



## Host Parasite Interactions Parasite Invasion Strategies

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### Strategies microbes use to invade the skin

1. **Infect skin itself** – Many microbes can infect the unbroken surface of the skin itself. Fungi and several species of bacteria have evolved to grow at a pH of 5. Most infections of unbroken skin take place in moister areas such as the feet and groin. Some bacteria such as *Propionibacterium acnes*, which causes acne, can even break down sebum and use it as a source of food.

- Fungi (can survive low pH) - athlete's foot, ringworm
- Bacteria – Staphylococci, coryneforms
- Viruses – wart viruses live in dead skin cells

2. **Take advantage of breaks in skin** – Breaks in the skin allow direct access into the body.

- Cuts
- Catheters - which allow direct access into already sick patients
- Burns – *Pseudomonas*

3. **Arthropod vectors** – Many microbes enter the body when a tick or insect bite allows the microbe to cross the skin.

- Bacteria – Lyme disease, Rocky Mountain Spotted Fever
- Parasites – malaria, Chaga's disease, African sleeping sickness
- Viruses – yellow fever, viral encephalitis

4. **Animal bites** -

- Rabies - virus makes some animals confused and aggressive such that they bite

5. **Crossing Skin** – Larval stages of various worms can bore directly across the skin.

- *Shistosoma*, swimmer's itch - larval worms in water
- Hookworm - larval worms in soil

## Strategies microbes use to invade the eyes

**1. Take advantage of small scratches in the conjunctiva** - Small scratches in the conjunctiva can be introduced in several ways, sand, dust, insects, contact lenses. Scratches make it easier for microbes to infect the conjunctiva.

- *Chlamydia trachomatis* (causes blindness) can attach to the conjunctiva and cause infection, especially when small scratches are present
- Viruses - enterovirus 70, coxsackie A24, adenovirus 8 also attach to the conjunctiva and cause infection

**2. Insects may produce scratches and introduce pathogens at the same time**

- Chaga's disease, transmitted by the reduvid bug (kissing bug)

**3. Cold viruses are introduced into the eye** - when people rub their eyes after touching a surface contaminated with a cold virus.

- The viruses are then washed by tears into the nose through a small duct
- Once in the nose the virus then infects the mucus membranes.

## Strategies microbes use to invade the mouth

**1. Attach to teeth**

- *Streptococcus mutans* (causes dental caries or cavities) converts glucose into dextran, which is sticky, and then attaches to teeth

**2. Attach to epithelial cells** - Host cells have a wide variety of proteins and carbohydrates on their surface that serve as receptors and markers. Invading microbes take advantage of this and produce proteins which allow specific attachment to a particular host surface protein.

**3. Take advantage of reduced saliva** - Saliva is continually washing the surfaces of our mouth and removing potential invaders which are then swallowed. Dehydrated individuals can suffer more oral infections

**4. Lysozyme resistance** - Inhabitants of the mouth co-evolved with lysozyme and are thus at least partially resistant to lysozyme.

## Strategies microbes use to invade the nose

### 1. Avoid being trapped by currents -

Tuberculosis, is transmitted on extremely small particles that are inhaled deep into lungs

**2. Attach to epithelial cells** - Host cells have a wide variety of proteins and carbohydrates on their surface that serve as receptors and markers. Invading microbes take advantage of this and produce proteins which allow specific attachment to a particular host surface protein.

- Rhinovirus which is one cause of the common cold binds a specific receptor (I-CAM) on the surface of respiratory cells.
- Rhinovirus also increases I-CAM expression by respiratory cells so that more virus can bind

## Strategies microbes use to invade the throat or bronchi

**1. Attach to epithelial cells** - Host cells have a wide variety of proteins and carbohydrates on their surface that serve as receptors and markers. Invading microbes take advantage of this and produce proteins which allow specific attachment to a particular host surface protein.

- M protein of *Streptococcus pyogenes* (causes Strep throat) binds pharyngeal cells
- Hemagglutinin on influenza virus binds sialic acid on epithelial cells

**2. Destroy or slow cilia** - When cilia are destroyed or slowed, the mucociliary escalator is no longer able to move mucus up into the throat. Thus invading microbes are no longer removed and are able to establish an infection.

- Influenza virus, *Bordetella pertussis* (whooping cough), and *Haemophilus influenza* all interfere with ciliary activity
- Smoking damages and paralyzes cilia
- Dry air also damages cilia

**3. Break down mucus** - When mucus is broken down it becomes watery. The mucociliary escalator is no longer able to trap and remove potential invaders.

- Influenza virus produces an enzyme, neuraminidase, that breaks down mucus

## Strategies microbes use to invade the lungs

**1. Take advantage of damaged mucus and cilia** - When the mucociliary escalator is damaged, access to the lung is much easier since potential invaders are not removed. Some infections of the upper airway (Influenza virus, *Bordetella pertussis* (whooping cough), and *Haemophilus influenza*) leave patients particularly susceptible to secondary lung infections

- Bacteria - *Mycoplasma* and *Chlamydia pneumoniae*
- Viruses - many that cause "walking pneumonia"

**2. Escape phagocytosis** - Many bacteria produce a capsule which is a slimy polysaccharide layer that surrounds the bacteria and prevents phagocyte from attaching to bacteria.

- *Streptococcus pneumoniae*
- *Haemophilus influenza*
- *Bordetella pertussis*

**3. Live within phagocytes** - some bacteria can actually live within the cells which are designed to destroy them.

- *Mycobacterium tuberculosis* is surrounded by a waxy layer of mycolic acids that protects it from the degradative enzyme of the phagocyte.
- *Chlamydia* escape from the phagosome such that they are not exposed to the toxic environment of the lysosome.

## Strategies microbes use to invade the stomach

1. **Grow in the stomach** - Until recently, it was thought that no invading microbes were able to grow and colonize the stomach due to the very low pH. Recently, *Helicobacter pylori* has been shown to grow in the stomach and cause stomach ulcers. It survives stomach acid by secreting urea, thus raising the pH around itself.

2. **Survive stomach acid transiently** - All bacteria, viruses, and protozoa that pass through the stomach in order to infect the intestines must be at least transiently resistant to acid. There are several ways microbes protect themselves from stomach acid

- Capsule - a slimy polysaccharide layer covering the microbe
- Cyst - some microbes produce very resistant cysts

### Examples

- *Vibrio cholera* – the bacteria which causes cholera
  - not very acid resistant,
  - need  $10^8$  organisms for infection
  - Low stomach acidity makes one more susceptible to cholera ( $10^3$  –  $10^4$ )
- *Shigella dysenteriae* – the bacteria which causes dysentery
  - more acid resistant than *V. cholera*
  - only 10 organisms needed for infection

Some enteric pathogens even require passage through acid to activate them, this ensures that they activate in the correct environment.

## Strategies microbes use to invade the intestines

**1. Attachment** - All organisms living in the small intestine must attach to avoid being swept out of the intestine by peristalsis.

- *E. coli* secretes its own receptor rather than binding to host proteins
- Pili or fimbriae are commonly used to attach to villi of intestines
- *Giardia* uses specialized sucker cups, which change to evade immune response

**2. Invade epithelial cells** - Some microbes can enter and live in epithelial cells of the intestine.

- *Shigella* - causes dysentery
- enteric viruses

**3. Cross epithelial cells and enter blood** - Some invaders are able to cross the epithelial cell layer and enter the bloodstream. In this case the infection does not remain localized in the intestine, but rather spreads throughout the body.

- polio virus
- *Salmonella typhi* - causes typhoid fever

**4. Kill epithelial cells** - Some microbes produce toxins which inhibit eucaryotic protein synthesis and thus kill the intestinal epithelial cells. This leads to bloody diarrhea.

- *Shigella dysenteriae*
- *E. coli* O157:H7 - the strain which has caused problems recently

**5. Outcompete normal flora/take advantage of disruption of normal flora** - Many intestinal infections occur after a course of antibiotics which have disrupted the normal flora of the intestine, thus allowing other microbes to grow.