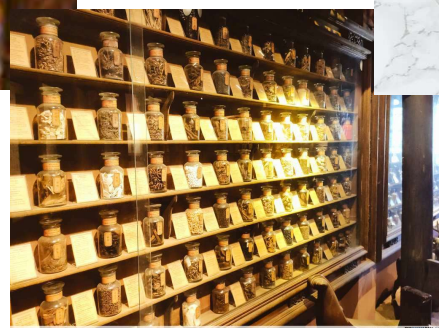


Infecções bacterianas de trato digestório

Dr. Svetoslav Dimitrov Todorov



Daegu Museum of Eastern Medicine

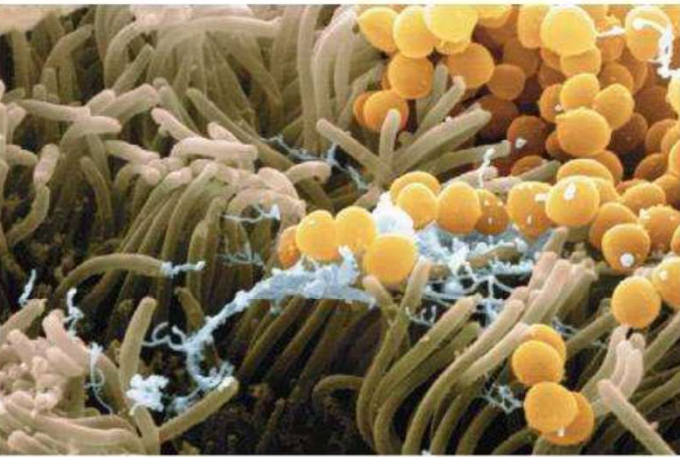


Paris Museum of Medicine



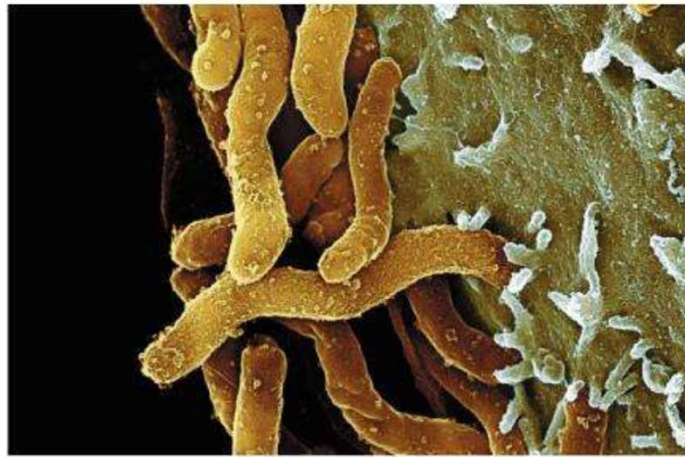
Museum of Microbiology, Amsterdam

Representative normal microbiota for different regions of the body



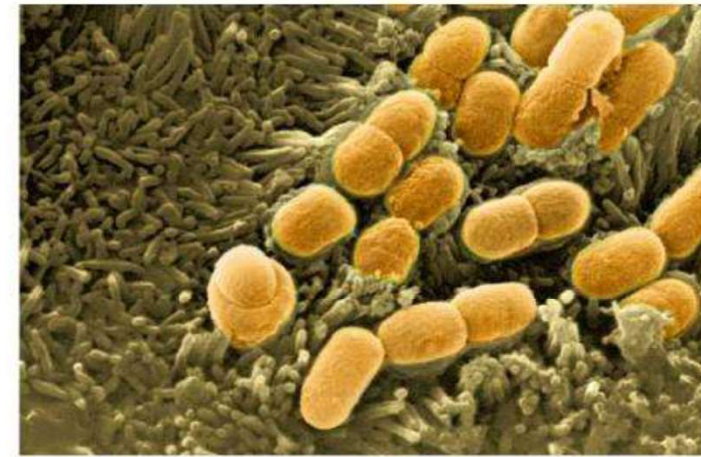
(a) Bacteria (orange spheres) on the surface of the nasal epithelium

SEM 2 μm



(b) Bacteria (brown) on the lining of the stomach

SEM 2.5 μm



(c) Bacteria (orange) in the small intestine

SEM 1 μm

- ✓ A typical human body contains 1×10^{13} body cells, yet harbours an estimated 1×10^{14} bacterial cells.
- ✓ **Human Microbiome Project** began in 2007 to analyse microbial communities called *microbiomes* that live in and on the human body.
- ✓ Its goal is to determine the relationship between changes in the human microbiome and human health and disease.

The dose makes the poison,

a principle of toxicology, was first expressed by Paracelsus.

It means that a substance can produce the harmful effect associated with its toxic properties only if it reaches a susceptible biological system within the body in a high enough concentration (dose).



Paracelsus

(**Philippus Aureolus Theophrastus Bombastus von Hohenheim**, 11 November or 17 December 1493 – 24 September 1541) was a German-Swiss Renaissance physician, botanist, alchemist, astrologer, and general occultist

Important food born pathogens... and other poisons

**Chemical agents
(heavy metals, pesticides,..and other
-cids)**

**Natural toxins produced by
microorganisms, plants and animals
(toxins, alcaloides, histamine...)**

Viruses (hepatite, poliovirus)

Parasites (amebas, helmintos)

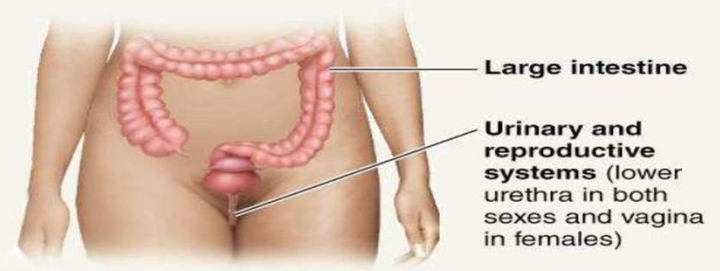
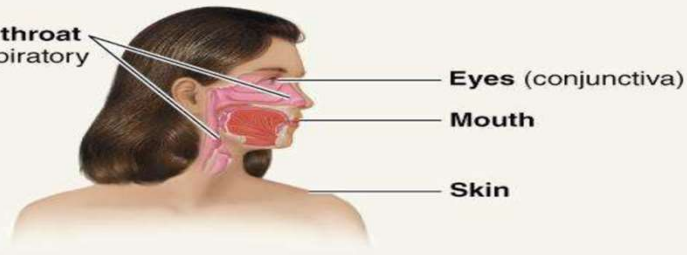
Pathogenic bacteria

Toxicogenic fungus

Representative Normal Microbiota by Body Region

TABLE 14.1 Representative Normal Microbiota by Body Region

Region	Principal Components	Comments
Skin	<i>Propionibacterium</i> , <i>Staphylococcus</i> , <i>Corynebacterium</i> , <i>Micrococcus</i> , <i>Acinetobacter</i> , <i>Brevibacterium</i> ; <i>Candida</i> (fungus), <i>Malassezia</i> (fungus)	<ul style="list-style-type: none"> • Most of the microbes in direct contact with skin do not become residents because secretions from sweat and oil glands have antimicrobial properties. • Keratin is a resistant barrier, and the low pH of the skin inhibits many microbes. • The skin also has a relatively low moisture content.
Eyes (Conjunctiva)	<i>Staphylococcus epidermidis</i> , <i>S. aureus</i> , diphtheroids, <i>Propionibacterium</i> , <i>Corynebacterium</i> , streptococci, <i>Micrococcus</i>	<ul style="list-style-type: none"> • The conjunctiva, a continuation of the skin or mucous membrane, contains basically the same microbiota found on the skin. • Tears and blinking also eliminate some microbes or inhibit others from colonizing.
Nose and throat (upper respiratory system)		
Nose and Throat (Upper Respiratory System)	<i>Staphylococcus aureus</i> , <i>S. epidermidis</i> , and aerobic diphtheroids in the nose; <i>S. epidermidis</i> , <i>S. aureus</i> , diphtheroids, <i>Streptococcus pneumoniae</i> , <i>Haemophilus</i> , and <i>Neisseria</i> in the throat	<ul style="list-style-type: none"> • Although some normal microbiota are potential pathogens, their ability to cause disease is reduced by microbial antagonism. • Nasal secretions kill or inhibit many microbes, and mucus and ciliary action remove many microbes.
Mouth	<i>Streptococcus</i> , <i>Lactobacillus</i> , <i>Actinomyces</i> , <i>Bacteroides</i> , <i>Veillonella</i> , <i>Neisseria</i> , <i>Haemophilis</i> , <i>Fusobacterium</i> , <i>Treponema</i> , <i>Staphylococcus</i> , <i>Corynebacterium</i> , and <i>Candida</i> (fungus)	<ul style="list-style-type: none"> • Abundant moisture, warmth, and the constant presence of food make the mouth an ideal environment that supports very large and diverse microbial populations on the tongue, cheeks, teeth, and gums. • Biting, chewing, tongue movements, and salivary flow dislodge microbes. Saliva contains several antimicrobial substances.

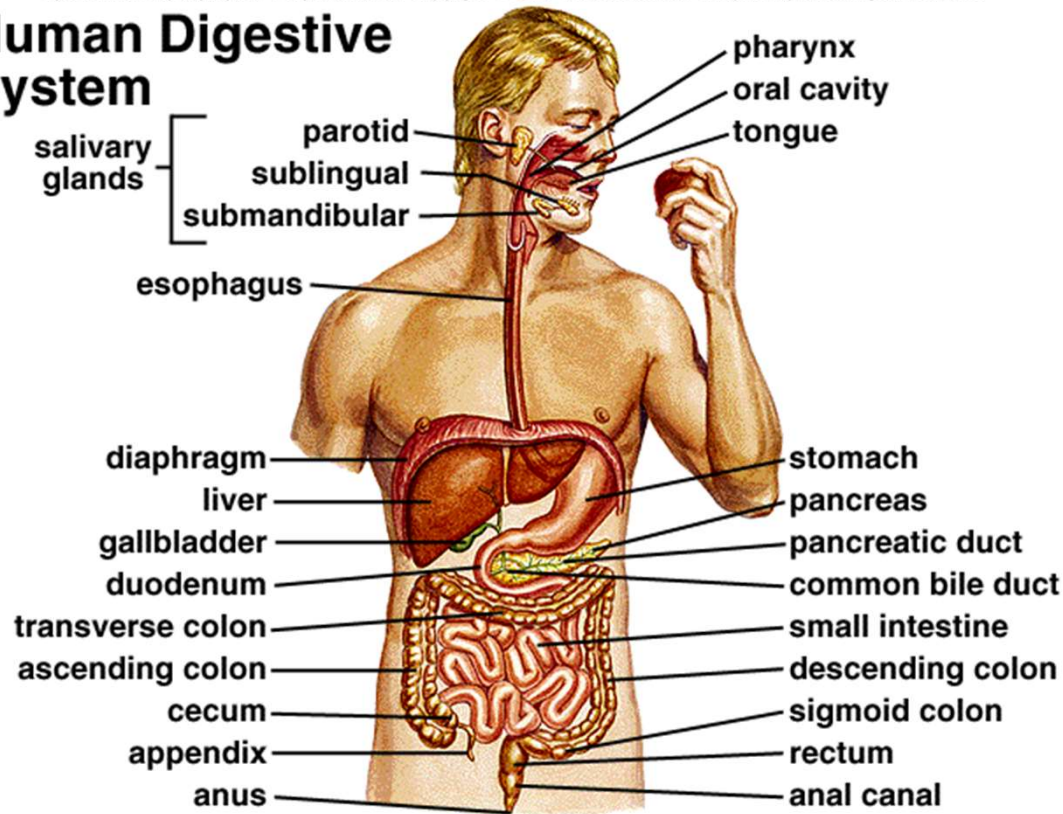


Representative Normal Microbiota by Body Region

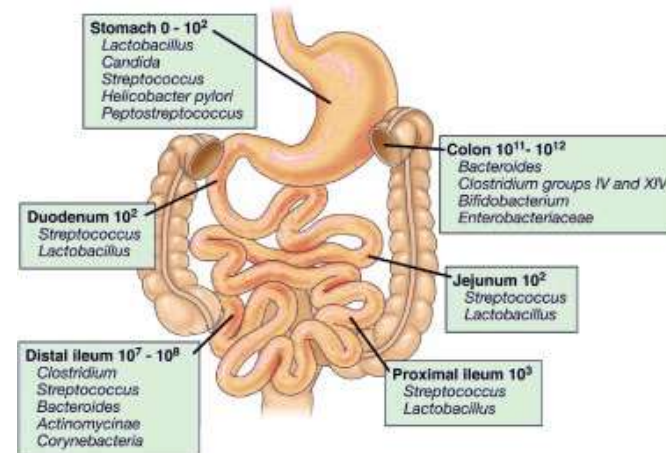
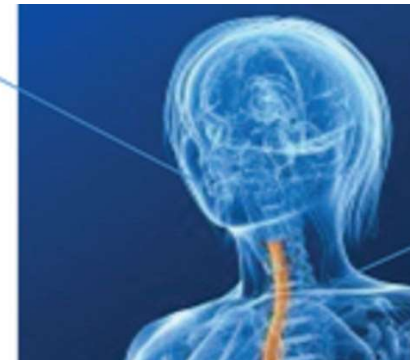
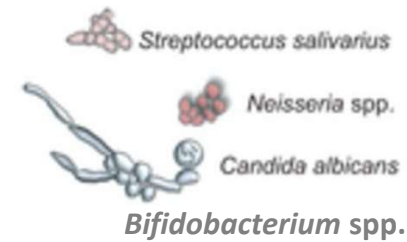
TABLE 14.1 Representative Normal Microbiota by Body Region

Region	Principal Components	Comments
Large Intestine	<i>Escherichia coli</i> , <i>Bacteroides</i> , <i>Fusobacterium</i> , <i>Lactobacillus</i> , <i>Enterococcus</i> , <i>Bifidobacterium</i> , <i>Enterobacter</i> , <i>Citrobacter</i> , <i>Proteus</i> , <i>Klebsiella</i> , <i>Candida</i> (fungus)	<ul style="list-style-type: none"> • The large intestine contains the largest numbers of resident microbiota in the body because of its available moisture and nutrients. • Mucus and periodic shedding of the lining prevent many microbes from attaching to the lining of the gastrointestinal tract, and the mucosa produces several antimicrobial chemicals. • Diarrhea also flushes out some of the normal microbiota.
Urinary and Reproductive Systems	<i>Staphylococcus</i> , <i>Micrococcus</i> , <i>Enterococcus</i> , <i>Lactobacillus</i> , <i>Bacteroides</i> , aerobic diphtheroids, <i>Pseudomonas</i> , <i>Klebsiella</i> , and <i>Proteus</i> in urethra; lactobacilli, <i>Streptococcus</i> , <i>Clostridium</i> , <i>Candida albicans</i> (fungus), and <i>Trichomonas vaginalis</i> (protozoan) in vagina	<ul style="list-style-type: none"> • The lower urethra in both sexes has a resident population; the vagina has its acid-tolerant population of microbes because of the nature of its secretions. • Mucus and periodic shedding of the lining prevent microbes from attaching to the lining; urine flow mechanically removes microbes, and the pH of urine and urea are antimicrobial. • Cilia and mucus expel microbes from the cervix of the uterus into the vagina, and the acidity of the vagina inhibits or kills microbes.




Human Digestive System

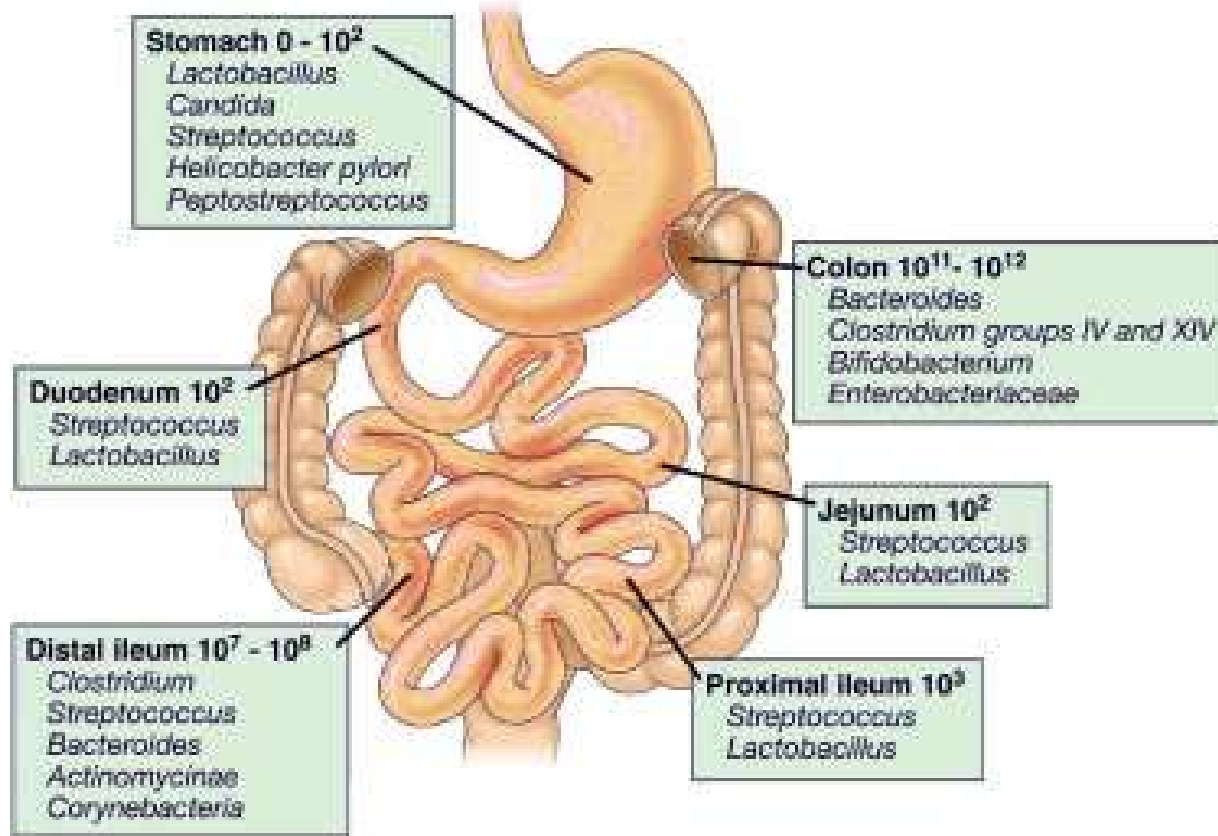


Mouth, Pharynx & Respiratory System



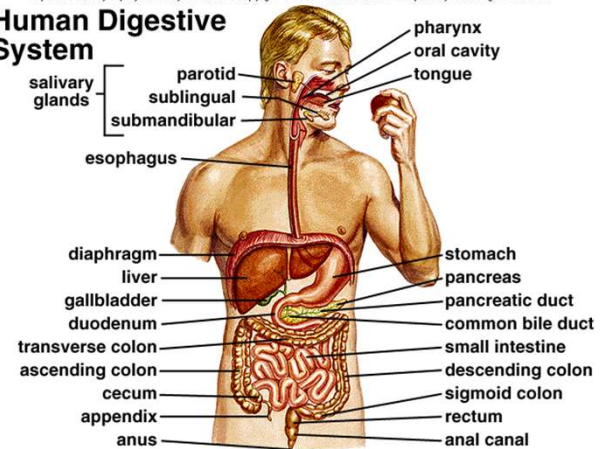
Mouth, Pharynx & Respiratory System

-  *Streptococcus salivarius*
-  *Neisseria* spp.
-  *Candida albicans*
- Bifidobacterium* spp.

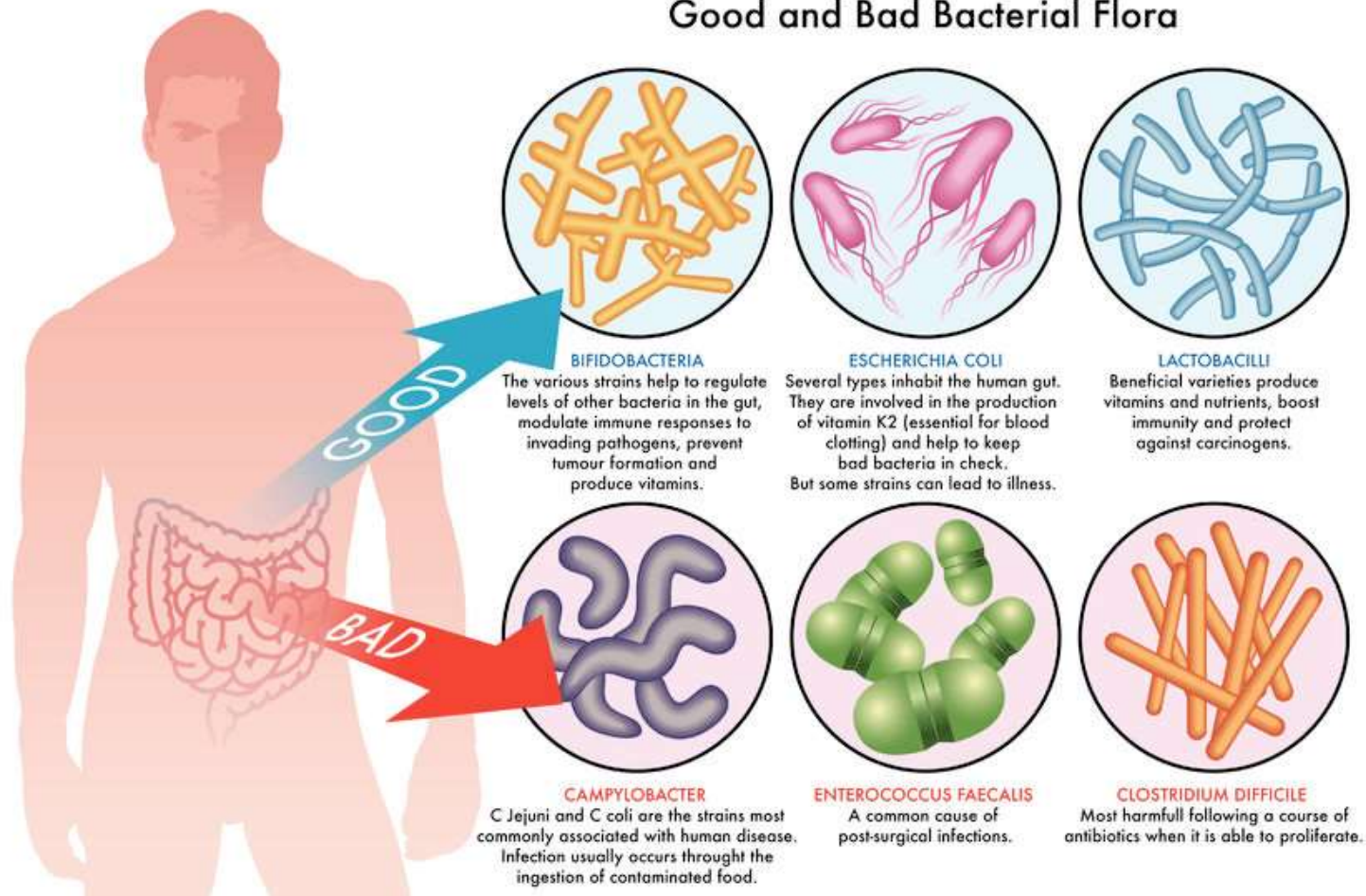


Sylvia S. Mader, Inquiry into Life, 8th edition. Copyright © 1997 The McGraw-Hill Companies, Inc. All rights reserved.

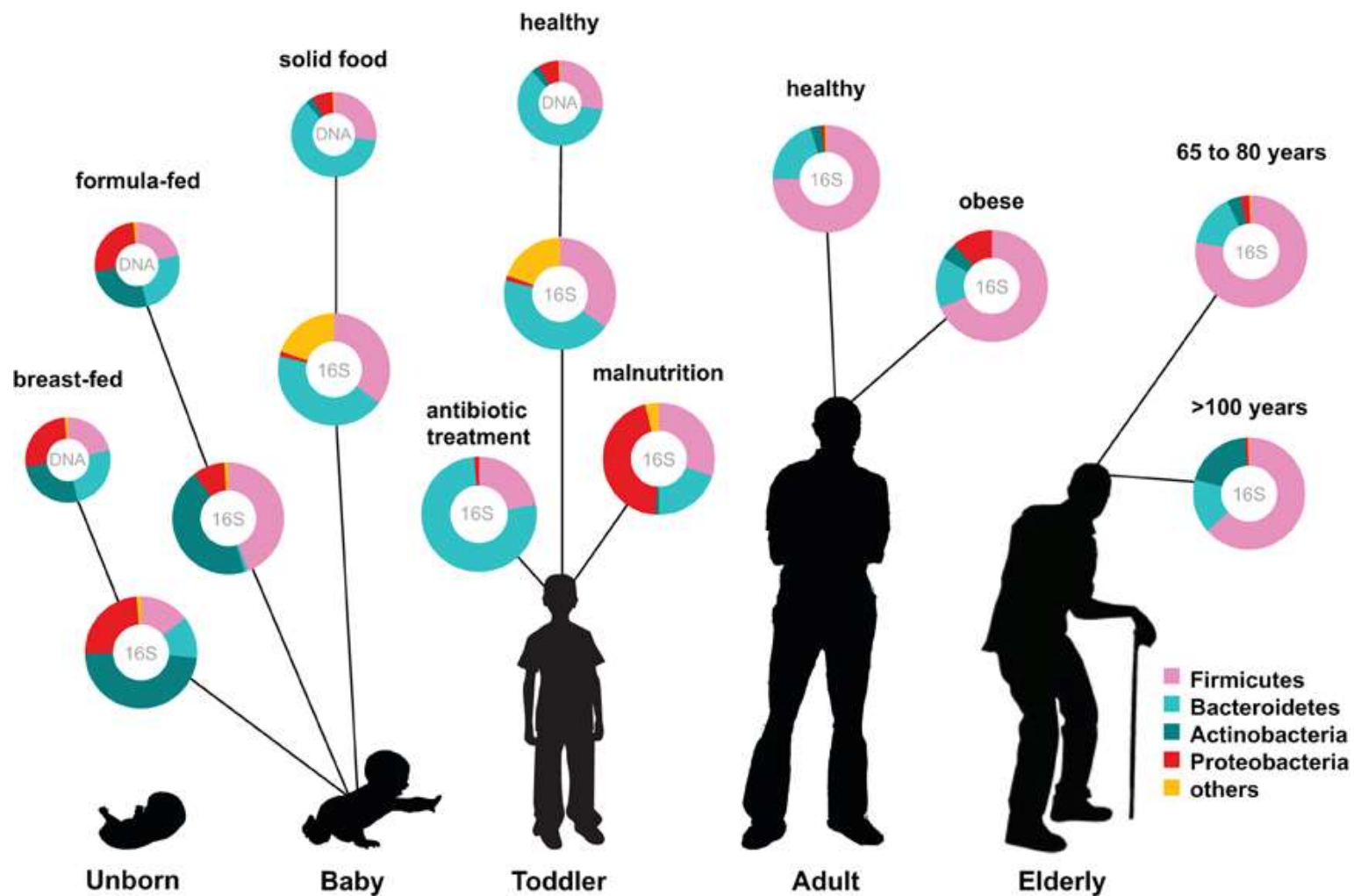
Human Digestive System



Good and Bad Bacterial Flora



90% of the bacterial phlotypes are member of two phyla Bacteroidetes and Firmicutes, followed by Actinobacteria and Proteobacteria (Sivieri et al., 2017).



To manipulate the bacterial balance via antimicrobials producing bacteria, can be a way to have treatment of obesity?

Defense mechanisms

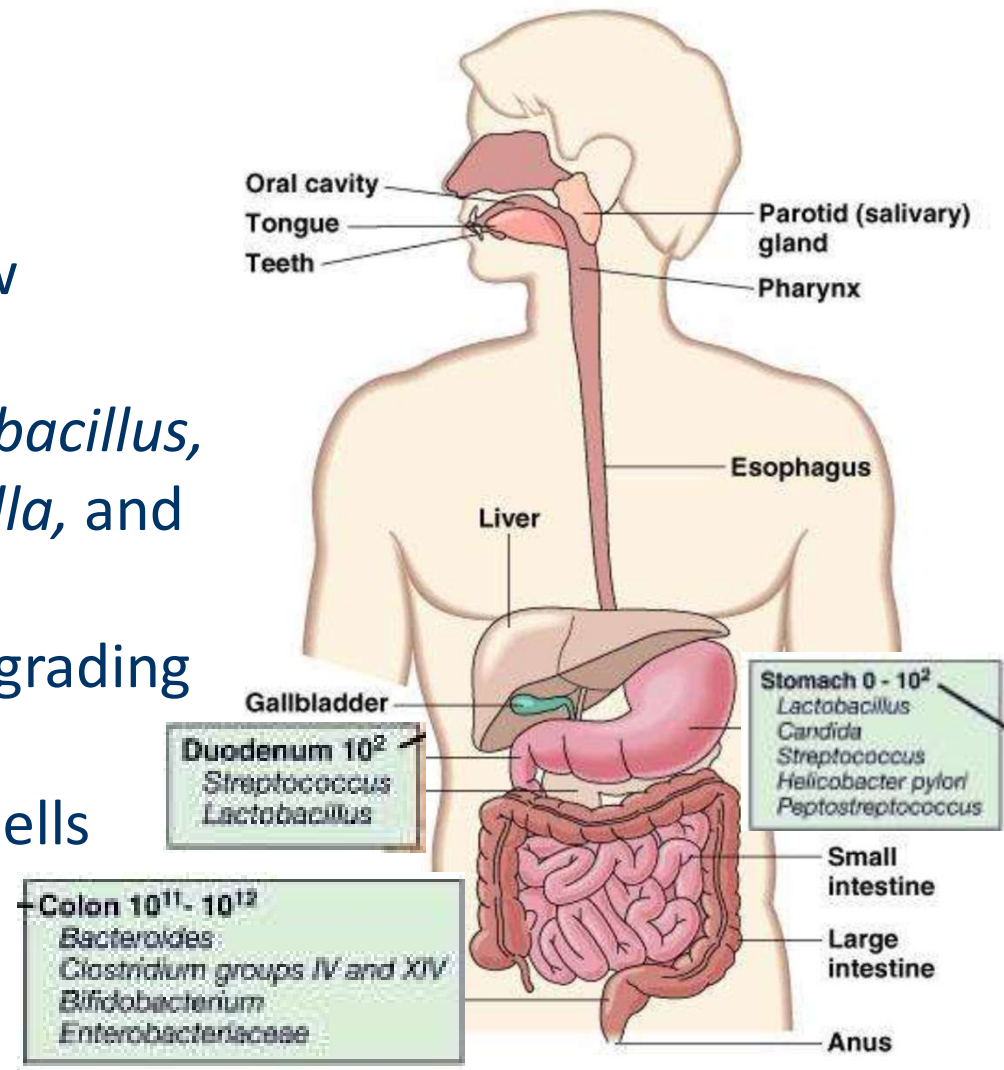
- ❖ Defense microbiota in mouth, bacterial interaction, antimicrobial properties of saliva
- ❖ Acid levels of the stomach, and digestive enzymes
- ❖ Intestinal mucosa layer (some pathogens, such as *E.coli* can produce mucin)
- ❖ Presence of beneficial microbiota in the GIT
- ❖ Phagocytes, specialized cell responsible for defense against pathogens
- ❖ Antibodies, immunoglobulins (Ig), produced by lymphocytes

Microbial Disease of the Digestive Systems

- Diseases of the digestive system are **the second most common** illnesses in the United States and **principal** in low income countries.
- Transmitted in food and water
- Diseases of the digestive system usually result from the **ingestion of microorganisms** and **their toxins** in food and water.
- The **faecal-oral cycle** of transmission can be broken by:
 - Proper sewage disposal
 - Disinfection of drinking water
 - Proper food preparation and storage

Normal Microbiota of the Digestive System

- A wide variety of bacteria colonize.
- **>300 species** in intestine and mouth
- The stomach and small intestine have few resident microorganisms.
- The large intestine is the habitat of *Lactobacillus*, *Bacteroides*, *E. coli*, *Enterobacter*, *Klebsiella*, and *Proteus*.
- Bacteria in the large intestine assist in degrading food and synthesizing **vitamins**.
- Up to 30~40% of fecal mass is microbial cells ($10^{11} \sim 10^{12}$ /gram of faeces).



Bacterial Diseases of the Mouth

- Dental Caries (Tooth Decay)

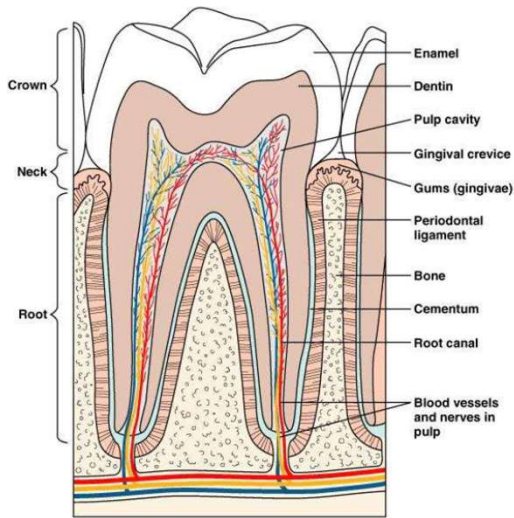
- Dental caries begin when tooth enamel and dentin are eroded, and the pulp is exposed to bacterial infection.

- ***Streptococcus mutans***, found in the mouth, uses **sucrose** to form **dextran** from **glucose** and **lactic acid** from **fructose**.

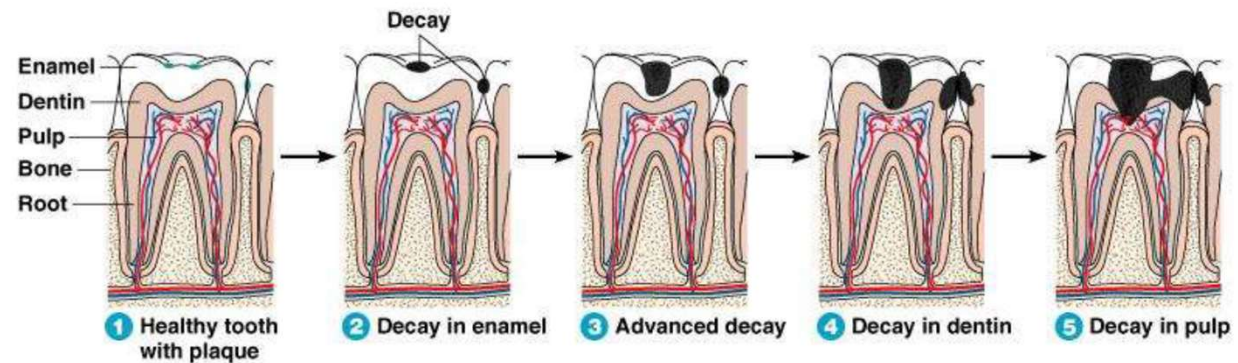
- Bacteria adhere to teeth and produce **sticky dextran**, forming dental plaque.

- **Acid** produced during carbohydrate fermentation destroys **tooth enamel** at the site of the plaque.

- Gram-positive rods and filamentous bacteria can penetrate dentin and pulp.

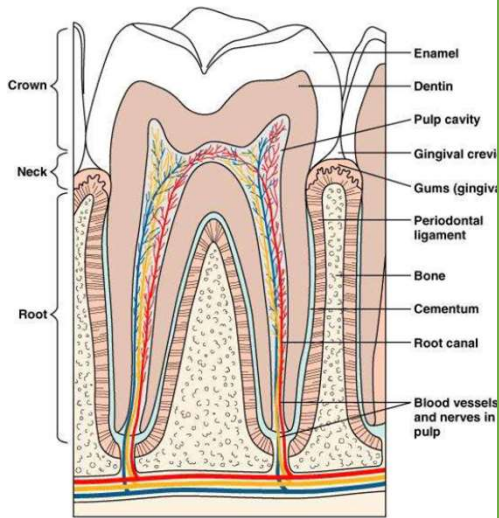


- Carbohydrates such as starch, **xylitol**, mannitol, and sorbitol are **not** used by cariogenic bacteria to produce dextran and do **not** promote tooth decay.
- Caries are prevented by restricting the ingestion of **sucrose** and by the physical removal of plaque.



Bacterial Diseases of the Mouth

- Dental Caries (Tooth Decay)

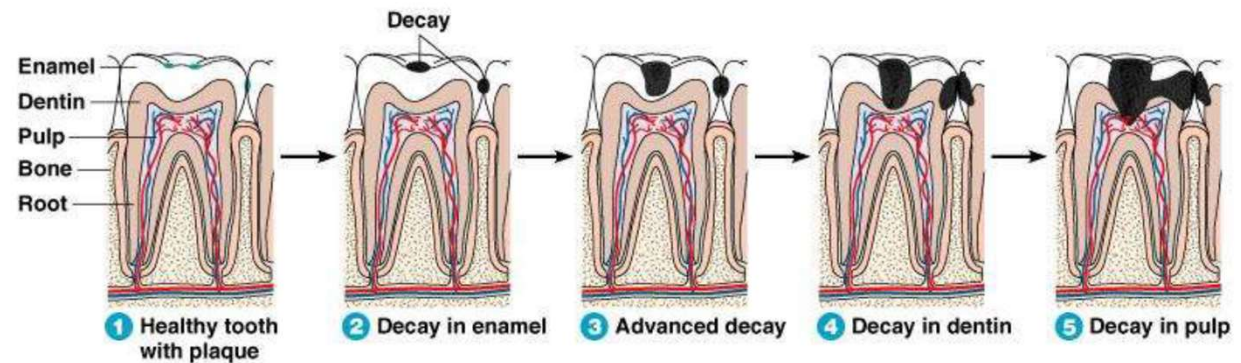


Sucrose \rightarrow glucose + fructose

Dextran

lactic acid

- Carbohydrates such as starch, **xylitol**, mannitol, and sorbitol are **not** used by cariogenic bacteria to produce dextran and do **not** promote tooth decay.
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Bacterial Diseases of the Mouth

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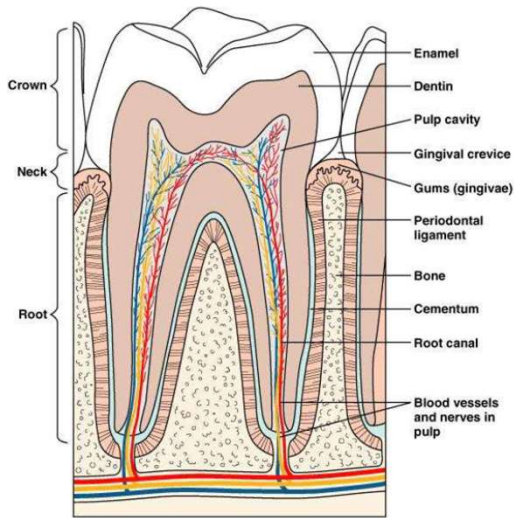
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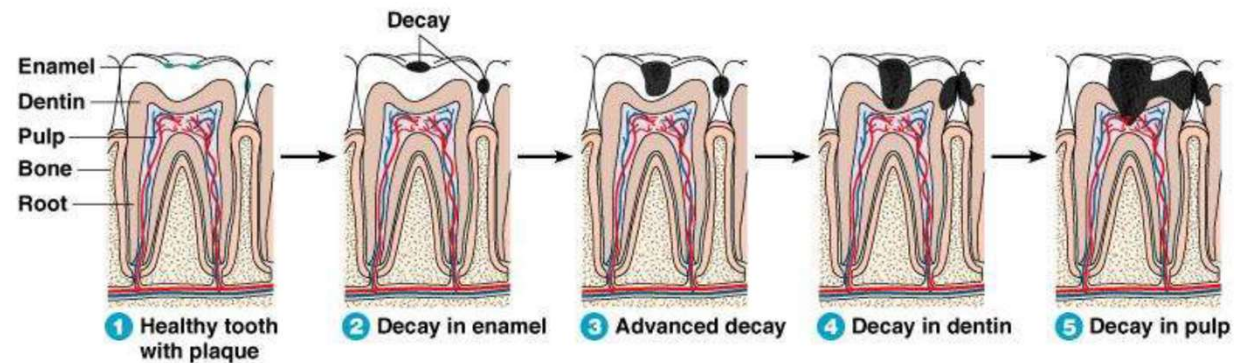
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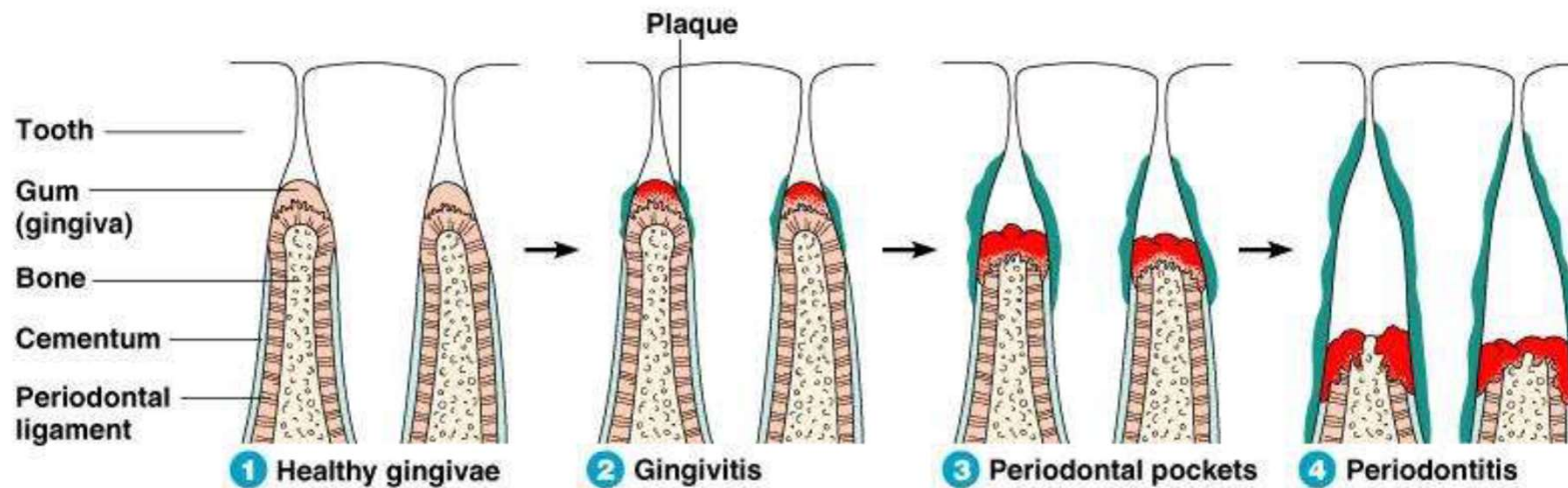
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Bacterial Diseases of the Mouth

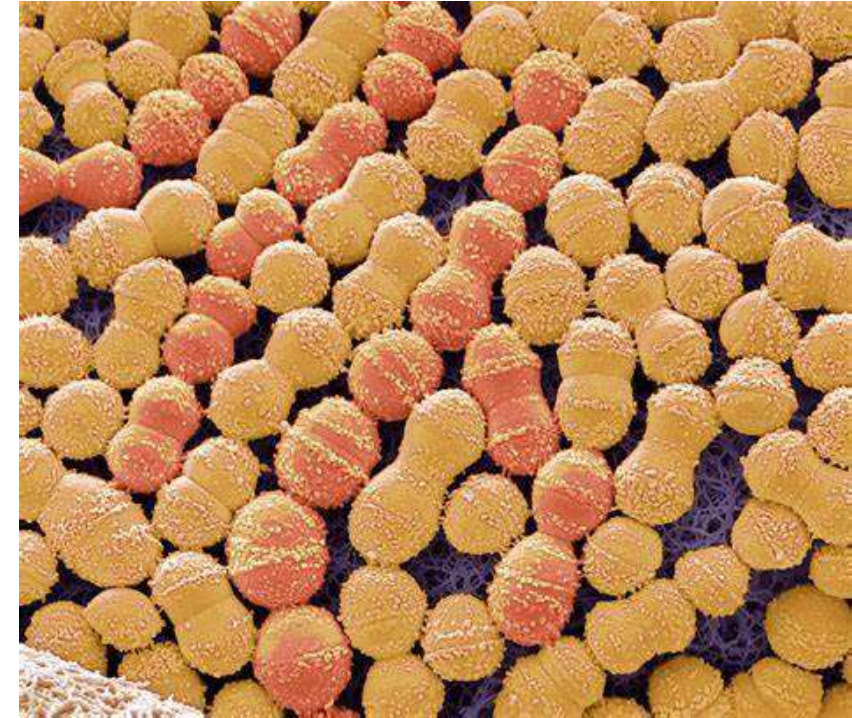


- Periodontal Disease
 - Caries of the cementum and gingivitis are caused by **streptococci, actinomyces**, and anaerobic Gram-negative bacteria.

Streptococcus mutans is a facultatively anaerobic, Gram-positive coccus (round bacterium) commonly found in the human oral cavity and is a significant contributor to tooth decay.

It is part of the "streptococci", an informal general name for all species in the genus *Streptococcus*. The microbe was first described by James Kilian Clarke in 1924.

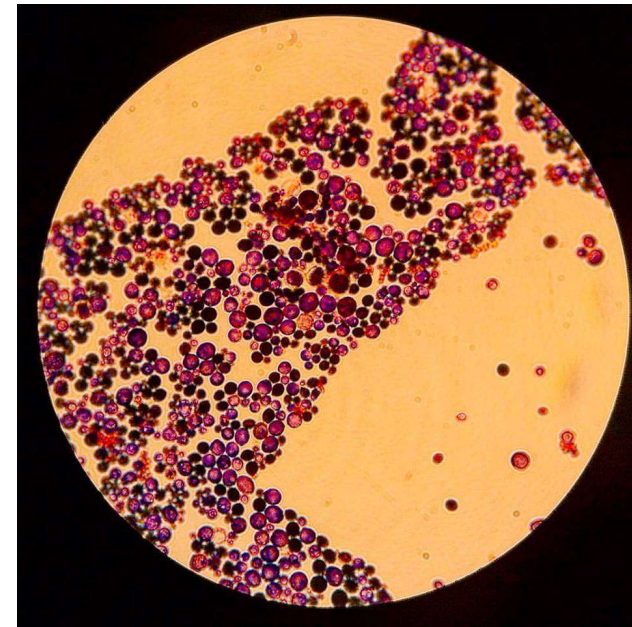
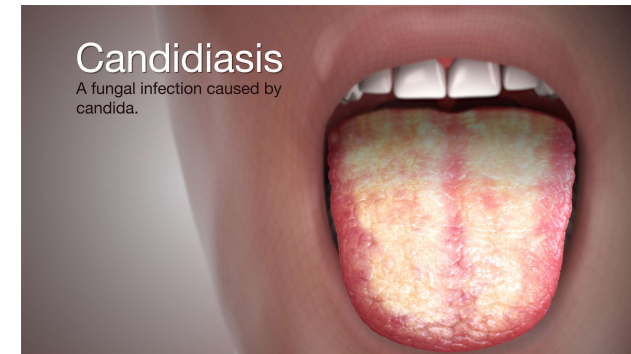
This bacterium, along with the closely related species *Streptococcus sobrinus*, can cohabit the mouth: Both contribute to oral disease, and the expense of differentiating them in laboratory testing is often not clinically necessary. Therefore, for clinical purposes they are often considered together as a group, called the **mutans streptococci**. This grouping of similar bacteria with similar tropism can also be seen in the viridans streptococci, another group of *Streptococcus* species.



Bacterial-fungal co-coaggregation can help to increase the cariogenic potential of *S. mutans*. A symbiotic relationship with *S. mutans* and ***Candida albicans*** leads to increased glucan production and increased biofilm formation. This therefore amplifies the cariogenic effect of *S. mutans*.

Oral streptococci comprise both harmless and harmful bacteria. However, under special conditions commensal streptococci can become opportunistic pathogens, initiating disease and damaging the host. Imbalances in the microbial biota can initiate oral diseases.

C. albicans is an opportunistic pathogenic yeast that can be found within the oral cavity. Its presence in the biofilm promotes higher levels of *S. mutans* when looking at early childhood caries. It stimulates the formation of *S. mutans* microcolonies.



Bacterial Diseases of the Lower Digestive System

- Symptoms usually include **diarrhea, gastroenteritis, dysentery**
- A **gastrointestinal infection** (Food Infection) is caused by the growth of a pathogen in the intestines.
 - Incubation times, the times required for bacterial cells to grow and their products to produce symptoms, range from **12 hours to 2 weeks**.
 - Symptoms of infection generally include a **fever**.
- A **bacterial intoxication** (Food Poisoning) results from the ingestion of preformed bacterial toxins.
 - Symptoms appear **1- 48 hours** after ingestion of the toxin.
 - Fever is not usually a symptom of intoxication.
- **Infections** and **intoxications** cause diarrhea, dysentery, or gastroenteritis.
 - These conditions are usually **treated with fluid and electrolyte replacement**.

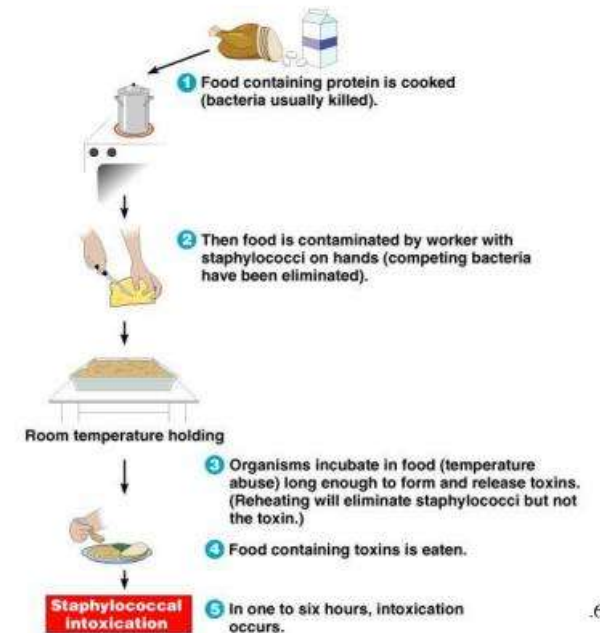
Staphylococcal Food Poisoning

- Staphylococcal food poisoning is caused by the ingestion of an **enterotoxin** produced in **improperly stored foods**.
- *S. aureus* is inoculated into foods during preparation.
- The bacteria grow and produce enterotoxin in food stored at room temperature.
- The exotoxin is **not denatured by boiling** for 30 minutes.



Staphylococcal Food Poisoning

- *Staphylococcus aureus* enterotoxin is a superantigen



Staphylococcal Food Poisoning

- Foods with **high osmotic pressure** and those not cooked immediately before consumption are most often the source of **staphylococcal enterotoxigenesis**.
- Diagnosis is based on symptoms. Nausea, vomiting, and diarrhea begin **1~6 hours after** eating and last about 24 hours.
- Laboratory identification of *S. aureus* isolated from foods is used to trace the source of contamination.
- Serological tests are available to detect toxins in foods.

1) Food poisoning:

- Enterotoxin is responsible for manifestations of staphylococcal food poisoning.
- Eight types of enterotoxin are currently known, named A, B, C1-3, D, E, and H.
- It usually occurs when preformed toxin is ingested with contaminated food.
- The toxin acts directly on the autonomic nervous system to cause the illness, rather than gut mucosa.

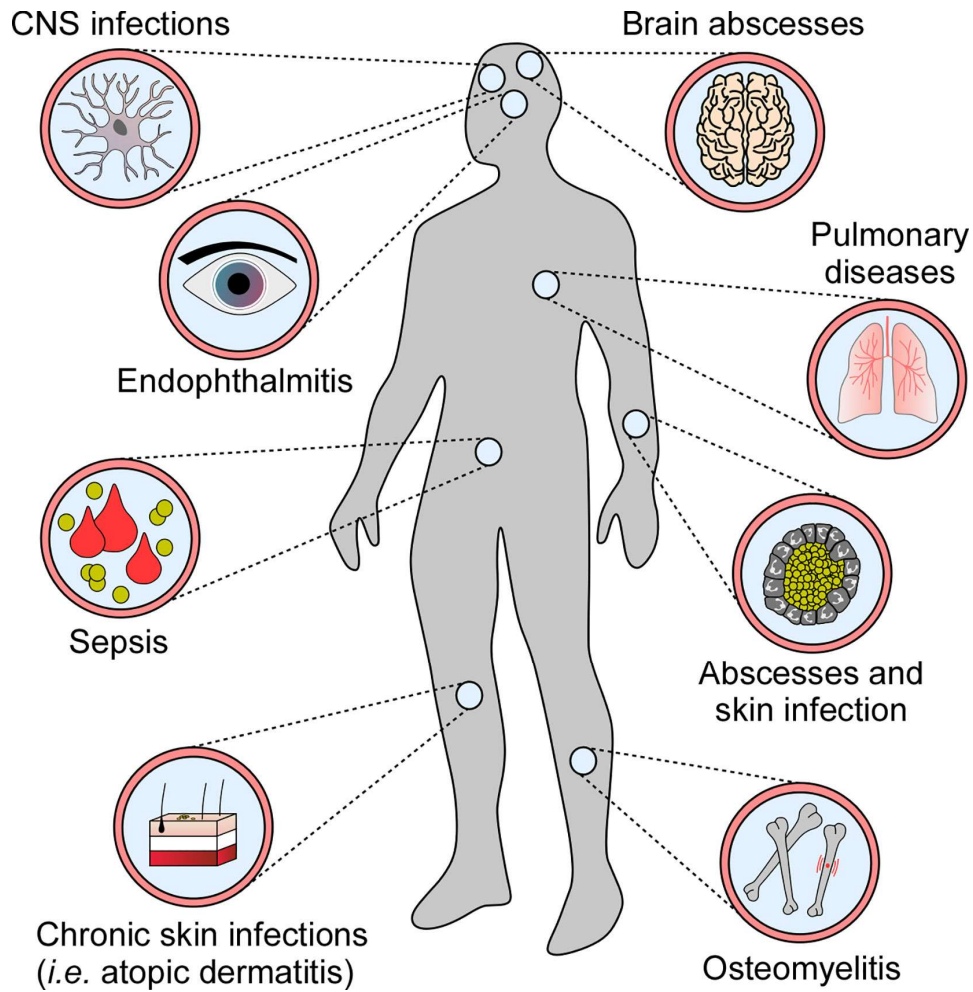
What is Staph food poisoning?

Staph food poisoning is a gastrointestinal illness caused by eating foods contaminated with toxins produced by the bacterium *Staphylococcus aureus* (Staph) bacteria.

About 25% of people and animals have Staph on their skin and in their nose. It usually does not cause illness in healthy people, but Staph has the ability to make toxins that can cause food poisoning.

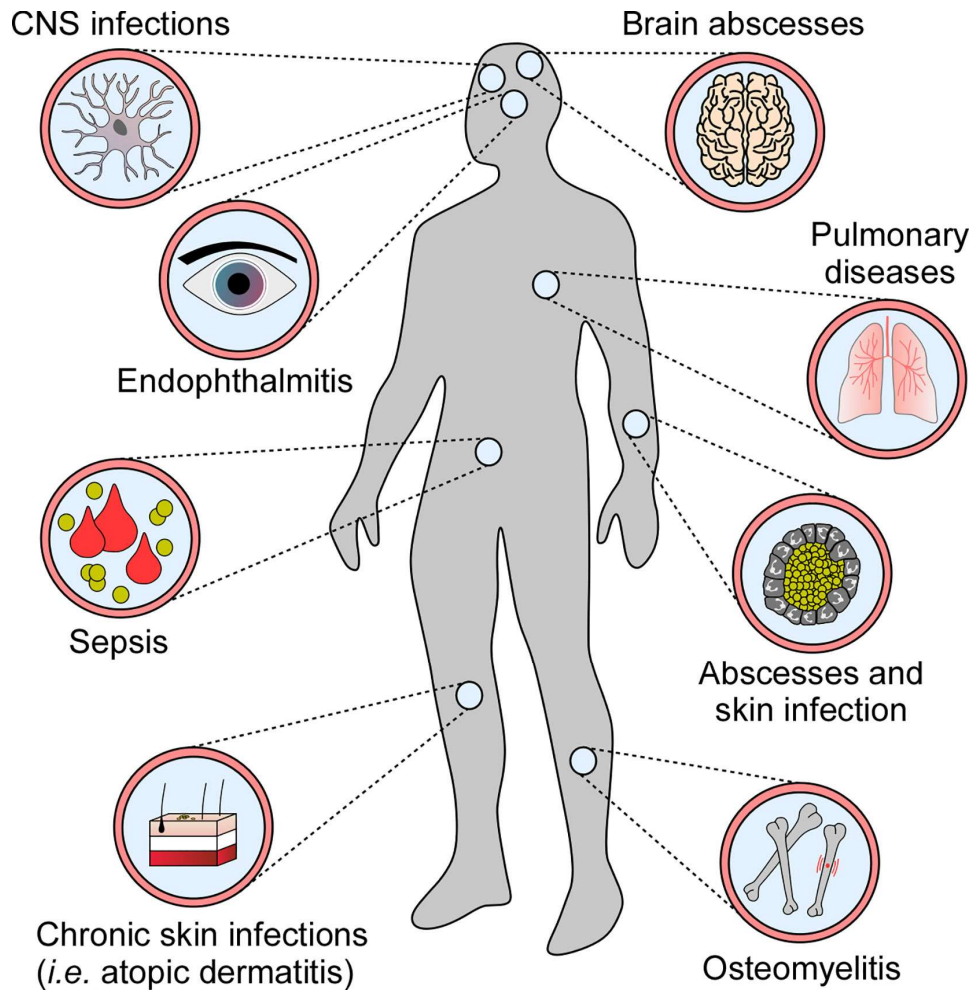
What are the symptoms of Staph food poisoning?

- Staph food poisoning is characterized by a sudden start of nausea, vomiting, and stomach cramps. Most people also have diarrhea.
- Symptoms usually develop within 30 minutes to 8 hours after eating or drinking an item **containing Staph toxin**, and last no longer than 1 day. Severe illness is rare.
- The illness cannot be passed from one person to another.



Staphylococcal diseases associated with programmed cell death. *S. aureus* exploits programmed cell death to cause various diseases in human and animal hosts.

<https://doi.org/10.3389/fimmu.2020.621733>



How is Staph food poisoning treated?

The most important treatment is drinking plenty of fluids. Your healthcare provider may give you medicine to decrease vomiting and nausea. People with severe illness may require intravenous fluids.

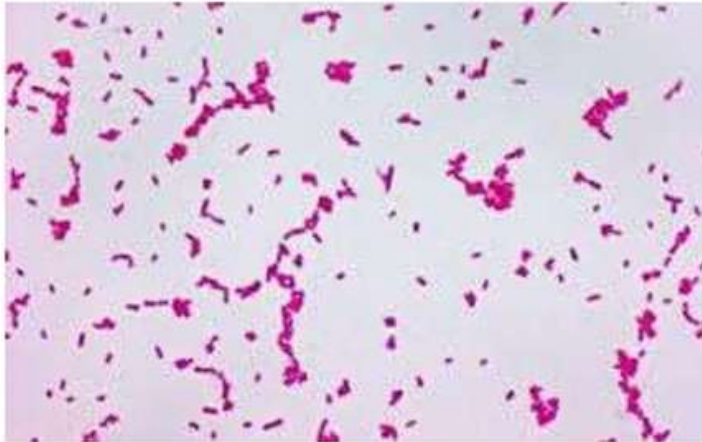
Antibiotics are not useful in treating this illness because the toxin is not affected by antibiotics.

Staphylococcal diseases associated with programmed cell death. *S. aureus* exploits programmed cell death to cause various diseases in human and animal hosts.

<https://doi.org/10.3389/fimmu.2020.621733>

Shigella dysenteriae appearance

- **Gram-negative** rods with rounded ends
- **nonmotile**
- **non-spore-forming**



Ken A.

Shigella dysenteriae



Shigella dysenteriae is a species of the rod-shaped bacterial genus *Shigella*.

Shigella species can cause shigellosis (bacillary dysentery).

Shigellae are Gram-negative, non-spore-forming, facultatively anaerobic, nonmotile bacteria.

S. dysenteriae has the ability to invade and replicate in various species of epithelial cells and enterocytes.

Identification: Selective medium are applied: XLD (**Xylose Lysine Deoxycholate**) agar, DCA (**deoxycholate citrate**) agar, or Hektoen enteric agar are inoculated;

- ① All give colorless colonies as the organism is not a lactose fermenter.
- ② Inoculation of a TSI slant shows an alkaline slant and acidic, but with no gas, or H₂S production.
- ③ Following incubation on selective media, the culture appears nonmotile with no H₂S production.
- ④ Addition of Kovac's reagent* to the selective media tube following growth typically indicates no indole formation (serotypes 2, 7, and 8 produce indole).
- ⑤ Mannitol tests yields negative results.
- ⑥ Ornithine Decarboxylase tests yield negative results.

*Kovac's reagent is a biochemical reagent consisting of isoamyl alcohol, para-dimethylaminobenzaldehyde (DMAB), and concentrated hydrochloric acid. It is used for the diagnostic indole test, to determine the ability of the organism to split indole from the amino acid tryptophan. The indole produced yields a red complex with para-dimethylaminobenzaldehyde under the given conditions.

Shigella dysenteriae is a species of the rod-shaped bacterial genus *Shigella*.

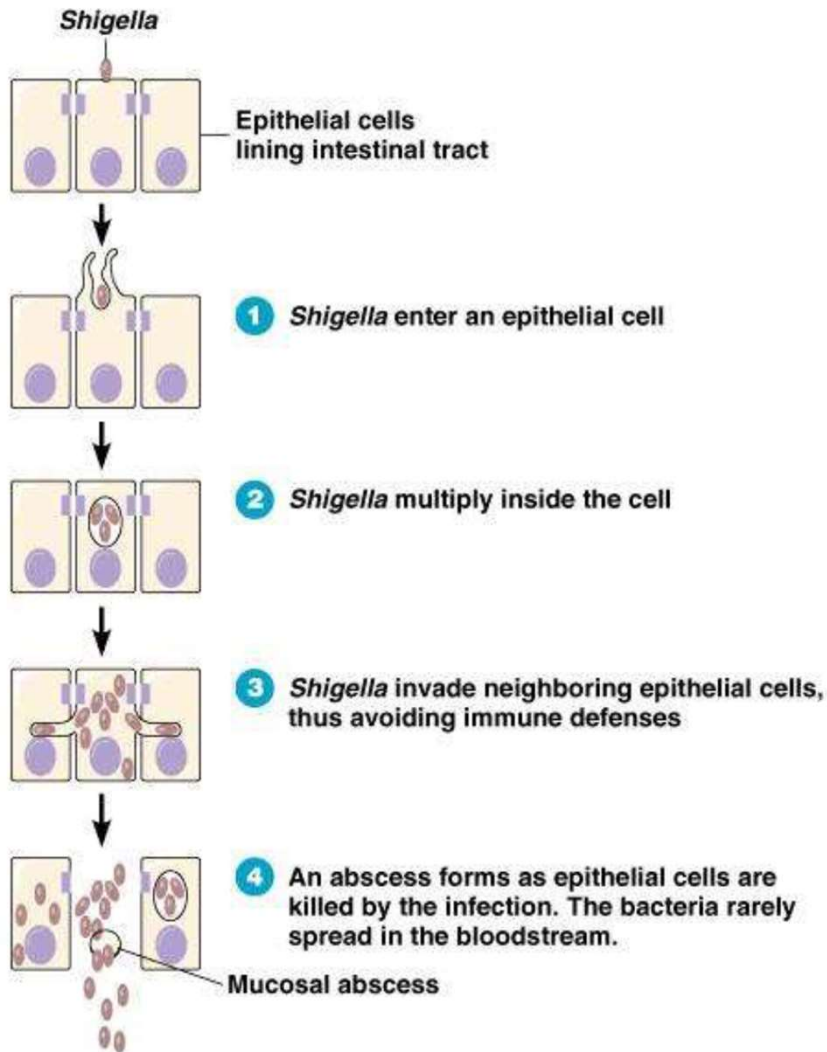
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Shigellae are Gram-negative, non-spore-forming, facultatively anaerobic, nonmotile bacteria.

S. dysenteriae has the ability to invade and replicate in various species of epithelial cells and enterocytes.

Treatment for shigellosis, independent of the subspecies, requires an antibiotic. Commonly used antibiotics include **ampicillin, ciprofloxacin, ceftriaxone**, among others. Opioids should be avoided for treatment of Shigellosis.

Shigellosis (Bacillary Dysentery)



- Shigellosis is caused by four species of *Shigella*.
- Symptoms include **blood** and **mucus** in stools, abdominal cramps, and fever.
- Infections by *S. dysenteriae* result in ulceration of the intestinal mucosa.
- Bacteria do **not** usually spread in the bloodstream.
- **ID50 is 1,000 bacteria**

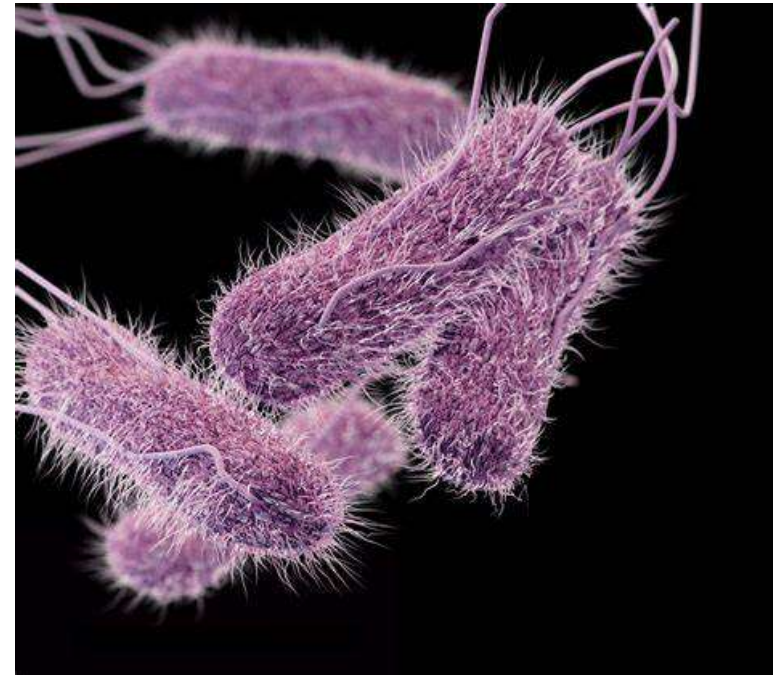
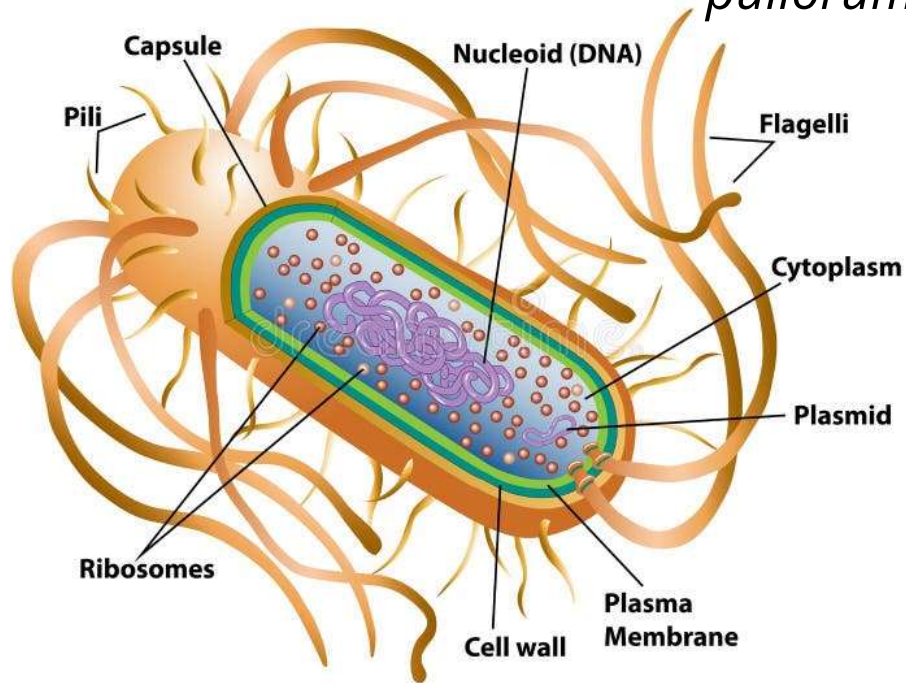
Salmonellosis

Salmonella is a Gram-negative rod-shaped bacterium that belongs to the enterobacteria family.

It has a cell diameter of about 0.7 to 1.5 μm and a length of 2 to 5 μm . **It is non-acid fast, non-capsulated and non-sporing.**

Most serotypes are motile with peritrichous flagella (all around the cell body), except for *S. galinerum* and *S. pullorum*, which are non-motile

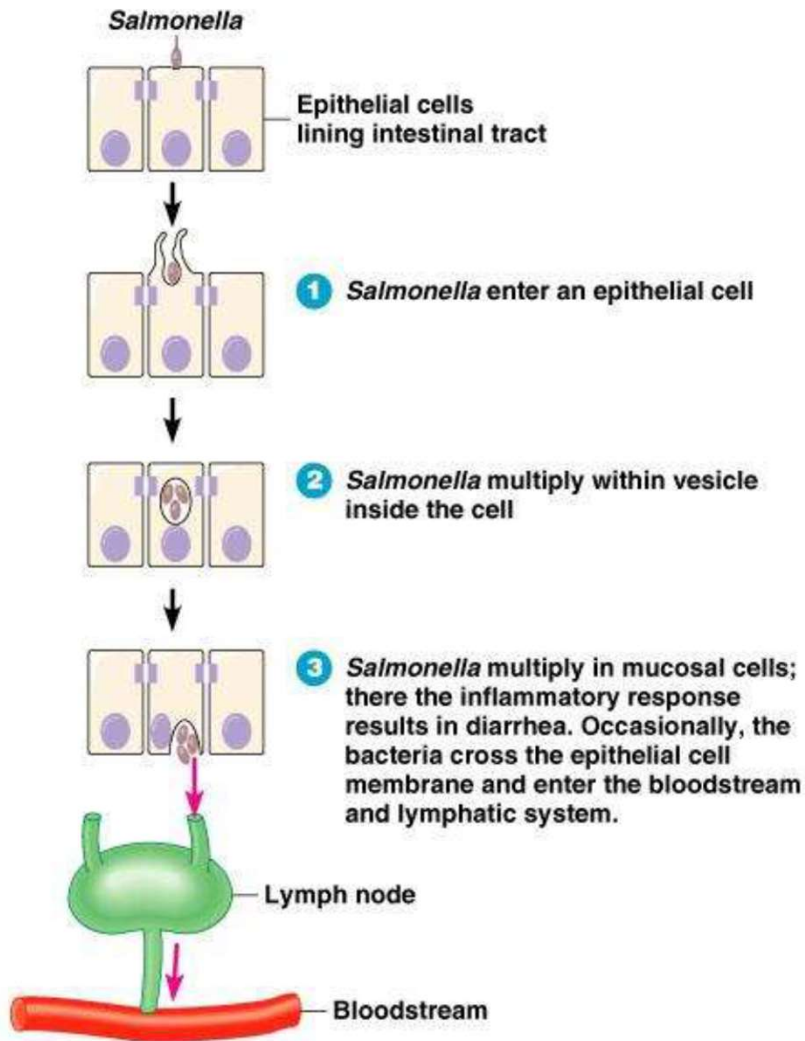
Structures of Salmonella Bacteria



- ✓ Salmonella is a bacterial genus, part of phylum Pseudomonadota.
- ✓ First reports on Salmonella were from 1880 by Karl Eberth, a German bacteriologist, who observed a bacterium in the spleens of typhoid patients.
- ✓ In 1884, Georg Theodor Gaffky, a student of Robert Koch, confirmed Eberth's discovery and isolated the bacteria in pure culture.

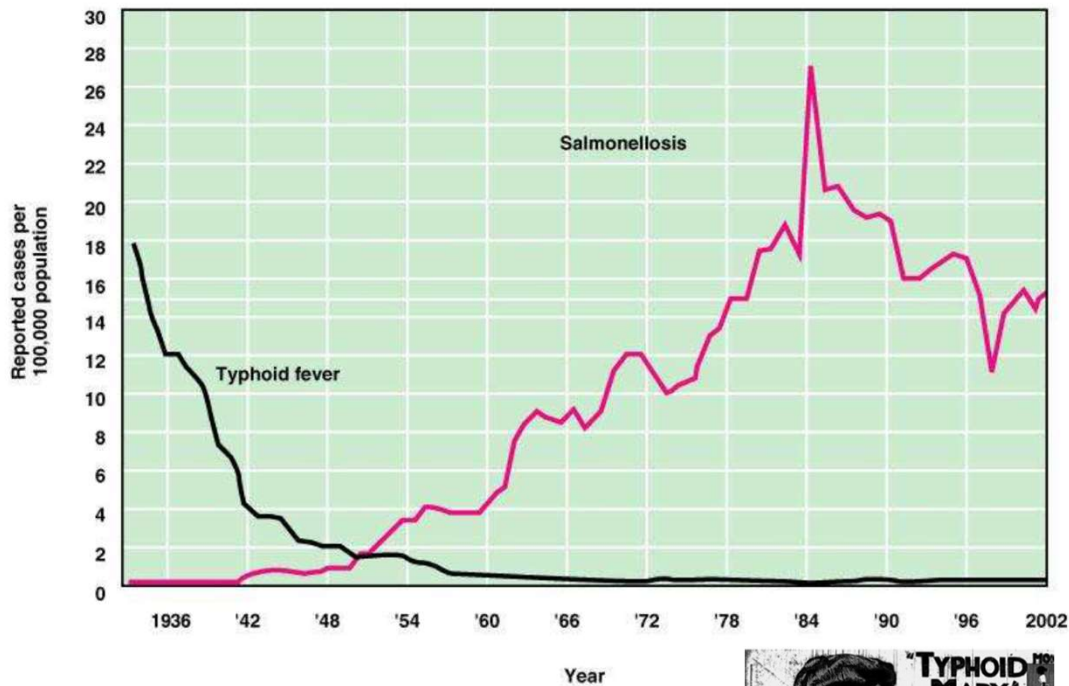
- ✓ The genus *Salmonella* was named only in 1900 by Harvey Pirie, a South African bacteriologist, in honor of Daniel Elmer Salmon, an American veterinarian.
- ✓ The bacterium that Salmon and his colleague Theobald Smith found in pigs was later shown to be different from the one that causes typhoid fever in humans.
- ✓ The first recorded outbreak of salmonellosis associated with humans with food consumption was reported in 1919 by Edwin Oakes Jordan, an American microbiologist, who traced the infection to contaminated cheese.

Salmonellosis



- Salmonellosis, or *Salmonella* gastroenteritis, is caused by many *Salmonella* species.
- Transmission between **animal products** and **humans**.
- Symptoms include nausea, abdominal pain, and diarrhea and begin 12- 36 hours after eating **large numbers of *Salmonella***.
- **Bacteria enter the bloodstream and lymphatic system**
- **Septicemia** can occur in infants and in the elderly.
- **Fever** might be caused by **endotoxin**.
- Mortality is lower than 1%, and recovery can result in a **carrier state**.
- **Heating food to 68 °C** will usually kill *Salmonella*.

Salmonellosis and Typhoid Fever Incidence



Mary Mallon in a 1909

Newspaper illustration

Born: September 23, 1869

County Tyrone, Northern Ireland

Died November 11, 1938 (aged 69)

Residence United States

Nationality British

Known for Healthy carrier of typhoid fever

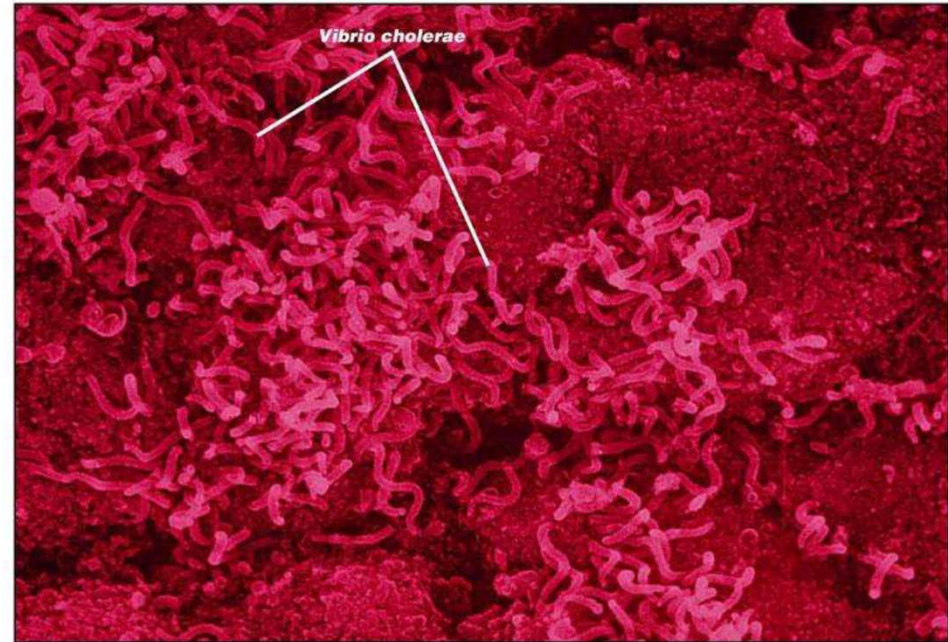


- *Salmonella typhi* causes typhoid fever (~ 40°C); the bacteria are transmitted by contact with human faeces.
- Fever and malaise occur after a 2-week incubation period.
- Symptoms last 2~3 weeks.
- Bacteria spread throughout body in phagocytes
- 1-3% recovered patients become carriers, harboring *Salmonella* in their gallbladder
- *S. typhi* is harbored in the gallbladder of chronic carriers (1~3% of patients). “Typhoid Mary”
- Vaccines are available for high-risk people.

Cholera

- *Vibrio cholerae* produces an **exotoxin** that alters the membrane permeability of the intestinal mucosa.
- The resulting vomiting and diarrhoea cause a loss of body fluids (**12~20 liters in a day**).
- “Rice water stool” from the mass of intestine mucous, epithelial cells, and bacteria.
- The incubation period is approximately 3 days.
- The symptoms last for a few days.
- Untreated cholera has a **50%** mortality rate.
- Diagnosis is based on the isolation of *Vibrio* from faeces.
- **Tetracycline** is used for treatment.
- The 1991~1994 epidemic in Latin America resulted in over 1 million cases and 9,600 deaths.

- *Vibrio cholerae* serotypes that produce cholera toxin
- Toxin causes host cells to secrete Cl^- , HCO_3^- , and water.



Noncholera Vibrios

- **Usually from contaminated crustaceans or mollusks**
 - *V. cholerae* serotypes other than O:1, O:139
 - *V. parahaemolyticus*
 - *V. vulnificus*

***Escherichia coli* Gastroenteritis**

- *E. coli* gastroenteritis may be caused by enterotoxigenic, enteroinvasive, or enterohemorrhagic strains of *E. coli*.
- The disease occurs as epidemic diarrhea in nurseries, **as traveler's diarrhea (50~65%)**, as endemic diarrhea in less developed countries, and as haemorrhagic colitis.
- 50% of feedlot cattle may have enterohemorrhagic strains in their intestines
- In adults, the disease is usually **self-limiting** and does not require chemotherapy.
- Enterohemorrhagic *E. coli*, such as *E. coli* O157:H7, produces **Shiga-like toxins** that cause inflammation and bleeding of the colon.
 - O = cell wall antigen
 - H = flagellar antigen
- Shiga-like toxins can affect the kidneys to cause haemolytic uremic syndrome.
- ID50 is estimated to be fewer than **10 bacteria**

Enterohemorrhagic *Escherichia coli* O157:H7 (EHEC)

- Originally identified in 1982 after 2 outbreaks of severe bloody diarrhoea in 47 individuals occurred in Oregon & Michigan.
- Epidemiologic investigation found all these patients had eaten **ground beef** from the same fast food restaurant prior to illness.
- **O157:H7** was isolated from the stool of patients and hamburger meat.
- Each year, 73,000 illnesses, 2,000 hospitalizations, and 69 deaths in the United States alone.
- Recently, super-bacteria (modified EHEC) occurred in Germany.
- EHEC infectious disease is determined to **level 1 legal communicable disease** in Korea in 2000.
- Certain antibiotics increase **production/release of toxins** by EHEC.

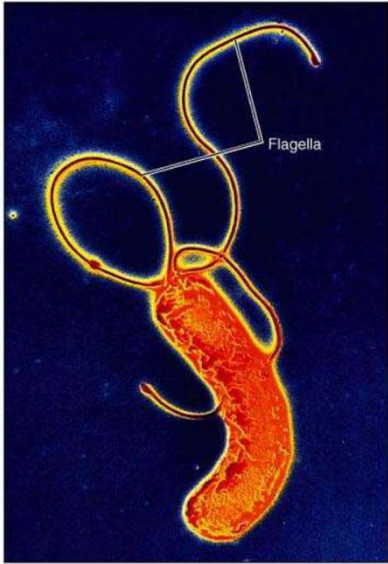


Enterohemorrhagic *Escherichia coli* O157:H7 (EHEC)

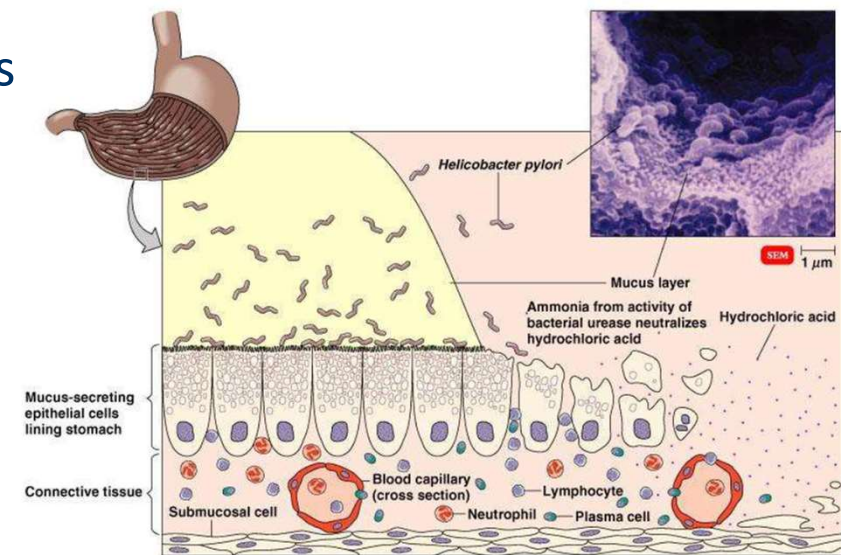
- Predominant cause of haemorrhagic colitis
 - Symptoms
 - Bloody diarrhoea
 - Abdominal cramps
 - TTP (Thrombotic Thrombocytopenic Purpura)
 - Death
- Infectious dose = 10~100 CFU
- Shiga toxins
 - Produced by **lysogenic phage**.
 - Vascular damage (haemorrhagic colitis) & systemic effects of infection, HUS.
 - Antibiotic therapy has **no effect** on the duration of acute diarrhoea



Helicobacter Peptic Ulcer Disease



- *Helicobacter pylori* converts urea to ammonia, which neutralizes stomach acid
- The bacteria colonize the stomach mucosa and cause peptic ulcer disease.
- **Only 15%** of those infected develop ulcers, so certain host factors are probably involved.
- Bismuth (Pepto-Bismol®) and several antibiotics may be useful in treating peptic ulcer disease.
- Some probiotics are recommended as alternative for treatment of peptic ulcer disease.



Some other digestive tract associated pathogens

- ***Campylobacter jejuni***
 - Usually transmitted in cow's milk
- ***Yersinia* Gastroenteritis**
 - *Y. enterocolitica* and *Y. pseudotuberculosis*
 - Can reproduce at 4°C
 - Usually transmitted in meat and milk
- ***Clostridium perfringens* Gastroenteritis**
 - Grow in intestinal tract producing exotoxin
- ***Bacillus cereus* Gastroenteritis**
 - Ingestion of bacterial exotoxin produces mild symptoms

Clostridium difficile

- With the introduction of broad-spectrum antibiotics in the 1980s, antibiotic- and chemotherapy-associated diarrhoea became more common.
- **Pseudomembranous colitis** was first described as a complication of *C. difficile* infection in 1978.
- *C. difficile* causes disease when competing bacteria in the gut have been wiped out by antibiotic treatment.
- In severe cases, *C. difficile* can cause "**pseudomembranous colitis**," a severe inflammation of the colon.

Clostridium difficile

- **Pseudomembranous colitis** is harmful because the bacteria release toxins that can cause bloating and diarrhoea, with abdominal pain, which may become life-threatening.
- In more serious cases, oral administration of metronidazole or **vancomycin** can be used.
- Faecal bacteriotherapy or **Faecal Microbiota Transplantation(FMT)** is about 90% effective in those in whom antibiotics have not worked.
- It involves infusion of bacterial flora acquired from the faeces of a healthy donor to reverse the bacterial imbalance responsible for the recurring nature of the infection.
- The procedure replaces normal, healthy colonic flora that had been wiped out by antibiotics, and re-establishes the persons resistance to colonization by *Clostridium difficile*.

Cytomegalovirus (CMV) Inclusion Disease

- CMV (Herpes virus) causes intra-nuclear inclusion bodies and cytomegaly of host cells.
- CMV is transmitted by saliva, urine, semen, cervical secretions, and human milk.
- CMV inclusion disease can be asymptomatic, a mild disease, or progressive and fatal.
- Immuno-suppressed patients may develop pneumonia.

Cytomegalovirus (CMV) Inclusion Disease

- Inflammation of the liver is called **hepatitis**. Symptoms include loss of appetite, malaise, fever, and jaundice.
- Viral causes of hepatitis include hepatitis viruses, Epstein-Barr (EB) virus, and Cytomegalovirus (CMV).

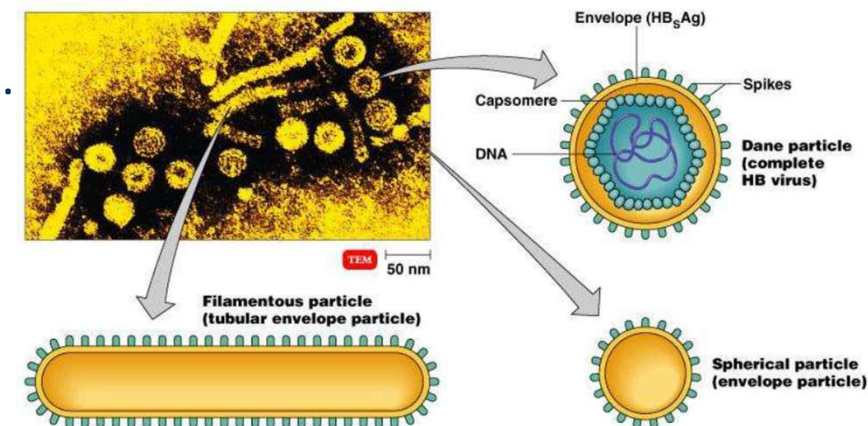
Hepatitis

Hepatitis A

- Hepatitis A virus (HAV) causes hepatitis A; at least **50%** of all cases are **subclinical**.
- HAV is ingested in **contaminated food or water**, grows in the cells of the intestinal mucosa, and spreads to the liver, kidneys, and spleen in the blood.
- The virus is eliminated with **faeces**.
- Passive immunization can provide temporary protection.
- A vaccine is available.

Hepatitis B

- Hepatitis B virus (HBV) causes hepatitis B, which is frequently serious.
- HBV is transmitted by **blood transfusions, contaminated syringes, saliva, sweat, breast milk, and semen**.
- Blood is tested for **HBS Ag** before being used in transfusions.
- The average incubation period is 3 months
- Recovery is usually complete, but **some patients (~10%)** develop a **chronic infection** or become carriers.
- A vaccine against **HBS Ag** is available.
- α -INF, ramivudine (3TC)



Hepatitis C

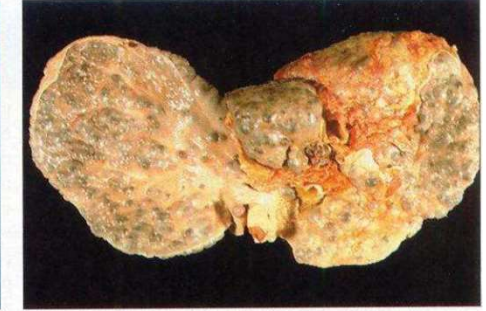
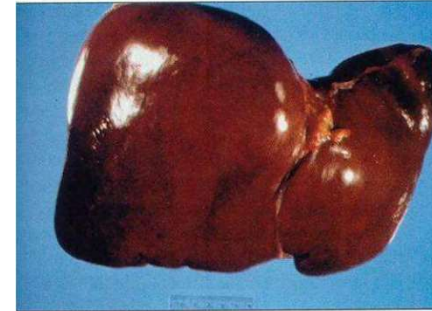
- Hepatitis C virus (HCV) is transmitted via **blood**.
- A majority cases, as high as **85%**, progress to chronic hepatitis.
- About 20% of chronically infected patients develop **liver cirrhosis** or **liver cancer**.
- Blood is tested for HCV antibodies before being used in transfusions.
- α -INF, ramivudine (3TC)

Hepatitis D (Delta Hepatitis)

- Hepatitis D virus (HDV) has a circular strand of RNA and uses HBs Ag as a coat.

Hepatitis E

- Hepatitis E virus (HEV) is spread by the faecal-oral route.



Effects of hepatitis C on human liver.

Viral Gastroenteritis

- Viral gastroenteritis is most often caused by a **rotavirus**
- Almost all children become infected by their first birthday.
- Low grade fever, diarrhoea, and vomiting for a week

- **Rotavirus**
- 3 million cases annually
- 1-2 day incubation, 1 week illness

- **Norovirus**
- 50% of U.S. adults have antibodies
- 1-2 day incubation. 1-3 day illness

- Treated with rehydration



Fungal Diseases of the Digestive System

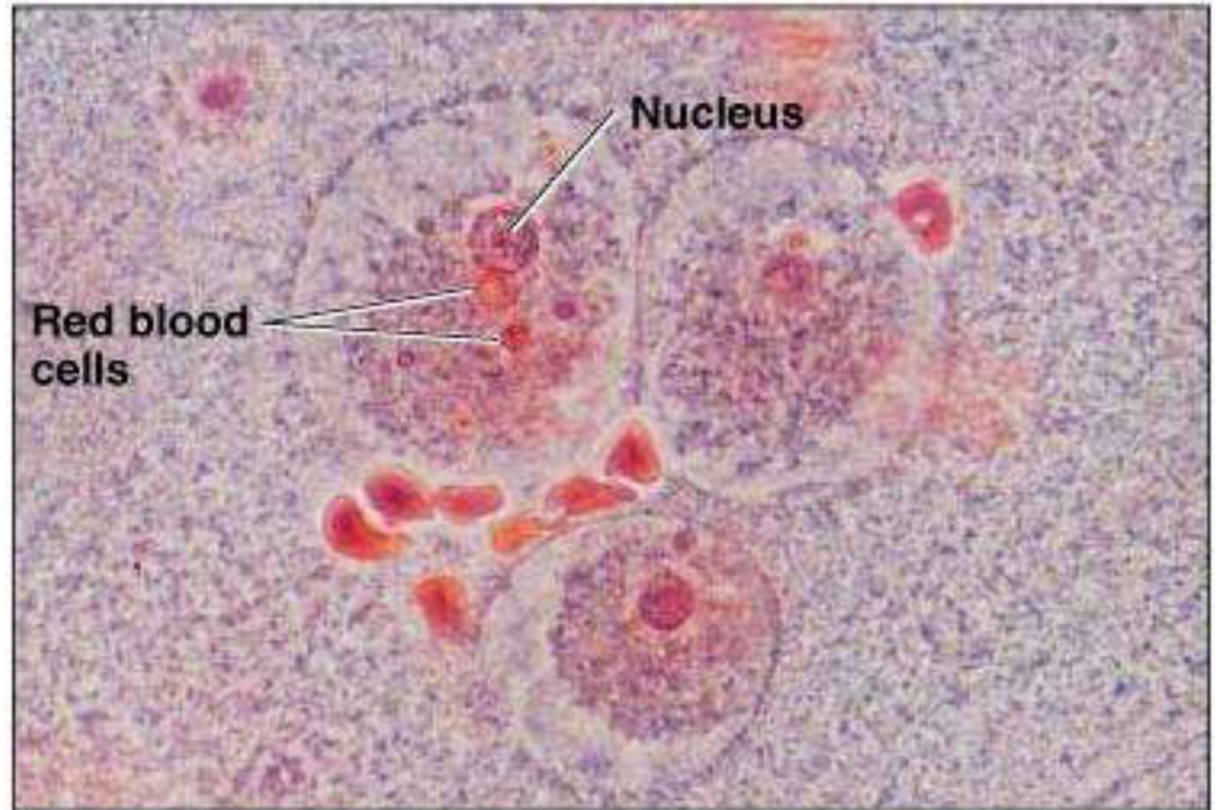
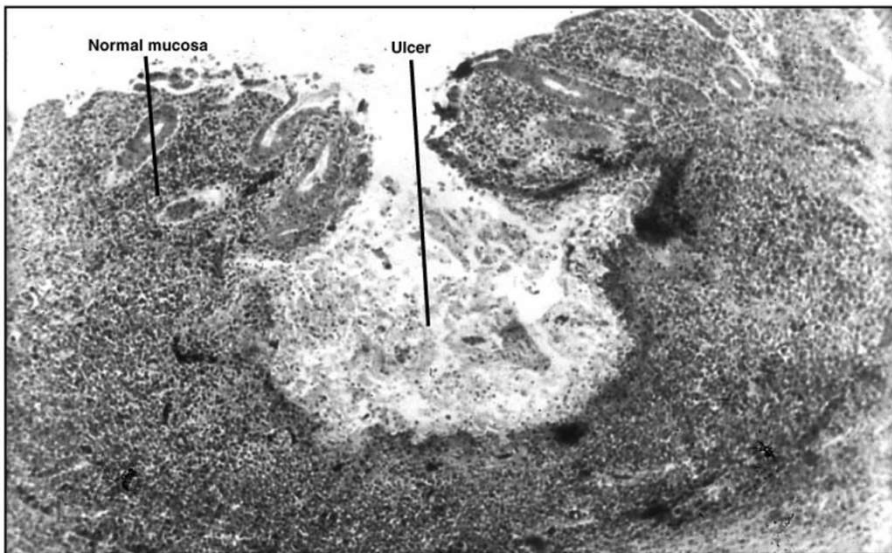
- **Mycotoxins** are toxins produced by some fungi.
- Mycotoxins affect the blood, nervous system, kidneys, or liver.

- Ergot Poisoning
- Produced from *Claviceps purpurea*
- Cause hallucinogenic symptoms similar to that cause by LSD.

- Aflatoxin Poisoning
- Aflatoxin is a mycotoxin produced by *Aspergillus flavus*.
- Damage to livestock
- Cirrhosis of the liver and liver cancer

Amoebic Dysentery

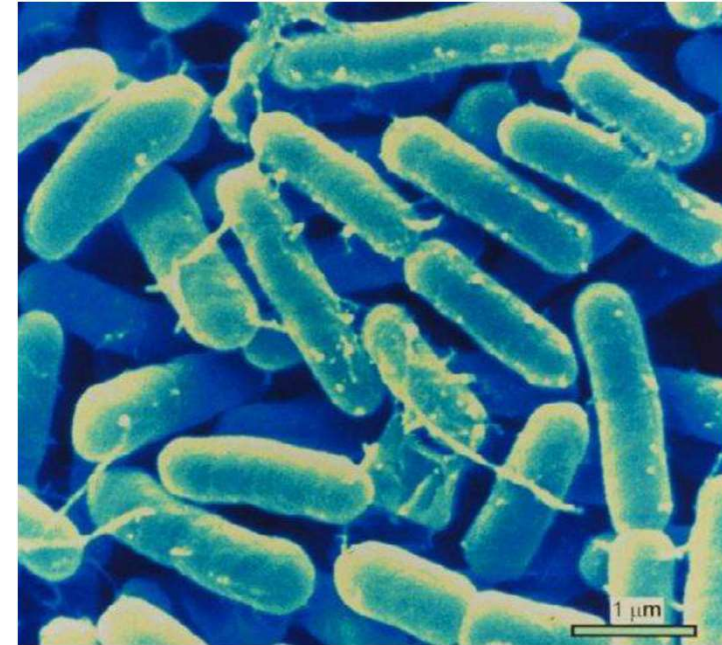
- *Entamoeba histolytica*
- Amoeba feeds on RBCs and GI tract tissues
- Diagnosis by observing trophozoites in faeces
- Treated with metronidazole



(b) *Entamoeba histolytica*

Enterobacter (Cronobacter) sakazakii

- Name *Enterobacter sakazakii* proposed in 1980
- Identifications of *Enterobacter sakazakii* is based on:
 - DNA hybridization studies
 - Biochemical reactions
 - Yellow - pigmented colonies



***E. sakazakii* and the environment**

- Surface water
- Mud
- Rotting wood
- Bird dung
- Rodents
- Domestic animals
- Cow's milk



Enterobacter sakazakii

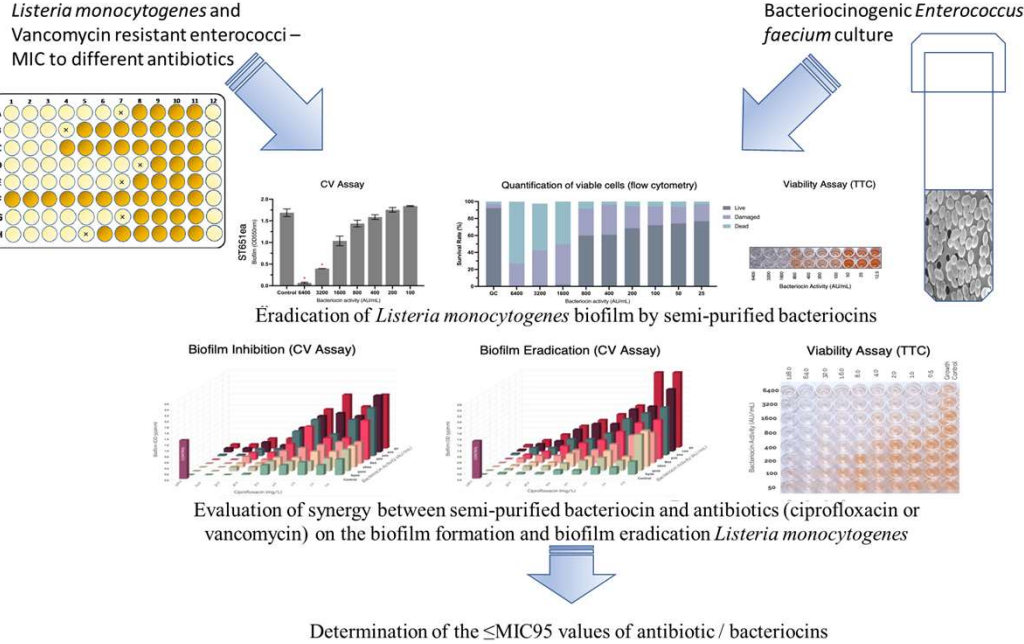
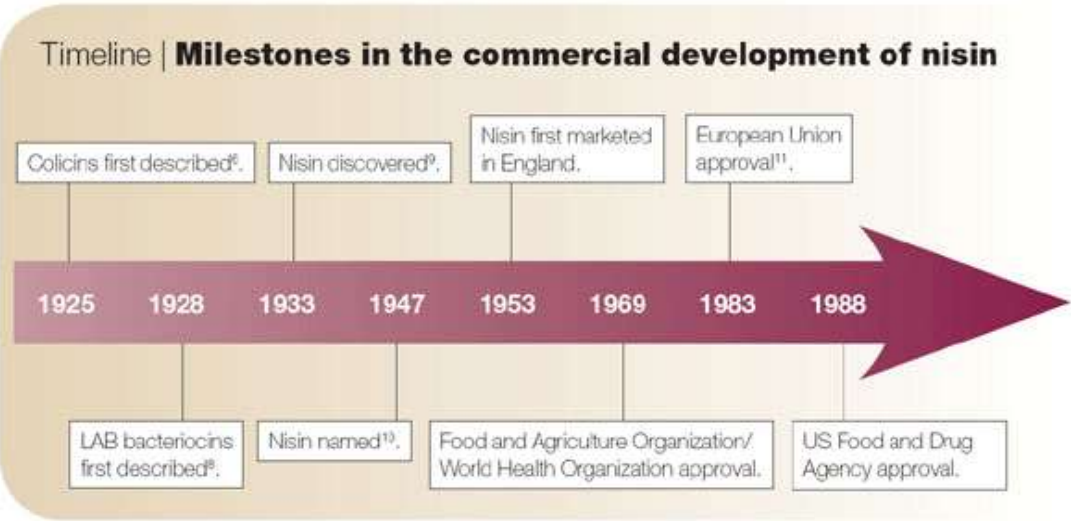
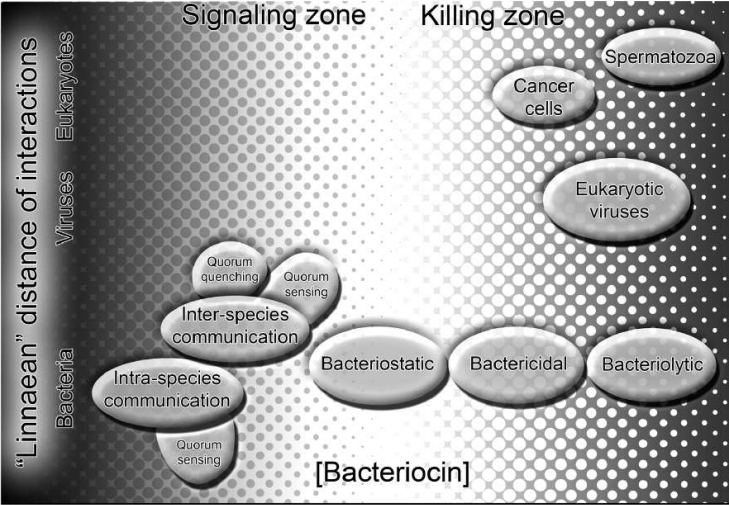
- Incidence in **dried infant-formula** on the Canadian market found to be 6.7%
- Minimum growth temperature 5.5 - 8.0 °C
- Generation time at room temperature 40 min
- Four of eighteen strains produce enterotoxin
- Heterogeneity among strains



Possible alternative to the antibiotics

Bacteriocins and other antimicrobial peptides

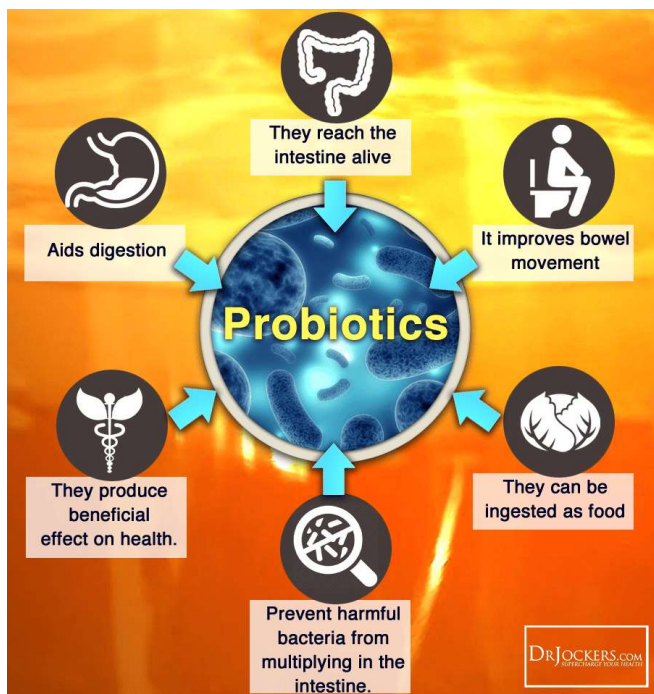
By definition, bacteriocins produced by lactic acid bacteria are ribosomal synthesized polypeptides that exhibit bactericidal or bacteriostatic activity against genetically closely related bacteria (De Vuyst and Vandamme, 1994; Klaenhammer, 1988).



Possible alternative to the antibiotics

Probiotics

Probiotics are dietary supplements containing potentially beneficial bacteria or yeasts. According to the currently adopted definition by FAO/WHO, probiotics are: *'Live microorganisms which when administered in adequate amounts confer a health benefit on the host'*.



Probiotic-Rich Foods to aid digestion & gut health



Potential benefits:

- Managing Lactose Intolerance
- Prevention of Colon Cancer
 - Cholesterol Lowering
 - Lowering Blood Pressure
- Improving Immune Function and Preventing Infections
 - *Helicobacter pylori*
- Antibiotic-associated diarrhea
 - Reducing Inflammation
- Improving Mineral Absorption
- Prevents Harmful Bacterial Growth Under Stress
 - Irritable Bowel Syndrome and Colitis

TABLE 25.2

Microbial Diseases of the Digestive System

Disease	Pathogen	Comments
Bacterial Diseases of the Mouth		
Dental caries	Primarily <i>Streptococcus mutans</i>	Accumulations of plaque allow localized acid production by bacteria, forming hole in tooth.
Periodontal disease	Various; primarily <i>Porphyromonas</i> spp.	Presence of bacterial plaque initiates inflammatory response that destroys bone and tissue.
Bacterial Diseases of the Lower Digestive System		
Staphylococcal food poisoning	<i>Staphylococcus aureus</i>	An exotoxin in food causes rapid onset of nausea, vomiting, and diarrhea.
Shigellosis (bacillary dysentery)	<i>Shigella</i> spp.	Bacteria are shed in human feces; ingested, they invade and multiply in intestinal epithelial cells. Infection spreads to neighboring cells, causing tissue damage and dysentery.
Salmonellosis	<i>Salmonella enterica</i>	Bacterial inhabitants of animal intestinal tracts contaminate foods; when ingested, they invade and multiply in intestinal epithelial cells. They do not invade neighboring cells but can enter the bloodstream, causing nausea and diarrhea.
Typhoid fever	<i>Salmonella typhi</i>	Typhoid pathogen is shed in human feces; incubation period about 2 weeks. Symptoms include high fever, disseminated infection, significant mortality rate.

TABLE 25.2

(continued)

Disease	Pathogen	Comments
Bacterial Diseases of the Lower Digestive System		
Cholera	<i>Vibrio cholerae</i> O:1 and O:139	Exotoxin causes diarrhea with large loss of water and electrolytes; no invasion of tissue.
<i>Vibrio</i> gastroenteritis Non-O1	<i>V. cholerae</i>	Mild diarrhea
<i>Vibrio parahaemolyticus</i> gastroenteritis	<i>V. parahaemolyticus</i>	Exotoxin causes choleralike diarrhea, but generally milder.
<i>V. vulnificus</i> gastroenteritis	<i>V. vulnificus</i>	Very dangerous for people suffering from liver disease.
Enterotoxigenic <i>E. coli</i> gastroenteritis	<i>Escherichia coli</i>	Watery diarrhea that resembles mild form of cholera; typical traveler's diarrhea.
Enteroinvasive <i>E. coli</i> gastroenteritis	<i>E. coli</i>	Enterotoxin causes <i>Shigella</i> -like dysentery.
Enterohemorrhagic <i>E. coli</i> gastroenteritis	<i>E. coli</i> O157:H7	Causes hemorrhagic colitis (very bloody stools) and hemolytic uremic syndrome (blood in urine, possible kidney failure).
<i>Campylobacter</i> gastroenteritis	<i>Campylobacter jejuni</i>	Microaerophilic pathogen found in animal intestinal tracts; very common cause of gastroenteritis.
<i>Helicobacter</i> peptic ulcer disease	<i>Helicobacter pylori</i>	Pathogen is adapted to survive in stomach; presence leads to peptic ulcers.

TABLE 25.2 (continued)

Disease	Pathogen	Comments
<i>Yersinia</i> gastroenteritis	<i>Yersinia enterocolitica</i>	Pathogen is inhabitant of intestinal tract of animals; grows slowly at refrigerator temperatures. Symptoms are abdominal pain and diarrhea, usually mild. May be confused with appendicitis.
<i>Clostridium perfringens</i> gastroenteritis	<i>Clostridium perfringens</i>	Usually limited to diarrhea.
<i>Bacillus cereus</i> gastroenteritis	<i>Bacillus cereus</i>	May take form of diarrhea or nausea and vomiting; probably caused by different toxins.
Viral Diseases of the Digestive System		
Mumps	Mumps virus	Painful swelling of parotid glands.
Hepatitis A	Hepatitis A virus (HAV)	Mild disease, mostly malaise; often subclinical. Fecal-oral transmission; low mortality rate.
Hepatitis B	Hepatitis B virus (HBV)	Transmitted by blood and other body fluids, including sexual activity. Severe disease likely to cause liver damage; about 10% of cases become chronic.
Hepatitis C	Hepatitis C virus (HCV)	Similar to hepatitis B but much more likely to become chronic.
Hepatitis D	Hepatitis D virus (HDV)	Very severe liver damage with high mortality rate. Must be coinfecting with HBV.
Hepatitis E	Hepatitis E virus (HEV)	Similar to hepatitis A; fecal-oral transmission. Pregnant women may have high mortality rate.
Viral gastroenteritis	Rotavirus, calciviruses (or Norwalk)	Self-limiting.

TABLE 25.2

(continued)

Disease	Pathogen	Comments
Helminthic Diseases of the Digestive System		
Tapeworms	<i>Taenia saginata</i> (beef tapeworm); <i>T. solium</i> (pork tapeworm); <i>Diphyllobothrium latum</i> (fish tapeworm)	Helminth lives off undigested intestinal contents with few symptoms; pork tapeworm may cause larvae to form in many organs (neurocysticercosis) and cause damage; in this case, eggs are infectious. Usually transmitted by ingesting larvae in meats.
Hydatid disease	<i>Echinococcus granulosus</i>	Larvae form in body; may be very large and cause damage. Transmitted by ingesting tapeworm eggs.
Pinworms	<i>Enterobius vermicularis</i>	Itching around anus.
Hookworms	<i>Necator americanus</i> , <i>Ancylostoma duodenale</i>	Larvae enter through skin. Large infections may result in anemia.
Ascariasis	<i>Ascaris lumbricoides</i>	Helminths live off undigested intestinal contents. Transmitted by ingesting eggs from feces. Usually few symptoms.
Trichinosis	<i>Trichinella spiralis</i>	Larvae encyst in striated muscle. Transmitted by ingestion of larvae in meats. Usually few symptoms, but large infections may be fatal.

TABLE 25.2

(continued)

Disease	Pathogen	Comments
Fungal Diseases of the Digestive System		
Ergot poisoning	Mycotoxin produced by <i>Claviceps purpurea</i>	Ingestion causes neurological or circulatory problems.
Aflatoxin poisoning	Mycotoxin produced by <i>Aspergillus flavus</i>	Mycotoxin probably contributes to liver cancer.
Protozoan Diseases of the Digestive System		
Giardiasis	<i>Giardia lamblia</i>	Protozoan adheres to intestinal wall, may inhibit nutritional absorption. Causes diarrhea.
Cryptosporidiosis	<i>Cryptosporidium parvum</i>	Shed in animal feces, protozoan enters water supply; causes self-limiting diarrhea but may be life-threatening if immunosuppressed.
<i>Cyclospora</i> diarrheal infection	<i>Cyclospora cayentanensis</i>	Usually ingested with fruits and vegetables; causes watery diarrhea.
Amoebic dysentery (amoebiasis)	<i>Entamoeba histolytica</i>	Amoeba lyses epithelial cells of intestine, causes abscesses; significant mortality rate.