Influenza**](https://phtc-online.org/learning/courses/MB/unit01/lesson08_vir/topic01/_pg01.cfm)
* [**HIV**](https://phtc-online.org/learning/courses/MB/unit01/lesson08_vir/topic01/_pg01.cfm)
* [**SARS**](https://phtc-online.org/learning/courses/MB/unit01/lesson08_vir/topic01/_pg01.cfm)

# Virus: The Basics

Viruses are small, obligate, intracellular parasites, meaning that they require a host cell for their growth and replication. They take over, or invade, their host's cell machinery to produce copies of their genetic material or produce their progeny. They can also survive outside a host, but cannot grow or replicate without one. They are generally species specific, infecting bacteria, plants or animals.

### Viruses have these unique characteristics:

* Unlike prokaryotic and eukaryotic cells, they are energy-less. They float around until they come in contact with an appropriate cell
* They are basic life forms composed of a protein coat, called a **capsid**, that surrounds and protects the genetic material.
* Viruses do not have organelles or ribosomes.
* Some viruses are further enclosed by an external lipid bilayer membrane, or envelope, that surrounds the capsid and may contain glycoproteins. Some viruses also carry some structural proteins and enzymes inside their capsid.
* The genetic material is either DNA or RNA – never both. The nucleic acid may be single- or double-stranded. The genetic material contains instructions to make millions of clones of the original virus.
* Replication of the genetic material occurs when the virus takes control of the host cell's synthetic machinery to produce their progeny. Viruses contain all of the genetic information, but not the enzymes, needed to build millions of the original virus.

# Capsids

The virus capsid is the term for the protein coat. Capsomers consist of one or more polypeptide chains that are organized into a protein subunit. Capsids are composed of capsomers held together by noncovalent bonds, surrounding the nucleic acid molecule. Capsids range in size from 18µm to several hundred nanometers. This outer coat protects and shields the viral nucleic acid and harbors specific receptor sites for host attachment.

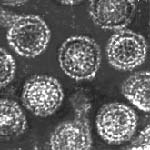
# Animation of virus capsid broken down by its constituent parts.

# Classifying Virus

### Viruses can be classified according to:

* Type of nucleic acid
* [Capsid](https://phtc-online.org/learning/courses/MB/glossary/glossary.cfm?searchGlossary=capsid) symmetry
* Site of capsid assembly
* Envelope
* Size and number of [capsomers](https://phtc-online.org/learning/courses/MB/glossary/glossary.cfm?searchGlossary=capsomers)

# Classifying Virus by Type of Nucleic Acid

  
**Example of a DNA virus (Hepadnaviridae)**

  
**Example of an RNA virus (Coronaviridae)**

Viruses are classified by the type of nucleic acid. They are either:

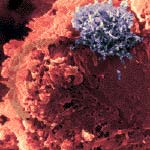
* DNA virus
* RNA virus

The nucleic acid strands can be single-stranded, double-stranded, linear, or looped, in separate segments or one continuous strand. The nucleic acid sequences can encode a simple message or encode hundreds of enzymes and structural proteins.

**Classification by Nucleic Acid: RNA Viruses**

  
**Coronaviridae - positive-stranded RNA virus**

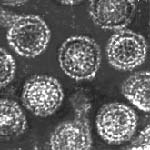
  
**Paramyxoviridae - negative-stranded RNA virus**

  
**Retroviridae - RNA virus that carry unique enzymes called reverse transcriptase**

**Classification by Nucleic Acid: DNA Viruses**

Unlike RNA, DNA cannot be translated directly into proteins. It must first be transcribed into mRNA, with subsequent translation of the mRNA into structural proteins and enzymes.

* Every DNA virus has both a negative and a positive strand. However, only the positive is read; the negative is ignored.
* Some carry enzymes for DNA repair.

  
**Hepadnaviridae**

  
**Herpesviridae**

  
**Parvoviridae**