Bacillus Species:
- **Aerobic** gram positive *spore forming* rods
- **B Cereus** -> food poisoning
- **B anthracis** [anthrax] -> cutaneous (malignant pustules over the skin), inhalation, ingestion (GI anthrax, very rare)
- **B thuringiensis** -> useful for research purposes

Bacillus Cereus:
- Causes **food poisoning** and endocarditis, meningitis, osteomyelitis, pneumonia, eye infection [Mainly in immunodeficient patients and those with prosthetic medical devices]
- **Enterotoxins** Two types:
  1. vomiting type [cerulide] – **heat stable** [they survive flash frying], incubation period ½ hour, nausea, **vomiting**, abdominal cramps, sometimes diarrhea, connected with chines food especially *rice and cereals*, it’s formed outside the body
  2. diarrheal type – **heat labile**, longer incubation period, **diarrhea** and abdominal cramps, sometimes nausea and vomiting, connected with contaminated *meat, vegetables and sauces*, it’s formed inside the colon

- **Diagnosis**: Clinical grounds , specimen from the suspect food
- **treatment and prevention**: self-limiting, antimicrobial therapy is NOT normally required
  1. vital signs [respiratory and heart rate, temperature, blood pressure]
  2. dehydration signs
  3. fluid and electrolytes replacement
<table>
<thead>
<tr>
<th><strong>B Cereus</strong></th>
<th><strong>B. Anthracis</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Motile</td>
<td>Non motile</td>
</tr>
<tr>
<td>Has no capsule -&gt; has no vaccine</td>
<td>Has capsule, main component D-glutamic acid -&gt; Has vaccine</td>
</tr>
<tr>
<td>Beta hemolysis</td>
<td>No hemolysis</td>
</tr>
<tr>
<td>produce alpha toxin [licithenase]</td>
<td>Doesn’t produce alpha toxin</td>
</tr>
<tr>
<td>Resistance to penicillin and cephalosporins</td>
<td>Sensitive to penicillin and cephalosporins</td>
</tr>
<tr>
<td>Large feathery white colonies</td>
<td>Medusa-head colonies</td>
</tr>
</tbody>
</table>
Clostridium species

- Most species of clostridia are motile and possess peritrichous flagella
- Anaerobes, gram positive, spore forming rods

1- Clostridium tetani – tetanus, rigid paralysis [hyper-tone]
2- Clostridium botulinum – botulism, flaccid paralysis [hypo-tone], most common in infants [floppy baby syndrome]
3- Clostridium perfringens – gas gangrene + food poisoning
4- Clostridium difficile – pseudomembranous colitis < antibiotics associated diarrhea

Clostridium botulinum:

- Botulism is characterized by symmetrical, descending, flaccid paralysis of motor and autonomic nerves usually beginning with cranial nerves
- Botulinum toxin: Highly toxic neurotoxin, Seven Serotypes (A-G), most important in human A + B + E, Absorbed by gut, carried by blood -> peripheral nerve synapses -> blocks release of Ach at the myo-neuronal junction -> reversible flaccid paralysis

- There are four clinical categories of botulism:
  1- foodborne botulism = adults botulism, toxin is formed outside the body
  2- wound botulism
  3- infant botulism = Most common food vehicle is honey containing spores that germinate inside the body
  4- inadvertent, following botulinum IM toxin injection
S & S:
- Initial symptoms can include nausea, vomiting, abdominal cramps or diarrhea -> Dry mouth, blurred vision, and diplopia are usually the earliest neurologic symptoms -> They are followed by inability to swallow, and speech difficulty -> In severe cases, extensive respiratory muscle paralysis leads to ventilatory failure
- The infants poor feeding, weakness, and signs of paralysis (floppy baby)
- **Infant botulism may be one of the causes of sudden infant death syndrome**

**Diagnosis:**
- Clinical ground
- **Toxin** may be found by ELISAs and PCR
- **Mouse bioassay** is the test of choice for the confirmation of botulism “gold standard”

**Treatment**
- Supportive treatment, especially adequate mechanical ventilation
- Antitoxin: trivalent (A, B, E)
- **NO antibiotics**

**Prevention and control:**
- **Canned food** must be sufficiently heated to ensure destruction of spores [boiled for more than 20 minutes]
- No honey for the first year infants
Clostridium perfringens:
- gram positive, spore-forming rods [**don’t show spores in lab cultures**], non-motile
- Anaerobic: “**stormy fermentation**” in milk media
- Double zone of hemolysis [alpha and beta hemolysis]
- Transmission: food borne, traumatic implantation
- Produce gas, crepitation, foul-smelling discharge
- Alpha toxin = licithenase, theta toxin = necrotizing toxin, epsilon toxin = edema factor, enterotoxin = causes food poisoning last only 1-2 days [self improvement]

**Diagnostic Laboratory Tests**
1- gram stain
2- thioglycolate medium + blood agar plates incubated anaerobically
3- **Nagler test**: toxin production and neutralization by specific anti-toxin

**Treatment and prevention**
1- surgical debridement
2- **Administration of antimicrobial drugs**
3- antitoxins are available
4- Food poisoning usually requires only symptomatic care

*extra note: C. perfringens is one of the causes of endometritis*
Clostridium difficile:
- colonizes the intestine of 50% of healthy neonates and 4% of healthy adults
- antibiotic associated diarrhea [long lasting] [Mild to moderate]: cephalosporins + clindamycin.
- Pseudomembranous colitis [severe forms] / fulminant colitis: medical emergency \rightarrow toxic mega colon
- Infection may be endogenous [This is due to suppression of the normal bowel flora and subsequent overgrowth of C. difficile] or exogenous [ingestion of environmental spores]
- Produces two major toxins: Toxin A (enterotoxin) and Toxin B (cytotoxin)
- Toxin A induces cytokine production with hypersecretion of fluid
- Toxin B induces depolymerization of actin with loss of cytoskeleton
- Hypervirulent strains are now recognized 027 + 078
- Most common cause of diarrhea associated with hospitals

**Diagnosis**
1- diarrhea
2- toxin A or toxin B detected in the stool
3- pseudo-membranes seen in the colon

**Treatment**
1- discontinue other antibiotics therapy
2- oral administration of vancomycin or metronidazole
3- limited-spectrum drugs should be considered first
4- autoclave bed bans (treatment kills spores)
5- fecal transplantation