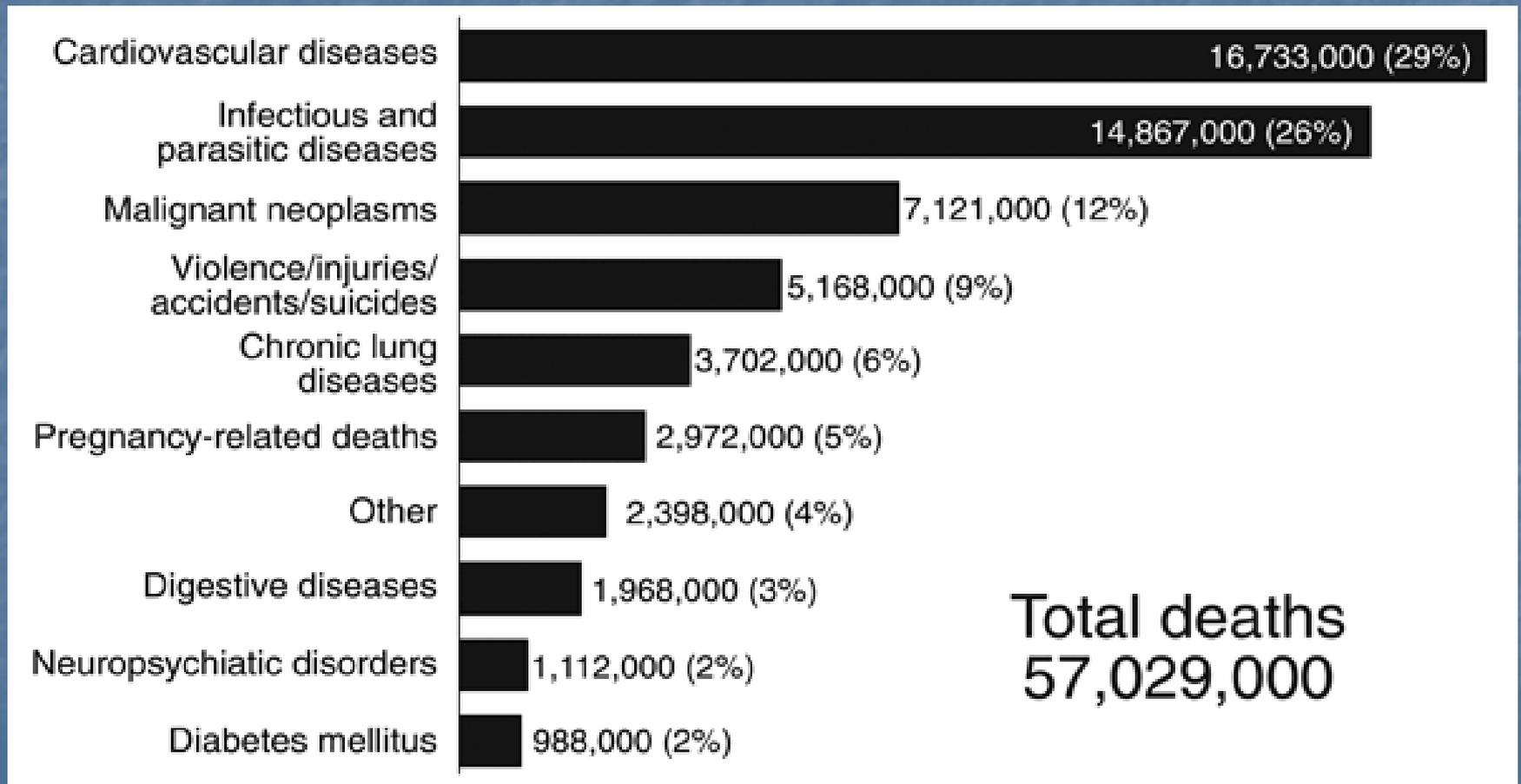


An
Introduction
to
Infectious Diseases

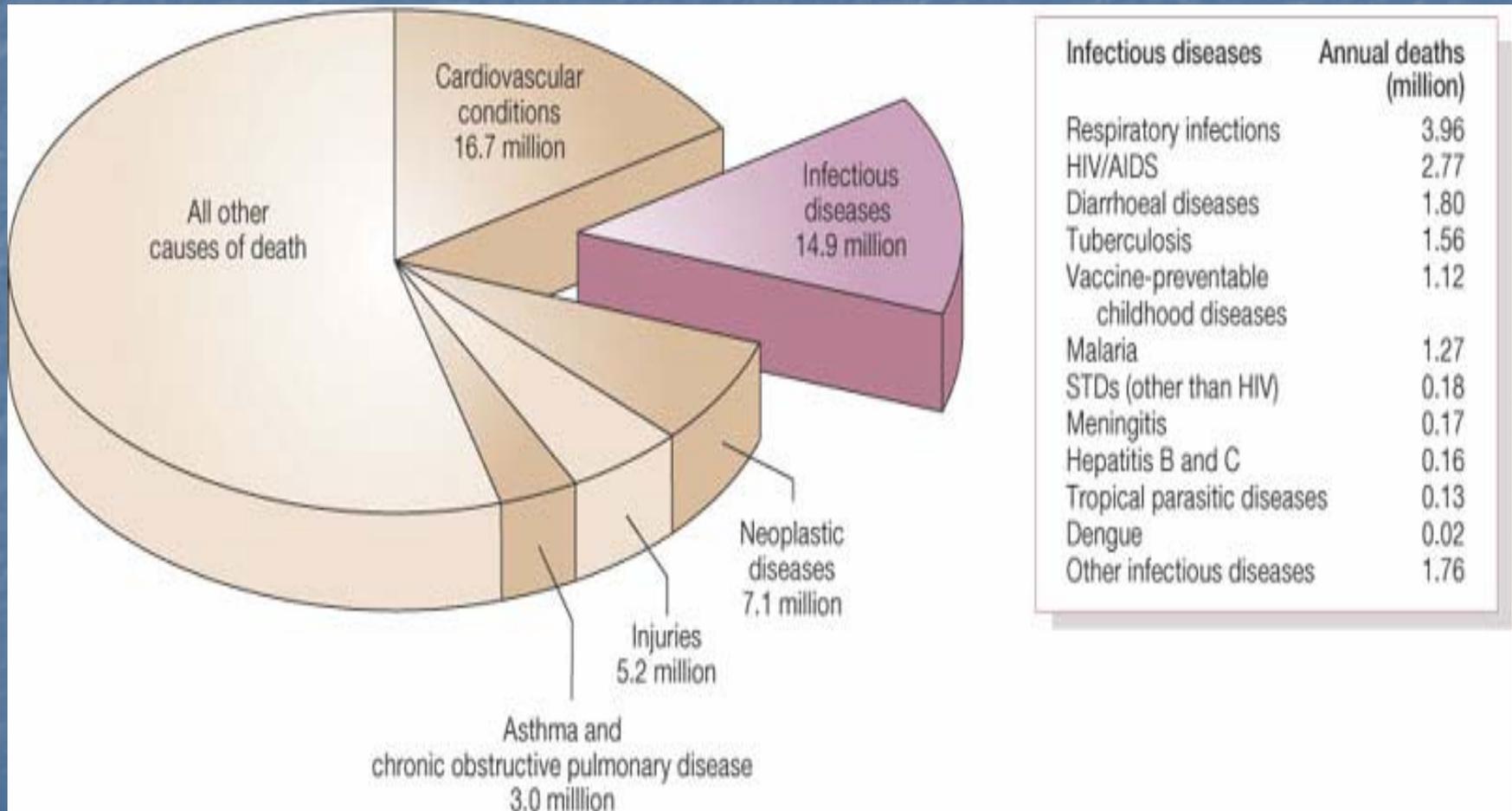
Shira Shafir, PhD, MPH

24 January 2008

Infectious Diseases



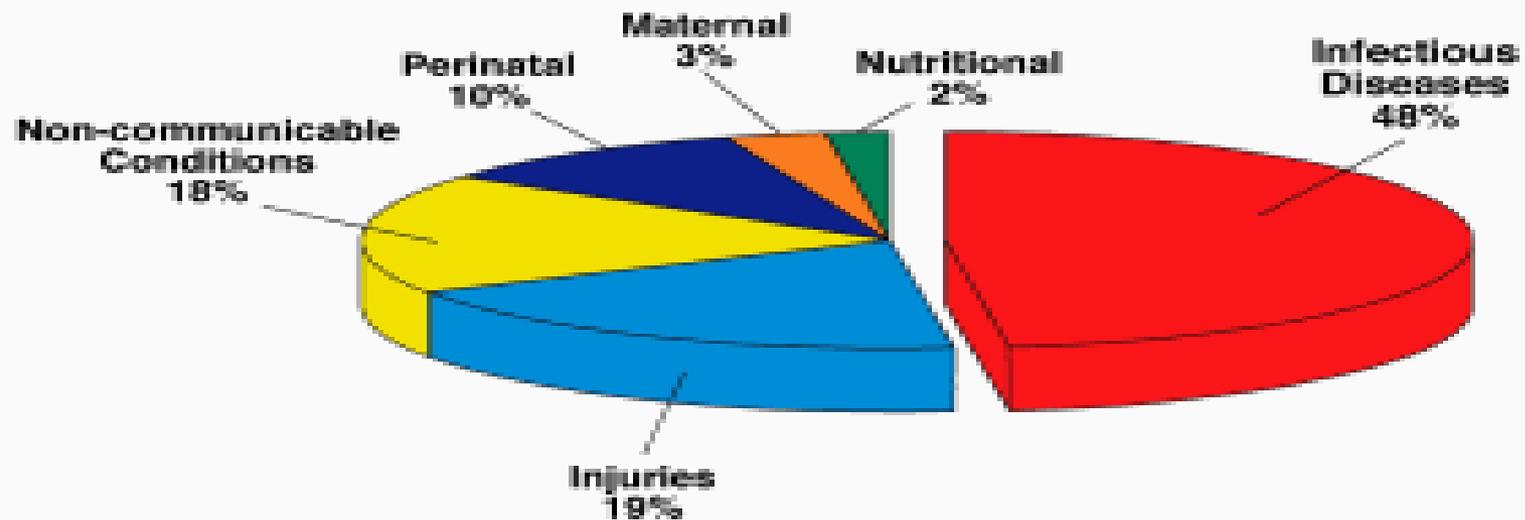
Infectious Diseases



About 15 million (>25%) of 57 million annual deaths worldwide are the direct result of infectious disease. Figure published by the World Health Organization.

Infectious Diseases

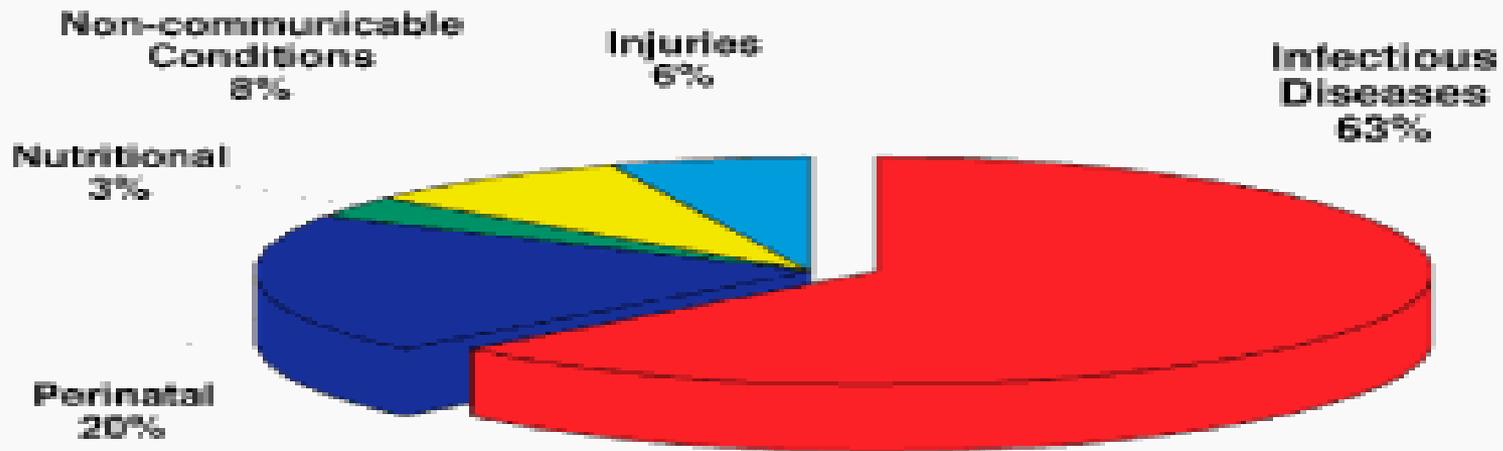
Leading Causes of Death Worldwide: Individuals <45 Years



Source: WHO

Infectious Diseases

Leading Causes of Death Worldwide: Children <5 Years

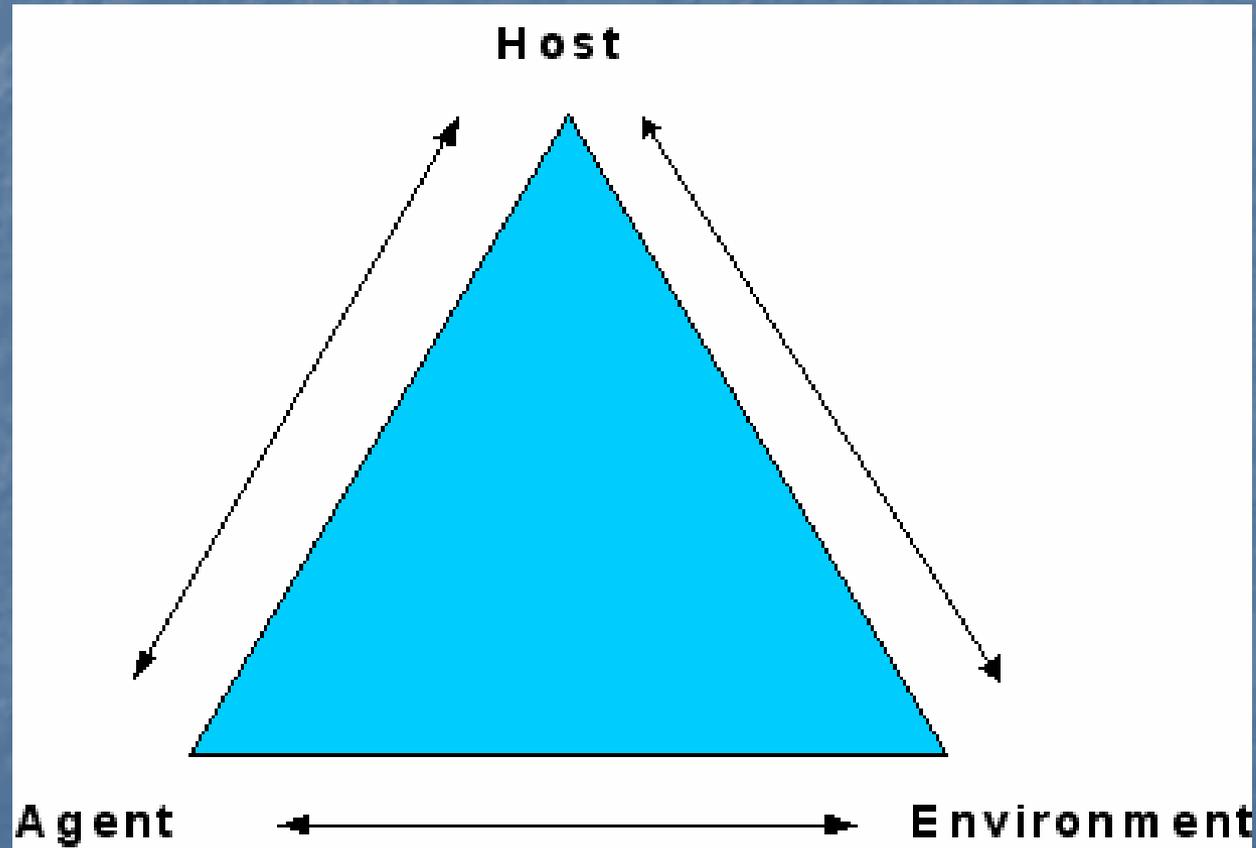


Source: WHO, 1999

Infectious Diseases

- Among the almost infinite varieties of microorganisms, relatively few cause disease in otherwise healthy individuals.
 - Microorganisms that cause disease are known as pathogens.
- Infectious disease results from the interplay between those few pathogens and the defenses of the hosts they infect.
- The appearance and severity of disease resulting from any pathogen depends upon the ability of that pathogen to damage the host as well as the ability of the host to resist the pathogen.

Infectious Diseases



Infectious Diseases

- While the spread of a pathogenic microorganism is influenced by characteristics of the host, the agent and the environment, the ability of the microorganism to cause disease is influenced by factors related to the agent and the host.

Infectious Diseases

- There's a distinct difference between infection and disease.
 - Infection, often the first step, occurs when pathogens enter the body and begin to multiply.
 - Disease occurs when the cells in the body are damaged — as a result of the infection — and signs and symptoms of an illness appear.

Portals of Exit and Entry

- In order for a pathogen to cause disease, it must leave its previous host and enter a new host.
- Portals of Exit and Entry include:
 - Nose (secretions)
 - Mouth (saliva, sputum)
 - Broken skin (blood)
 - Penis or Vagina (urine, semen or vaginal secretions)
 - Anus (feces)

Mode of transmission

- There are three general modes by which a pathogen can be transported from one host to another:
 - Direct
 - Airborne
 - Indirect

Mode of transmission

- Direct transmission:
 - By direct or immediate transfer of the agent to an appropriate portal of entry by personal contact, e.g. touching, biting, kissing, sexual intercourse
 - By the direct projection of droplets onto the new host (through sneezing, coughing), but this must occur over a very short distance (1 meter or less) to be considered direct
 - Example of spread by direct transmission:

Mode of transmission

- Airborne transmission- Transfer of an infectious agent via air over longer distances (greater than 1 meter)
 - Results when the agent can remain suspended in the air for longer periods of time and/or over larger areas
 - Occurs when agents are suspended in either droplet nuclei (fluid) or attached to dust particles
 - Examples of airborne transmission:

Mode of transmission

- Indirect transmission requires less intimate contact with the source
- Two major types of indirect transmission are:
 - Vehicle-borne
 - Vector-borne

Mode of transmission

- For vehicle borne transmission, contaminated inanimate materials transfer the agent.
 - These include fomites:
 - Fomites are objects such as clothes, bedding, eating utensils needles, surgical instruments, water, food, milk, blood and transplanted organs
 - Examples of vehicle borne diseases:

Mode of transmission

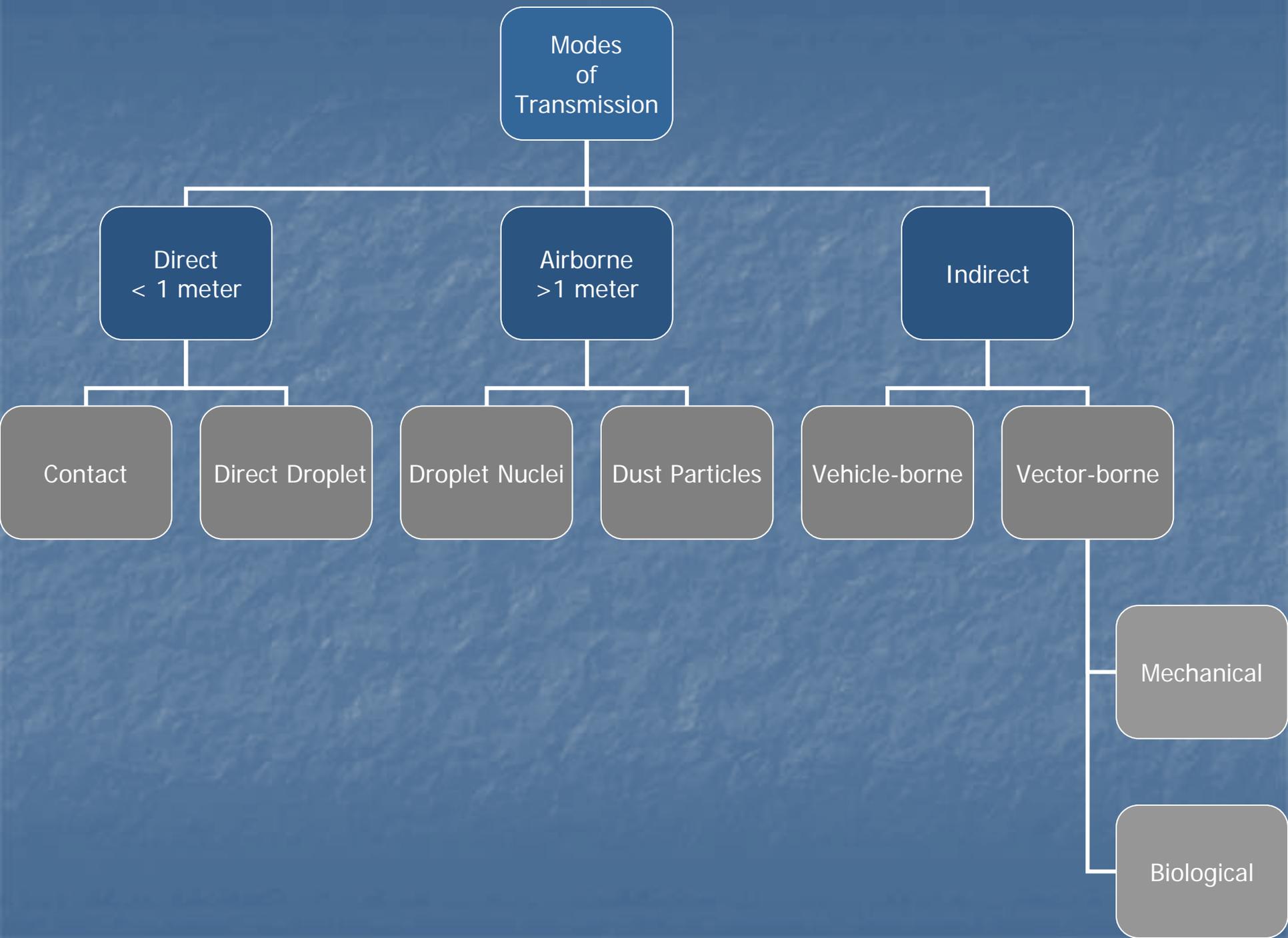
- Vector borne transmission involves a living organism (besides a human).
- Vector borne transmission usually involves an arthropod
- There are two general types of vector borne modes:
 - Mechanical
 - Biological

Mode of transmission

- For mechanical vector borne transmission, the organism is transmitted when it is carried on the vector's body or passed through the vector's gastrointestinal tract
- The agent does not multiply or develop in the mechanical host
 - Examples of mechanical vector-borne disease:

Mode of transmission

- With a biological vector, multiplication and/or some part of the agent's development must occur in the vector before the agent can be transferred to humans.
 - Examples of biological vector borne disease:



Modes of Transmission

Direct < 1 meter

Airborne > 1 meter

Indirect

Contact

Direct Droplet

Droplet Nuclei

Dust Particles

Vehicle-borne

Vector-borne

Mechanical

Biological

Infectious Diseases

- Infectious diseases are caused by pathogenic microorganisms, such as:
 - Bacteria
 - Viruses
 - Parasites
 - Fungi
 - Prions

Infectious Diseases

- Successful pathogens are those that are able to use the environment provided by the host.
- The nature and degree of exploitation varies from relationship to relationship, but the pathogen's primary requirement is a supply of metabolic materials from the host or nuclear synthetic machinery.

Infectious Diseases

- Intracellular pathogens take the things they need to survive and reproduce directly from the pool of nutrients available in the cell.
- Extracellular pathogens take the things they need to survive and reproduce from the nutrients present in tissue fluids, or they feed directly on the cells.

Infectious Diseases

- Pathogens within cells are protected from many of the host's defense mechanisms, like antibodies.
- While extracellular pathogens can grow and reproduce freely and can move extensively throughout the body, they are continuously exposed to the body's defense mechanisms.

Introduction

Bacteria

- Bacteria are unicellular prokaryotic organisms
 - They have no organized internal membranous structures such as nuclei, mitochondria, or lysosomes.
 - Their genomes are circular, double-stranded DNA that is associated with much less protein than eukaryotic genomes'.
 - Most bacteria reproduce by growing and dividing into two cells in a process known as binary fission.
- Despite these commonalities that group them together in the Kingdom Monera, there is a wide range of diversity among the bacteria.

Introduction

Bacteria

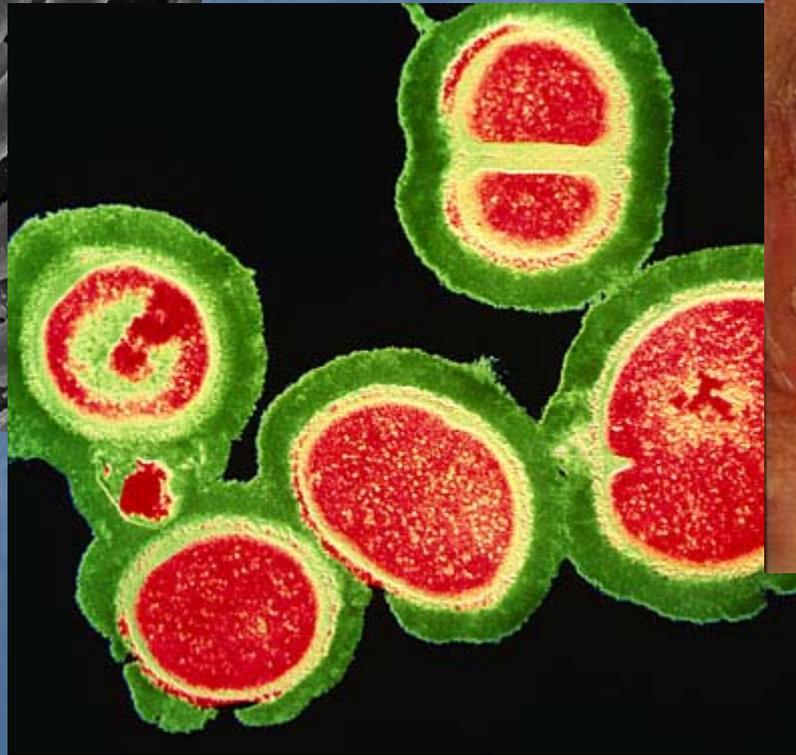
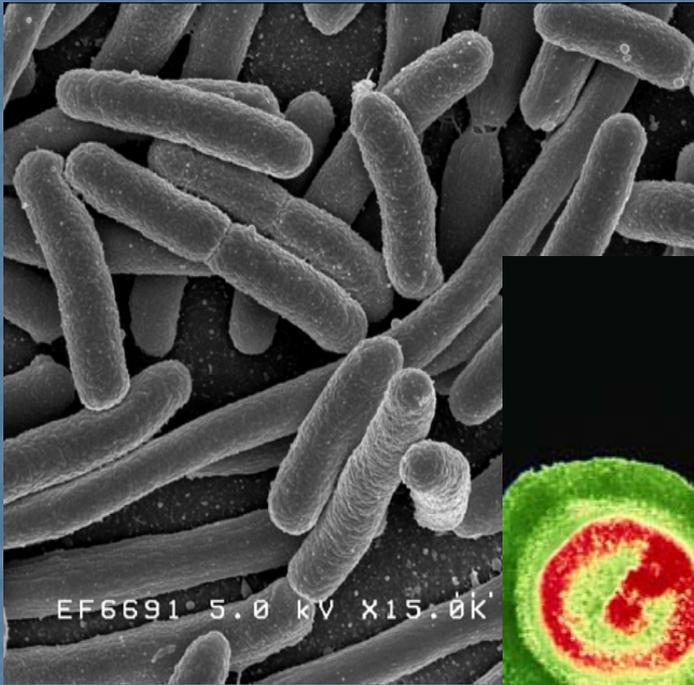
- In developed countries, 90 percent of documented infections in hospitalized patients are caused by bacteria.
- These cases probably reflect only a small percentage of the actual number of bacterial infections occurring in the general population, and usually represent the most severe cases.
- In developing countries, a variety of bacterial infections often exert a devastating effect on the health of the inhabitants.
 - Malnutrition, parasitic infections, and poor sanitation are a few of the factors contributing to the increased susceptibility of these individuals to bacterial pathogens.

Introduction

Bacteria

- The World Health Organization has estimated that each year, 3 million people die of tuberculosis, 0.5 million die of pertussis, and 25,000 die of typhoid.
- Diarrheal diseases, many of which are bacterial, are the second leading cause of death in the world (after cardiovascular diseases), killing 5 million people annually.

Introduction Bacteria



Introduction

Bacteria

- Bacteria, and only bacteria, can be treated using antibiotics.
- Antibiotics work by inhibiting one of the following:
 - Cell wall synthesis
 - Protein synthesis
 - Nucleic acid synthesis
 - Cell membrane function
- Some antibiotics are bacteriocidal (they kill the bacteria) and some are bacteriostatic (they prevent the bacteria from growing so the immune system can conquer the bacteria).

Introduction

Viruses

- Viruses are not organisms themselves because, apart from a host cell, they have no metabolism and cannot reproduce.
- A virus particle is composed of a viral genome of nucleic acid that is surrounded by a protein coat called a capsid.
 - In addition, many viruses that infect animals are surrounded by an outer lipid envelope, which they acquire from the host cell membrane as they leave the cell.
- Unlike organisms, in which the genetic material is always double-stranded DNA, viral genomes may be double- or single-stranded DNA (a DNA virus), or double- or single-stranded RNA (an RNA virus).

Introduction

Viruses

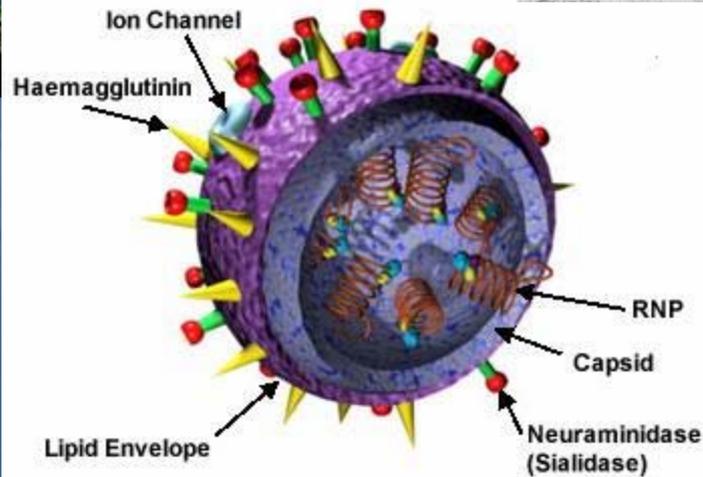
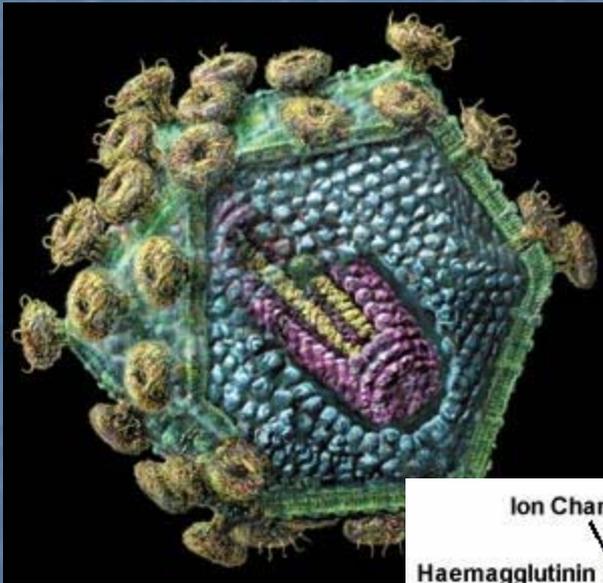
- Epidemiologic studies show that viral infections in developed countries are the most common cause of acute disease that do not require hospitalization.
- In developing countries, viral diseases also exact a heavy toll in mortality and permanent disability, especially among infants and children.

Introduction

Viruses

- Now that antibiotics effectively control many bacterial infections, viral infections pose a relatively greater and less controlled threat to human health.
- Some data suggest that all of the already established viral diseases soon may be expanded to include other serious human ailments such as juvenile diabetes, rheumatoid arthritis, various neurologic and immunologic disorders, and some tumors.

Introduction Viruses



Ebola Patient (Intensive Care)

Introduction

Viruses

- For most viral infections, there is no specific treatment because there are very few available anti-viral agents.
- This shortage is mostly due to the difficulty of interfering with viral activity without adversely affecting the host.
 - Research on HIV has stimulated intensive research on anti-viral drugs.
- Resistance also develops quickly to anti-virals because viruses can mutate quickly.

Introduction

Fungi

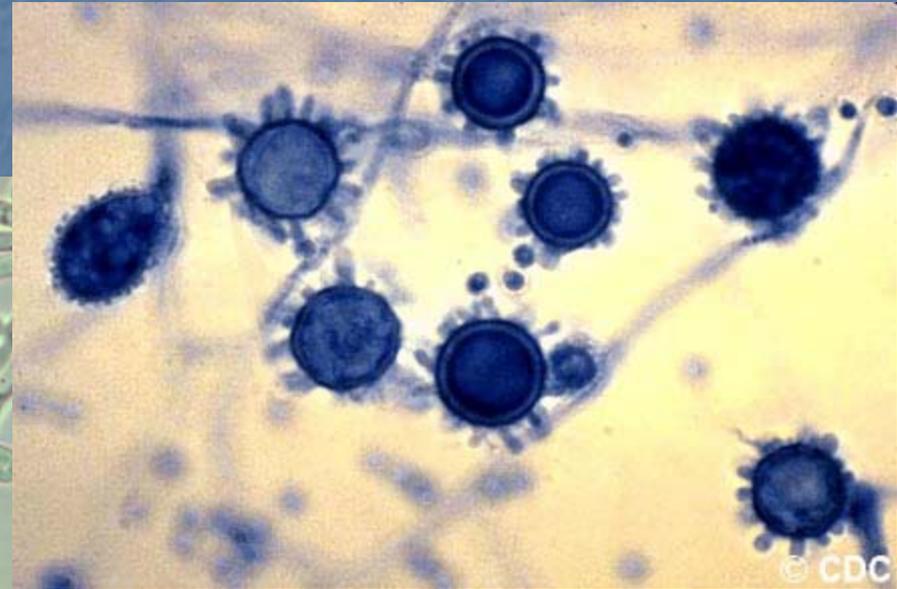
- Fungi are eukaryotic, heterotrophic organisms that have rigid cellulose- or chitin-based cell walls and reproduce primarily by forming spores.
- Most fungi are multicellular, although some, such as yeasts, are unicellular.
- Together with bacteria, fungi fulfill the indispensable role of decomposers in the environment.
- Many fungi also infect plants and animals.

Introduction

Fungi

- Of the approximately 70,000 recognized species of fungi, about 300 are known to cause human infections.
- Fungal diseases of healthy humans tend to be relatively benign, but the few life-threatening fungal diseases are extremely important.
- Fungal diseases are an increasing problem due to the use of antibacterial and immunosuppressive agents.
 - Individuals with an altered bacterial flora or compromised defense mechanisms (e.g., AIDS patients) are more likely than healthy people to develop opportunistic fungal infections such as candidiasis.

Introduction Fungi



Introduction

Fungi

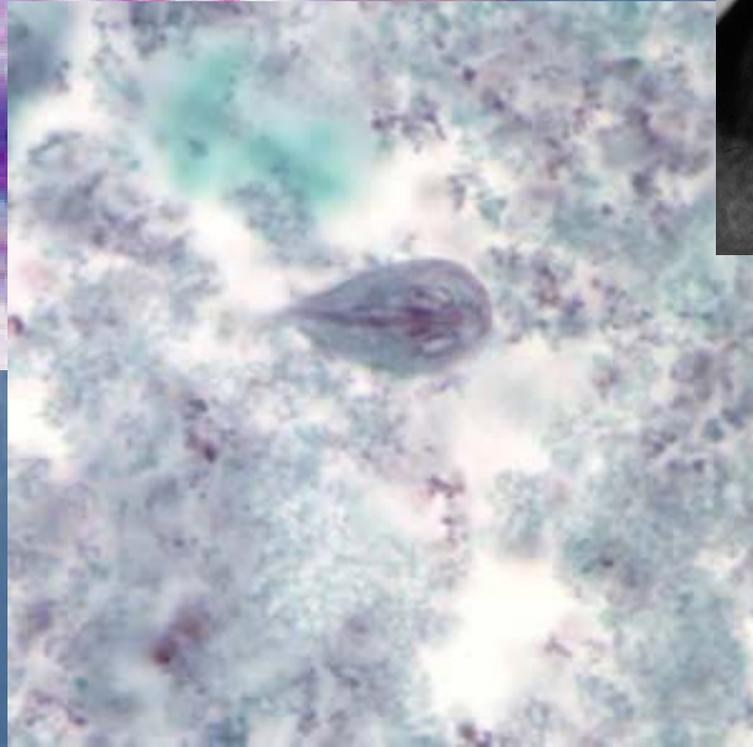
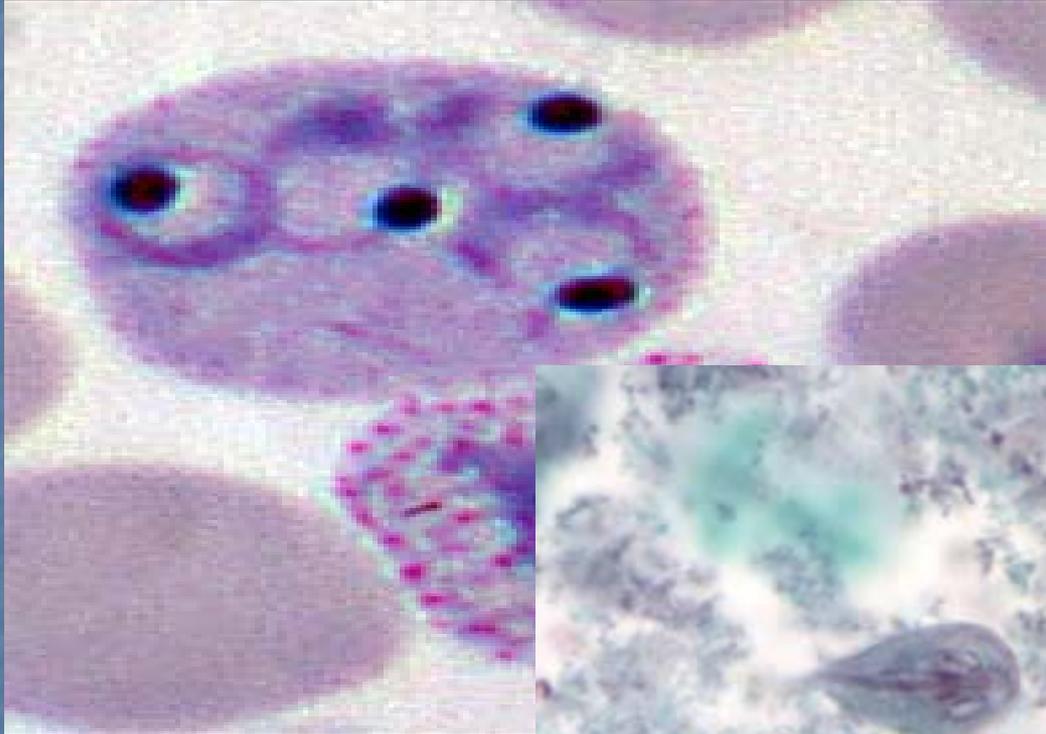
- Fungal infections are treated with anti-fungals, but the number of drugs available and suitable for treatment is very limited.
 - It is very difficult to develop drugs that kill fungal cells without damaging human cells.

Introduction

Protozoa

- Protozoa are unicellular, heterotrophic eukaryotic parasites that include the familiar amoeba and paramecium.
- Because protozoa do not have cell walls, they are capable of a variety of rapid and flexible movements.
- Protozoa can be acquired through contaminated food or water or by the bite of an infected arthropod such as a mosquito.

Introduction Protozoa

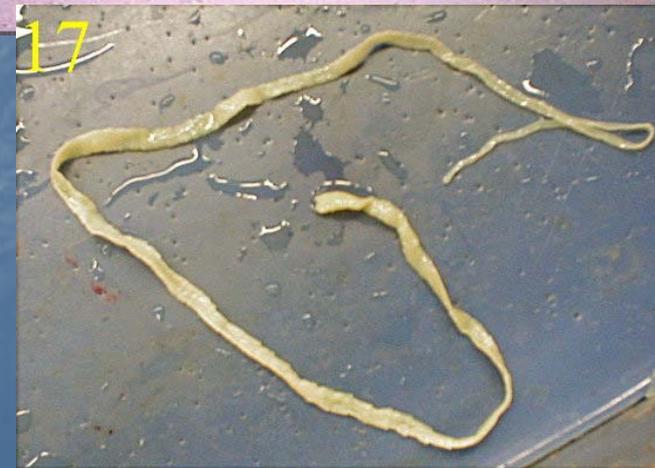


Introduction

Helminths

- Helminths are simple, invertebrate animals, some of which are infectious parasites.
- They are multicellular and have differentiated tissues.
- Because they are animals, their physiology is similar in some ways to ours.
 - This makes parasitic helminth infections difficult to treat because drugs that kill helminths are frequently very toxic to human cells.

Introduction Helminths



Introduction Helminths



Introduction

Parasites

- Infections of humans caused by parasites number in the billions and range from relatively innocuous to fatal.
- The diseases caused by these parasites constitute major human health problems throughout the world.
 - Approximately 30 percent of the world's population is infected with the nematode *Ascaris lumbricoides*.
- The incidence of many parasitic diseases (e.g., schistosomiasis, malaria) have increased rather than decreased in recent years.

Introduction

Parasites

- A wide array of drugs are available to treat protozoal and helminthic infections.
 - Drugs that have activity against protozoa are usually not active against helminths and vice versa.
- The problems of finding drugs that are toxic to the parasite but not to the person are considerable and a lot of anti-parasitic agents have unpleasant side effects.

Introduction

Prions

- During the past two decades, evidence has linked some degenerative disorders of the central nervous system to infectious particles that consist only of protein.
- These "proteinaceous infectious particles" have been named prions.
 - The known prion diseases include Creutzfeldt-Jakob disease (in humans), scrapie (in sheep), and bovine spongiform encephalopathy ("mad cow disease" in cattle); all known prion diseases frequently result in brain tissue that is riddled with holes.
- While some prion diseases are inherited, others are apparently due to infection by eating infected tissue or inadvertently through medical procedures such as tissue transplants.

Introduction

Prions

- Currently, there are no known treatments for prion infection.
- Prion infections in humans are always fatal.

Infectious Diseases Prevention and Control

- Infectious diseases can be controlled by drugs, immunizations and a “healthy” environment.
- Drugs and Immunizations aim to specifically control individual pathogens, while the healthy environment aims to improve health in general and prevent people from contracting all infectious diseases.

Strategies for Control of Infectious Diseases

General features	Water purification (waterborne diseases) Sewage disposal (enteric diseases) Improved nutrition (host defense) Improved housing (less crowding, dirt)
Food	Cold storage Pasteurization (milk and juices) Food inspection (meat, poultry, seafood) Adequate cooking
Zoonoses and arthropod-transmitted infections	Control of vectors (mosquitoes, fleas, ticks, lice) Control of reservoir animals
Specific disease treatment or prevention	Chemotherapy Vaccines
Miscellaneous measures	Changes in personal habits (reduced promiscuity, use of condoms, improved personal hygiene, control of IV drug use) Screening of transfused blood and donated organs

Infectious Diseases Epidemiology

- Epidemiology is the study of the distribution and determinants of health and diseases, morbidity, injuries, disability and mortality in populations.
- The word “epidemiology” derives from the word “epidemic” and all epidemiology was originally concerned with infectious diseases.

Infectious Diseases Epidemiology

- Epidemiologists have 4 main jobs:
 - **Describe** the occurrence of disease
 - Determine the “who,” “what,” “when,” and “where”
 - **Explain** the etiology of disease
 - Discover what is causing disease
 - Discover modes of transmission
 - **Predict** the occurrence of disease
 - Estimate the number of cases of disease that will occur
 - Identify the distribution of disease in populations
 - **Control** the distribution of disease
 - Prevent the occurrence of new cases of disease