TAXONOMY OF BACTERIA

TAXONOMY
Taxonomic classification based on:

- **gram staining**
  - gram positive
  - gram negative
- **mode of respiration**
  - aerobic
  - anaerobic
- **cell wall shape**
  - cocci
  - bacilli
  - spiral

TAXONOMY
- Gram Positive Bacilli
- Gram Positive Cocci
- Gram Negative Bacteria
- Spirochetes
- Rickettsia
- Chlamydia

GRAM-POSITIVE BACILLI
Clinically important genus

**Aerobic**

- *Bacillus*
- *Lactobacillus*
- *Listeria*
- *Erysipelothrix*
- *Corynebacterium*
- *Mycobacterium*

**Anaerobic**

- *Clostridium*
- *Propionibacterium*

AEROBIC GRAM-POSITIVE BACILLI

**BACILLUS**
genus of Gram-positive bacteria
ubiquitous in nature (soil, water, and airborne dust)
Some species are natural flora in the human intestines
most species are harmless saprophytes
two species are considered medically significant
- *B. anthracis*
- *B. cereus*

**B. anthracis**
causes anthrax in cows, sheep, and sometimes humans
Anthrax is transmitted to humans via direct contact with animal products or inhalation of endospores
Anthrax can be treated with penicillin or tetracycline
The anthrax bacteria can live in the soil for many years
Man may become infected with anthrax by inhaling contaminated soil particles or by handling wool or hair from diseased animals
Infection of the intestinal tract can occur by eating undercooked meat from diseased animals
*B. cereus*
can cause toxin-mediated food poisoning
It is known to inhabit many kinds of food including stew, cereal, and milk
The toxins released lead to vomiting and diarrhea
toxin production usually takes place after the infected foods are cooked
proper cold storage of food is recommended immediately after preparation

**LACTOBACILLUS**
ferment glucose into lactose
hence the name Lactobacillus
most common application of Lactobacillus is industrial
specifically for dairy production
yogurt, sauerkraut, pickles, buttermilk

*L. acidophilus*
make up part of the natural flora of the human vagina
create an acidic environment which inhibits growth of many bacterial species
leads to urogenital infections
Lactobacillus is generally harmless to humans

**LISTERIA**
Species of human pathogenic significance

*L. monocytogenes*
found in soil and water
Vegetables can become contaminated from the soil or from manure used as fertilizer
Animals can carry the bacterium without appearing ill and can contaminate foods of animal origin such as meats and dairy products
has been implicated in several food poisoning epidemics (Listeriosis)
normal inhabitant of the gastrointestinal tract and of animal feces infected suffer from vomiting, nausea, and diarrhea
those at high risk include newborns, pregnant women and their fetuses, the elderly, and persons lacking a healthy immune system

**ERYSIPELOTHRIX**
better known as a veterinary pathogen than as a human pathogen
This ubiquitous microbe has been found in many farm animals such as pigs, horses, and turkeys
can infect a human host and cause Erysipeloid, an inflammatory skin disease

**CORYNEBACTERIUM**
ubiquitous in nature
normally saprophytic and harmless to humans
exception is the bacterium *C. diphtheriae*
produces the toxin that causes diphtheria
a disease of the upper respiratory system in humans
unique in its exotoxin formation

**MYCOBACTERIUM**

*M. tuberculosis*
causative agent of tuberculosis
*M. leprae*
causative agent of leprosy

**ANAEROBIC GRAM-POSITIVE BACILLUS CLOSTRIDIUM**
anaerobic, ubiquitous in nature, especially fond of soil
secrete powerful **exotoxins** that are responsible for
tetanus
botulism
gas gangrene
clinically important species
*C. tetani*
*C. perfringens*
*C. botulinum*

**C. tetani**
causes tetanus (lockjaw) in humans
spores can be acquired from any type of skin trauma involving an infected device
If an anaerobic environment is present, the spores will germinate and eventually form active *C. tetani* cells
At the tissue level, the bacterium releases an exotoxin that causes nervous system irregularities
toxin's effect includes constant skeletal muscle contraction
due to a blockage of inhibitory interneurons that regulate muscle contraction
Immunization prevents *C. tetani* infections in children and adults the first four shots are administered within two years of birth followed up with periodic booster shots given every ten years

**C. perfringens**
can be contracted from dirt via large cuts or wounds
release of their exotoxin causes necrosis of the surrounding tissue
also produce gas which leads to a bubbly deformation of the infected tissues (gas gangrene)
can release an enterotoxin that may lead to severe diarrhea

**C. botulinum**
produces one of the most potent toxins in existence
cause of the deadly **botulism** food poisoning
may find their way into foods that will be placed in anaerobic storage such as cans or jars
once the jars are sealed, the spores germinate and the bacteria release their potent toxin
patients experience muscular paralysis and blurred vision
immediate treatment with anti-toxin is required for the patient to survive infantile botulism is much milder than the adult version
honey is the most common source of the spores which germinate in the child's intestinal tract
symptoms last a few days and then subside without the use of an antitoxin

**PROPIONIBACTERIUM**
aerobes
*P. acnes*
usually harmless microbe that has pathogenic potential has been linked to certain cases of endocarditis, wound infections, and abscesses. Ironically, it can infect acne sites on the skin but it does not cause them.

**GRAM-POSITIVE COCCI**
clinically relevant gram-positive cocc bacteria
- Micrococcus
- Staphylococcus
- Streptococcus

**MICROCOCCUS**
observed as spherical cells forming pairs or clusters
a common human skin contaminant
relatively harmless to humans because they maintain a saprophytic lifestyle
also found in freshwater environments or in soil
two common species are
  - *M. luteus*
  - *M. varians*

**STAPHYLOCOCCUS**
Clinically significant species are
- *S. aureus*
- *S. epidermidis*

*S. aureus*
can cause
  - soft tissue infections
  - toxic shock syndrome (TSS)
  - pneumonia
  - meningitis
  - boils
  - osteomyelitis (bone infection)
*enterotoxins* causes cramps and severe vomiting
also secretes *leukocidin*
toxin which destroys WBC and leads to the formation of puss and acne

*S. epidermidis*
an opportunistic pathogen which is a normal resident of human skin
individuals susceptible to infection
  - IV drug users
  - newborns
  - elderly
  - those using catheters or other artificial appliances

**STREPTOCOCCUS**
appear as chains
produce *exotoxins* which destroy
phagocytic cells
host connective tissue
fibrin (blood clots)
clinically significant genus
- *S. pyogenes*
- *S. pneumoniae*
- *S. agalactiae*
**S. mutans**

*S. pyogenes*

an opportunistic pathogen is responsible for about 90% of all cases of "Strep throat"
characterized by inflammation and swelling of the throat, as well as development of pus-filled regions on the tonsils
if the infection reaches the lungs it could lead to pneumonia or rheumatic fever

*S. pyogenes*

also causes impetigo, cellulitis, scarlet fever and erysipelas

*S. pneumoniae*

causes pneumonia, meningitis, and otitis media

*S. agalactiae*

the causative agent in mastitis in cows
has also been found to be a cause of sexually transmitted urogenital infections in females

*S. mutans*

inhabit the mouth
most tooth decay can be attributed to *S. mutans*

**GRAM-NEGATIVE BACTERIA**

Clinically significant genus

- Neisseria
- Haemophilus
- Bordetella
- Brucella
- Francisella
- Pasteurella
- Legionella
- Vibrio
- Helicobacter
- Vibrioids
- Enterobacteriaceae

**NEISSERIA**

diplococci which inhabit the mucous membranes
clinically significant

- *N. gonorrhoeae*
- *N. meningitidis*

*N. gonorrhoeae*

Gonorrhea is transmitted between humans through intimate contact of the mucous membrane
can be carried by men and women for many years without any sign or symptoms
Females infected with gonorrhea exhibit vaginal discharges, abdominal pain, and abnormal non-menstrual bleeding
In infected males, the disease is characterized by a urethral discharge of puss
this disease is treatable
sensitive to ultraviolet radiation, drying, and antibiotics
Use of the birth control pill can lower the glycogen concentration of the vaginal membrane
This environmental change inhibits the growth of acid-producing bacteria such as Lactobacillus, which are the natural flora of the vagina. The vaginal pH soon becomes less acidic and a variety of organisms are able to grow there.

*N. meningitidis*
- the second leading cause of meningitis
- inflammation of the membranes covering the central nervous system
- Early symptoms may include headache, fever, and vomiting
- Death can quickly follow due to endotoxin shock
- Infection doesn't always lead to death
- can often assume a carrier status with carriers not actually developing the disease

**HAEMOPHILUS**
- common in children can cause a secondary respiratory infection that usually inflicts those who already have the flu
  *H. influenzae*
  - occur as natural flora of the nose and pharynx
  - can confer severe illness in patients that are immunosuppressed or that have pre-existing respiratory ailments
  - most common cause of bacterial meningitis in children between the ages of five months and five years
  - The initial respiratory infection can spread to the blood stream and eventually the central nervous system
  - A stiff neck, lethargy, and the absence of the sucking reflex are common symptoms in infected babies
  - *H. influenzae* is the number one cause of Epiglottitis
  - potentially fatal disease may cause airway obstruction in children between the ages of 2 and 4
  - Haemophilus infection has also been associated with chronic bronchitis, pneumonia, earaches, conjunctivitis and chancroid (sexually transmitted)

**BORDETELLA**
- most important species in this genus is *B. pertussis*
  - causes whooping cough
  - highly contagious bacterium makes its way into the respiratory tract via inhalation
  - subsequently binds to and destroys the ciliated epithelial cells of the trachea and bronchi
  - whooping cough usually afflicts children less than a year old
  - A vaccine has reduced the incidence of this disease one hundred fold since its introduction

**BRUCELLA**
- causes *Brucellosis*
  - This organism is sometimes carried by animals and only causes incidental infections in humans
  - cattle, swine, goats, dogs
Brucella can enter the body via the skin, respiratory tract, or digestive tract. Symptoms can include high fever, chills, and sweating.

**FRANCISELLA**
- Causes tularemia, a disease that humans can catch from tick bites.
- This highly infectious disease is carried by rodents, deer, pets, and many other animals.
- Humans can acquire the organism in several different ways through lesions in skin.
- A sudden onset of flu-like symptoms (headache, fever, chills) is observed in infected individuals.

**PASTEURELLA**
- *P. multocida* is the species which most commonly infects humans.
- Humans can acquire the organism from dog or cat bites.
- Patients tend to exhibit swelling, cellulitis, and some bloody drainage at the wound site.
- Infection may also move to nearby joints where it can cause swelling and arthritis.

**LEGIONELLA**
- First discovery of Legionella came in 1976.
- Outbreak of pneumonia at an American Legion convention led to 29 deaths (Legionnaires’ disease).
- Respiratory transmission of this organism can lead to infection, which is usually characterized by a gradual onset of flu-like symptoms.
- Patients may experience fever, chills, and a dry cough as part of the early symptoms.
- Patients can develop severe pneumonia which is not responsive to penicillins.

**VIBRIO**
- Vibrio species are non-invasive pathogens.
- Can cause some of the most serious cases of diarrhea and thousands of people die from infection annually.
- Waterborne organisms are transmitted to humans via infected water or through fecal transmission.
- Most clinically important is *V. cholerae*.
- In countries with poor sewage or water treatment cholera is sometimes seen in epidemic proportions.
- Characterized by severe diarrhea which has a rice-water color and consistency.
- The diarrhea is so severe that about 60% percent of cholera deaths are due to dehydration.
- After cholera organisms are ingested, they descend to the intestinal tract where they release their exotoxin.
- Induces the epithelial cells to excrete salt.
- The cells then lose water which passively flows out of the cells.
- Fluid and electrolyte replacement is the key to treating cholera patients.
- Another strain which causes diarrhea can be found in raw seafood such as sushi and oysters.

**HELICOBACTER**
- Leading cause of peptic ulcers and chronic gastritis.
- Infected patients can be treated with an antacid as well as tetracycline to treat the ulcers and inhibit the growth of the organism.
VIBRIOIDS
Most interesting is a bacterial predator
slips in between the cell wall and cell membrane of a host bacterium and
parasitizes the organism

ENTEROBACTERIACEAE
among the most pathogenic and most often encountered organisms in clinical
microbiology
large rods are usually associated with intestinal infections
can cause meningitis, dysentery, typhoid, and food poisoning

ENTEROBACTERIACEAE
Clinically important
Escherichia coli
Shigella
Salmonella
Klebsiella
Proteus
Yersinia

ESCHERICHIA COLI
can cause urinary tract infections, pneumonia, meningitis, and traveler's
diarrhea
part of the normal flora of the human intestinal tract
plays a crucial role in food digestion by producing vitamin K from
undigested material in the large intestine
Pathogenic strains can cause severe cases of diarrhea in all age groups
by producing a powerful endotoxin
Treating E. coli infections with antibiotics may actually place the patient
in severe shock which could possibly lead to death
because more of the bacterium's toxin is released when the cell dies

SHIGELLA
In many cases Shigella infection will lead to diarrhea accompanied by
fever
an invasive pathogen which can be recovered from the bloody stool of
an infected host
Invasive pathogens colonize the host's tissues as opposed to growing
on tissue surfaces
is easily spread from host to host
the primary suspect in outbreaks of diarrhea

SALMONELLA
Can cause bacterial food poisoning
Transmission is usually through uncooked meats and eggs
Chickens are a major reservoir of Salmonella
explains its ubiquitous presence in poultry products
Ingesting contaminated foods can cause intestinal infection leading to
diarrhea, vomiting, chills, and headache
capsular properties can cause serious complications in
immunosuppressed individuals such as HIV / AIDS patients
S. typhosa causes typhoid fever (enteric fever)
characterized by fever, diarrhea, and inflammation of the infected
organs

KLEBSIELLA
produces large sticky colonies
K. pneumoniae infections are common in hospitals where they cause pneumonia and urinary tract infections in catheterized patients cause of septicemia

PROTEUS
can cause urinary tract infections and hospital-acquired infections usually only targets immunosuppressed individuals

YERSINIA
an invasive pathogen which can penetrate the gut lining and enter the lymphatic system and the blood
ingestion of contaminated foods, can cause a severe intestinal inflammation called yersiniosis
Release of its enterotoxin can cause severe pain similar to that found in patients with appendicitis
Y. pestis causes the bubonic, pneumonic, and septicemic plagues
Human contraction of bubonic plague is usually through flea bites
Once inside the body, Y. pestis releases a toxin which inhibits the Kreb’s cycle in host cells
Swelling of the lymph nodes, skin blotches, and delirium are sometimes observed within a few days of infection
Untreated infections usually result in death within a week of initial infection
the plague has historically been a deadly pathogen
inflicting Europeans in epidemic proportions during the fourteenth, fifteenth, and sixteenth centuries
lack of sanitation allowed the plague to go unchecked killing tens of millions

SPIROCHETES
Typically have a helical or spiral structure
clinically significant genus
Treponema
Borellia
Leptospira
TREPONEMA
T. pallidum is the causative agent of syphilis
BORELLIA
B. burgdorferi is the agent which causes Lyme Disease
typically spread by bites of small ticks
LEPTOSPIRA
members of this genus can cause leptospirosis
spread by contaminated urine from pets
pets are commonly immunized

RICKETTSIA
can reproduce only within a host cell
R. rickettsii is cause of Rocky Mountain Spotted Fever which is carried in the digestive tract of some species of ticks

CHLAMYDIA
do not require insects or ticks for transmission
C. trachomais is a sexually transmitted urethritis

END TAXONOMY