PATHOGENS

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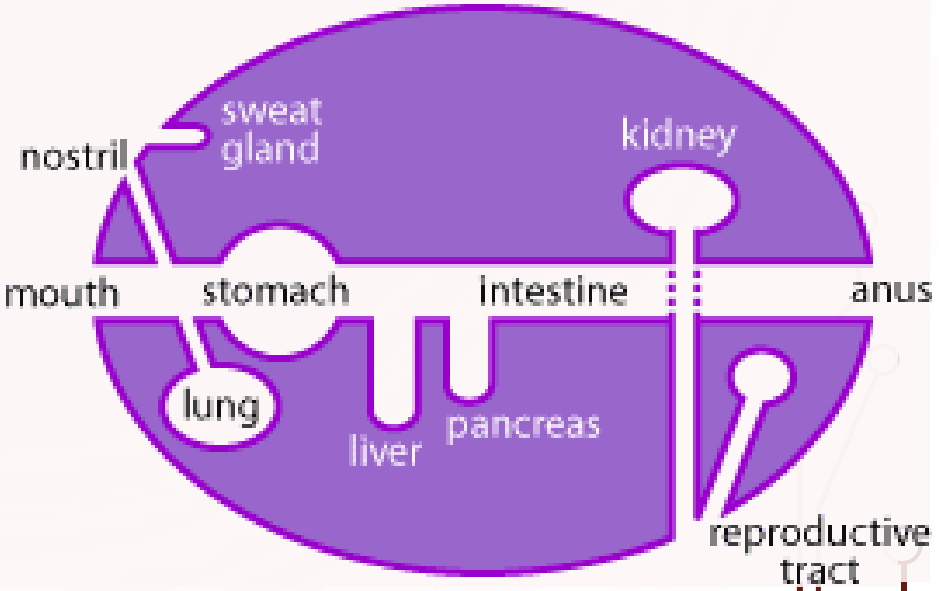
PATHOGENS

- **Any organism that is capable of causing a disease is called a <u>pathogen</u>.**
  - Most pathogens are <u>microorganisms</u> (bacterium, virus, or fungus) but most microorganisms do NOT cause disease.
  - Many microorganisms even provide some protection from infectious pathogens by slowing their growth through competition.

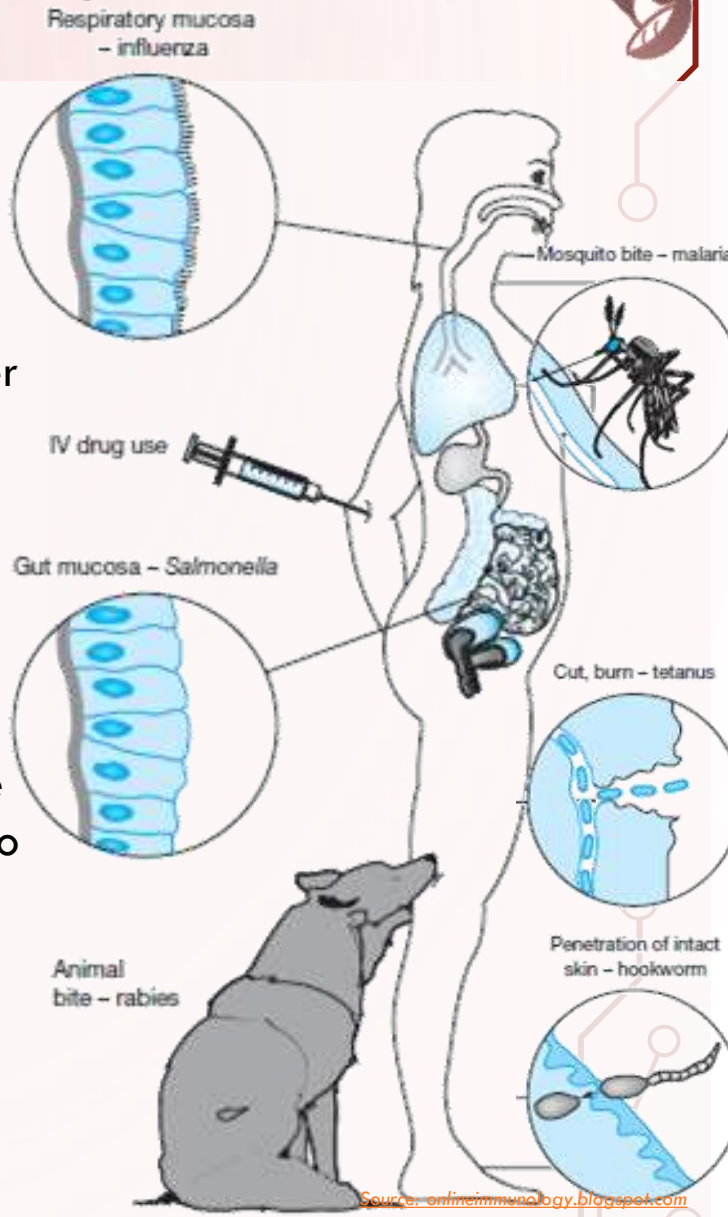
- **In order to cause disease a pathogen must be able to get entrance into a host (the affected organism), adhere to the host's tissue, and cause damage.**
  - A pathogen most commonly gains entrance into an animal via the mucus membranes, including the mouth, eyes, nostrils, and genitals.
  - Cuts or openings in the skin can also lead to infection.



Source: http://www.scq.ubc.ca/mucosal-immunity-and-vaccines/

PATHOGENS ARE SPECIFIC

- **Most pathogens attack a specific kind of tissue.**
  - While a pathogen can invade the tissue where they gained entrance into the host, most often a pathogen focuses on attacking a specific kind of tissue in the host (such as respiratory cells, intestinal tissue, or other specific kinds of cells).
- **While the growth and reproduction of a pathogen can cause problems inside the host's body, damage is more often due to the production of toxins or destructive enzymes by the pathogen.**
  - These toxins or enzymes are often used to enable the pathogen to further invade the host's tissues and/or to more easily acquire energy or nutrition from the host.
  - For example, some 'flesh-eating' diseases produce enzymes that break down tissue and dissolve fibrin blot clots in order to enable the pathogen to invade even more tissue in the host.



CATEGORIES OF PATHOGENS

- **There are six major kinds of pathogens that can cause infectious disease:**
  - Bacteria: single-celled organisms that lack cellular organelles and divide by fission (splitting in two).
  - Viruses: non-living nucleic acid surrounded by a protein coat that uses living cells to reproduce.
  - Fungi: eukaryotic (has organelles) organisms that reproduce by forming spores, can be unicellular or multicellular, and are common decomposers.
  - Protozoa: single-celled eukaryotic organisms that are mobile and feed off other organisms.
  - Helminths (worms): simple multi-celled invertebrates that often have multi-staged reproductive cycles.
  - Prions: non-living infectious proteins that most commonly affect the nervous system of the host.

Bacterium

Virus

Protozoan

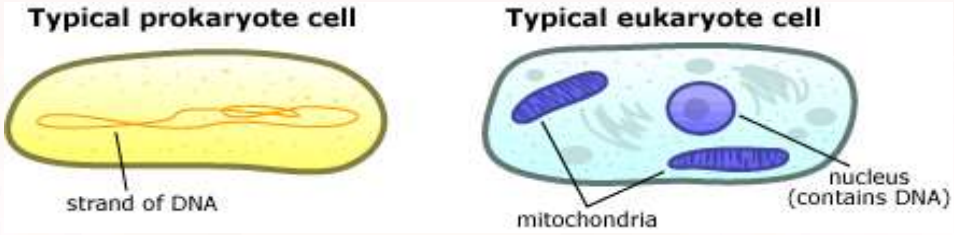
Fungus

Helminth

Source: www.riversideonline.com

BACTERIA (PROKARYOTES)

- **Bacteria are unicellular (single-celled) organisms.**
  - Bacteria are prokaryotes, meaning they lack a nuclei, mitochondria, or other cellular organelles. (Conversely, eukaryotes have organelles like a nuclei or mitochondria.)
  - They have circular, double-stranded DNA.
    - *They also have small additional 'packets' of DNA called plasmids.*
  - Most bacteria reproduce by growing and then dividing into two cells in a process called binary fission.
- **Bacteria are typically classified by their shape.**
  - Bacteria are most commonly classified as either *bacillus* (rodshaped), *coccus* (spherical), or *spirillum* (helical rods).
- **Bacteria can also be classified by how they obtain their energy.**
  - Some bacteria are photosynthetic, some oxidize inorganic compounds, and some break down organic compounds (such as sugar and amino acids).
  - Bacteria can also be classified as aerobes (need oxygen), anaerobes (can only live in the absence of oxygen) or facultative anaerobes (can live with or without oxygen).

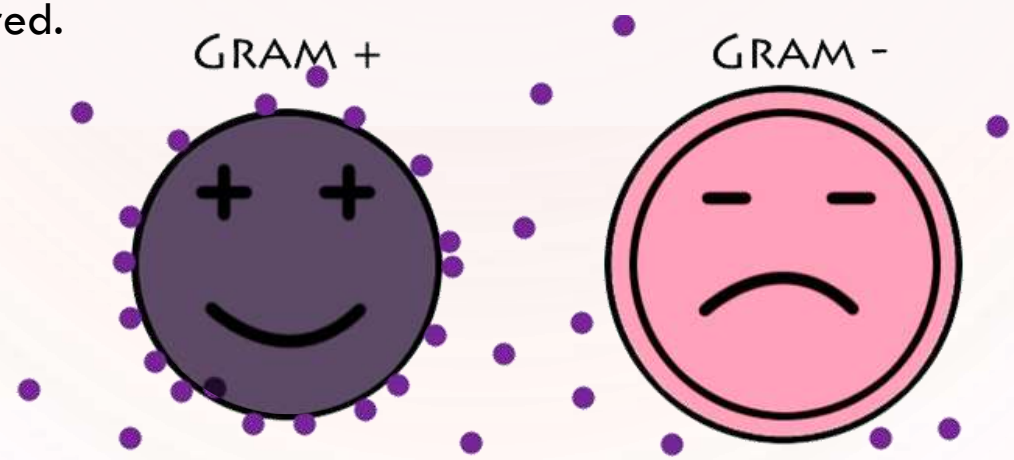


Source: http://evolution.berkeley.edu/evolibrary/images/endosymbiosis/cells.gif

GRAM NEG VS. GRAM POS

- **In regards to disease, bacteria are most commonly classified as Gram Positive or Gram Negative based on the presence or absence of an outer cell membrane.**
  - Both kinds of bacteria are very similar internally.
  - The main difference between a gram negative and a gram positive bacteria is based on their cell walls.

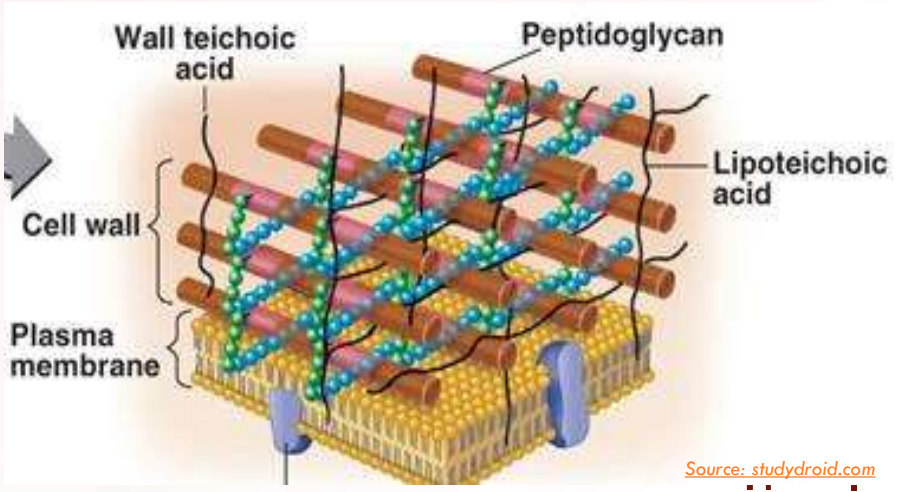
- **Gram positive and gram negative bacteria can be identified using a laboratory stain.**
  - When a gram stain is applied, gram positive bacteria turn purple and gram negative bacteria turn red.



Source: http://www.dbriers.com/tutorials/wp-content/uploads/2012/12/GramPositiveNegative21.jpg

GRAM POSITIVE BACTERIA

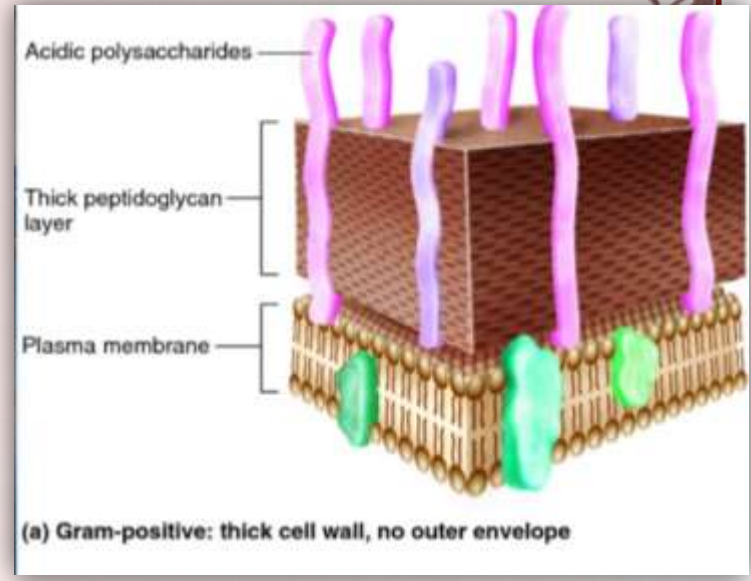
- **A gram positive bacteria has a cell wall made mainly of peptidoglycan.**
  - Peptidoglycan is a mesh-like substance in the cell wall and is similar to that of the exoskeleton of an insect.
- **Because the peptidoglycan cell wall is mesh-like, this means that substances can diffuse across the membrane and enter the inside of the bacterial cell.**
  - This makes gram positive bacteria susceptible to most antibiotics, and this makes it easier to treat a gram positive bacterial infection than it is to treat a gram negative bacterial infection.
  - Peptidoglycan can also be broken down by lysozyme enzymes produced by animal cells.

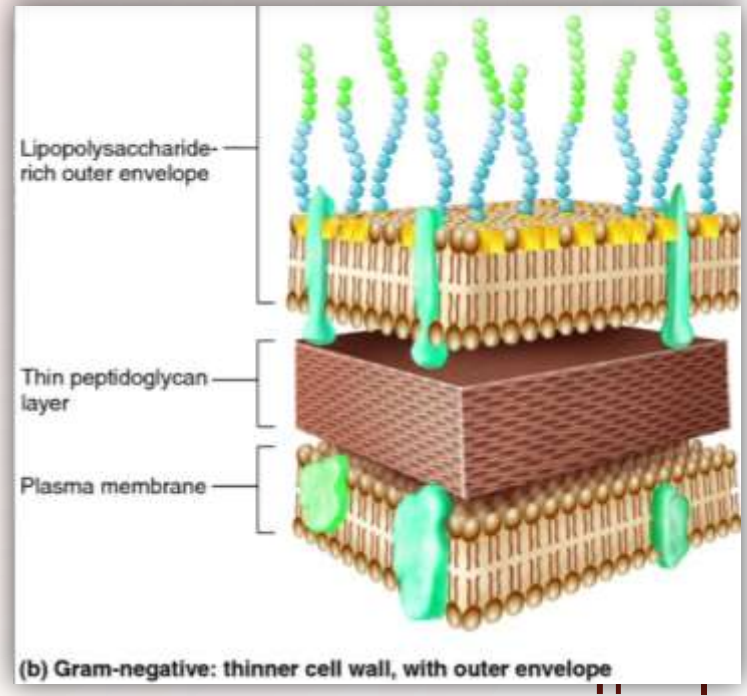


Source: studydroid.com

GRAM NEGATIVE BACTERIA

- **<u>Gram negative</u> bacteria have an extra layer of protection due to the presence of an outer membrane on the outside of their cell wall.**
  - This outer membrane is like a stiff canvas sack and blocks larger molecules including antibiotics and lysozymes.
  - The outer membrane is like a bulletproof shield for gram negative bacteria, repelling most molecules that would otherwise harm the bacterial cell.
  - The outer membrane also protects gram negative from drying and from harsh environments including the stomach acid of animals and engulfment by white blood cells.
  - Finally, the outer membrane can enable some species of gram negative bacteria to adhere (or 'stick') to the cells of their hosts to increase their likelihood of invasion and infection.

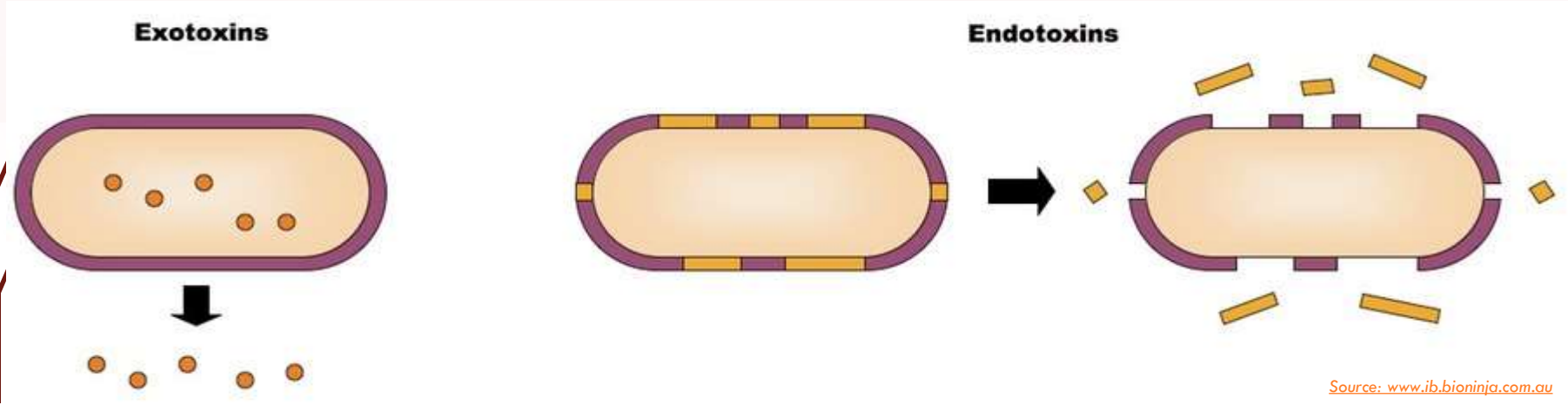




Source: http://biology-forums.com/index.php?action=gallery;sa=view;id=752

TOXINS

- **Gram negative bacteria contain endotoxins in their cell wall and outer membrane.**
  - Endotoxins are toxins found inside bacterial cells and are mostly only released if the cell if broken down.
    - *This is different from an exotoxin, which is a toxin released by a bacterial cell while it is still alive.*
    - *Exotoxins are much more common in gram positive bacteria, whereas endotoxins are more common in gram negative bacteria.*
  - If the outer membrane and cell wall of gram negative bacteria are broken down, these endotoxins will be released into the body of the host.
    - *Endotoxins are very resilient and can remain intact even after 30 minutes of boiling temperatures.*
  - These endotoxins cause an inflammatory response in animal hosts.



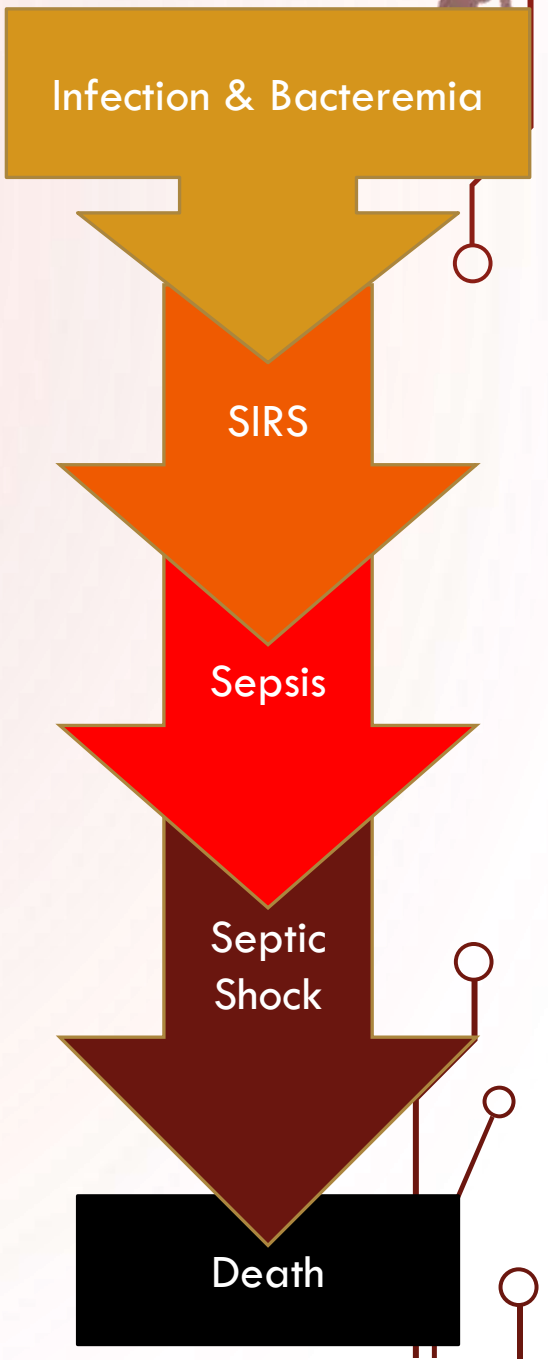
Source: www.ib.bioninja.com.au

SEPTIC SHOCK

- **The inflammatory response due to the presence of toxins from bacteria can lead to septic shock and even death.**
  - When a toxin is sensed by an animal's body, it causes a systemic (body-wide) inflammatory response.
    - *This means that all the blood vessels in the body expand.*
  - As vasodilation (expansion of the blood vessels) occurs, the blood pressure of the animal drops. This drop in blood pressure is known as hypotension.
    - *The heart will weaken as it works harder to compensate for the hypotension.*
  - As a result of this hypotension, organs will not receive adequate oxygen or nutrients due to impaired blood flow (hypoperfusion), and organ systems will begin to shut down.
    - *The kidneys will be unable to eliminate waste, allowing it to accumulate in the blood.*
    - *The respiratory system will begin to fail, resulting in even less oxygen flow to the body's organs and an increased rate of organ shut-down.*
  - When an infection causes life-threatening low blood pressure, this is known as septic shock.

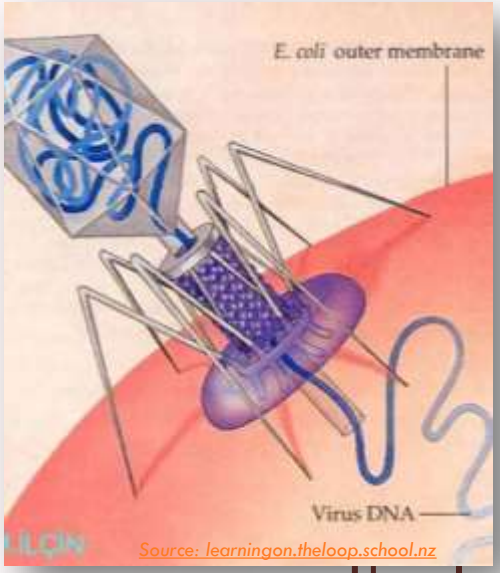
STAGES OF SEPTIC SHOCK

- **Septic shock has the following stages:**
  - Infection: presence of bacteria in what is normally sterile bodily tissue.
  - Bacteremia: presence of bacteria in the blood.
  - Systemic Inflammatory Response (SIRS): when blood vessel dilate (vasodilation) due to bacteremia, causing hypotension (drop in blood pressure) and hypoperfusion (lack of blood flow through an organ).
  - Sepsis: when inflammatory responses occur in tissues that are remote from the infection.
  - Sepsis becomes septic shock if the systemic inflammatory response leads to dangerously low blood pressure, and organ systems begin to fail as a result.



VIRUSES

- **The second category of disease-causing pathogens are <u>viruses</u>.**
  - A <u>virus</u> consists of genetic material surrounded by a protein coat.
    - *Viral genomes can be double or single stranded and can be DNA or RNA*
- **Viruses are non-living. They cannot reproduce on their own and they do not metabolize food for energy.**
  - Because a virus is not alive, it will not respond to an antibiotic.
- **To reproduce, a virus must hijack a cell and manipulate the cell so that it produces viral proteins instead of its normal cellular proteins.**
  - To do this, the virus inserts its genome into the host cell, and forces the cell to reproduce its own genome.
  - The cell then makes mRNA and tRNA in order to produce more viral proteins.
  - The cell assembles the viral proteins and genomes into new viruses.
  - These newly-assembled viruses are released from the cell and then infect other cells, repeating the process over and over.



Source: learningon.theloop.school.nz

RETROVIRUSES

- **Retroviruses are a kind of virus with the ability to insert their own genetic material into the genome of a cell.**
  - Retroviruses have a unique enzyme called reverse transcriptase that allows them to copy their RNA into the cell's genome.
  - As the host's cells divide, they reproduce the viral DNA, making retroviruses difficult to eliminate from a host.
- **Retroviruses also tend to have long latent periods (the time between infection and the exhibition of symptoms) which means that the disease often goes unnoticed and can more easily spread.**
  - HIV is an example of a retrovirus.
- **All viruses cause their respective diseases by interrupting normal cellular function.**
  - Some viruses use their own proteins to stop the creation of the host cell's proteins.
  - Some viruses cause the cell membrane to break open and rupture.
  - Some viral proteins are toxins.
  - The presence of some proteins causes the host's own immune system to attack and destroy its own cells to eliminate the virus.

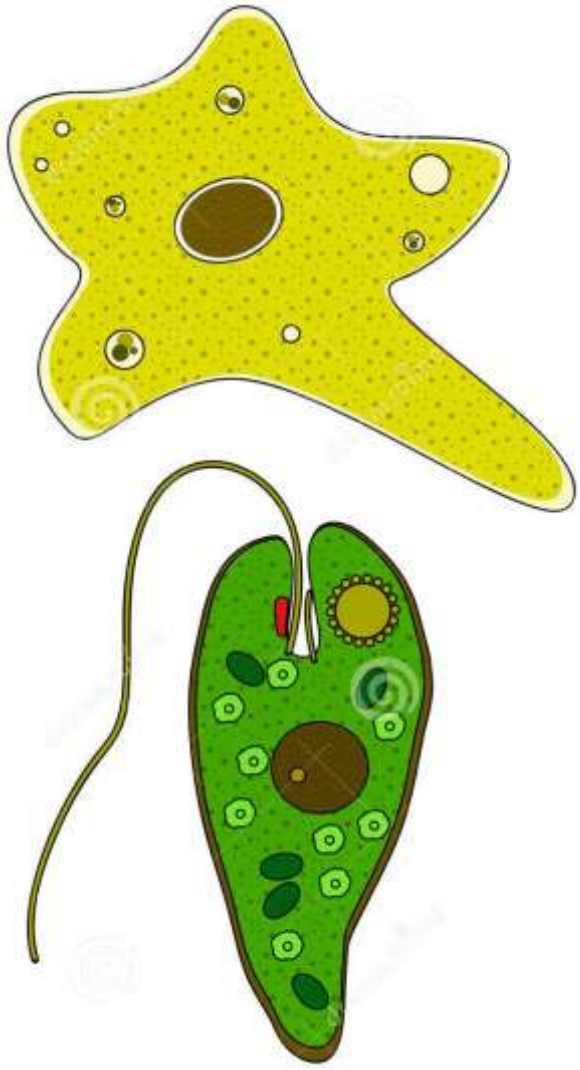
FUNGI

- **The third category of pathogens are fungi.**
  - Fungi, like animals and plants, are classified as their own kingdom of life.
  - Like animals and plants, fungi are eukaryotic, meaning they have cellular organelle.
- **Fungi can be either unicellular (such as yeast) or multicellular (such as mushrooms).**
  - With bacteria, fungi are the main decomposers in the environment.
  - Ringworm in livestock is a well-known example of a disease caused by a fungal pathogen.

Source: http://www.scabies-killer.com/images/ringworm.jpg

PROTOZOA

- **<u>Protozoa</u> are the fourth category of pathogens.**
  - Protozoa are single-celled eukaryotes (they have cellular organelles).
    - *The amoebas and paramecium are common examples.*
  - Protozoa lack cell walls, which make them flexible and capable of quick movements.
- **Protozoa often invade the tissue of their hosts, causing tissue erosion and degradation.**
  - Other protozoa, including *Giardia*, cause infection of the large intestine, causing it to swell which prevents nutrient absorption and causes diarrhea, gas, and cramping.
  - Malaria is caused by the *Plasmodium* protozoa; when Plasmodium gets into the blood, it destroys red blood cells and causes anemia, alternating fever & chills, exhaustion, and often death.



Source: http://thumbs.dreamstime.com/z/protozoa-22943129.jpg

HELMINTHS

- **Helminths, or parasitic worms, comprise the fifth category of pathogens.**
  - Helminths are multicellular eukaryotes with tube-like bodies.
  - There are three main classes of helminthes: nematodes (roundworms), cestodes (tapeworms), and trematodes (flukes).
  - Helminths are unique because they do not proliferate inside their hosts; their offspring will usually be passed in fecal matter from animal hosts so that they can infect other animals.
  - Most helminths develop slowly inside their hosts, and usually symptoms are mild and have a slow onset.
- **Helminths can affect their hosts in a variety of ways.**
  - Both adults and larva can cause diseases depending on the species.
  - The severity of the symptoms depends on the concentration of helminths inside the host.
  - Helminths affect the host's tissue in a number of ways, but typically they cause disruption either by physically disrupting the tissue of the host or by taking nutrients from the host's body.

Source: http://bingsti.ru/styled/files/0440043804 41-1.jpg

EXAMPLES OF HELMINTHS

- **Examples of helminth diseases include the following:**
  - Hookworms are a kind of helminth and cause anemia (lack of red blood cells) and malnutrition.
  - Some helminths burrow into the skin or eyes causing itching, infection, and inflammation.
  - Cysticercosis is caused by a pork tapeworm and causes bumps to develop in the skin and muscles as well as neurological problems.
  - Echinococcus tapeworms cause liver failure, lung disease, and brain abnormalities.

Source: http://www.poultryhub.org/wp-content/uploads/2012/05/Helminths-Ascaridia-galli-in-S.jpg

PRIONS

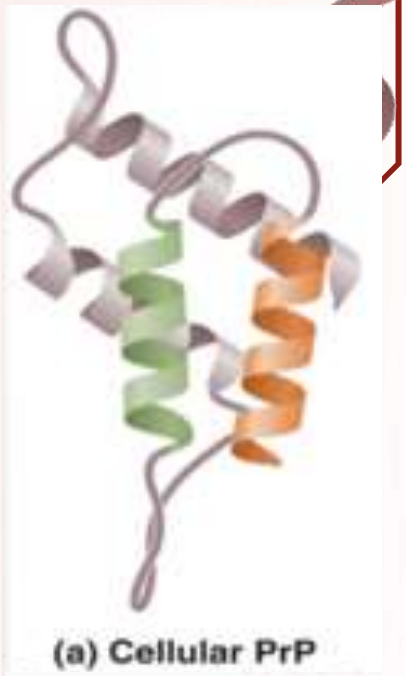
- **Prions are the most-recently discovered class of pathogens.**
  - Prions are infectious proteins. They are not alive and are not a kind of living species.

- **Prions affect their host by causing abnormal folding of the host's proteins.**
  - Like a key for a lock, the function of a protein depends on its shape.
  - When a prion alters the shape of a protein, it changes its function and makes it useless (much like if you bent a key at an angle, it would not work in a lock).
  - The abnormal folding or proteins leads to tissue loss in the brain of the host, leading to literal holes in the brain.
  - Bovine Spongiform Encephalopathy (BSE, or Mad Cow), Chronic Wasting Disease (CWD, common in deer and elk), and scrapie (common in sheep) are common forms of animal prion diseases.
  - Humans prion diseases include Creutzfeldt-Jakob Disease (CJD) and Kuru.

PRION DISEASES

- **Prion diseases are most commonly spread through ingestion of infected materials.**
  - For example, scrapie and mad cow disease (below) were transmitted to animals when they were fed rendered animal protein supplements from previously-infected animals.
  - Kuru was spread among the Fore people of New Guinea because of a practice of ritualized cannibalism.
  - CWD seems to be spread by saliva, urine, and feces and may have a correlation to populations of deer and elk that have high concentrations around a feeding area.
  - As of this time, there is no known treatment for any prion diseases.

Source: news.bbcimg.co.uk/media/images


(a) Cellular PrP


(b) Prion PrP

Source: quizlet.com

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