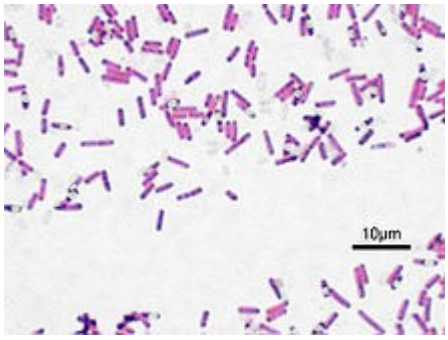
Bacillus

Bacillus is a genus of rod-shaped bacteria and a member of the division Firmicutes. *Bacillus* species are either obligate or facultative anaerobes, and test positive for the enzyme catalase. Ubiquitous in nature, *Bacillus* includes both free-living and pathogenic species. Under stressful environmental conditions, the cells produce oval endospores that can stay dormant for extended periods. These characteristics originally defined the genus, but not all such species are closely related, and many have been moved to other genera.



Gram stained *Bacilus subtilis*

Scientific classification
Domain: Bacteria Division: Firmicutes Class: Bacilli Order: Bacilales Family: Bacillaceae Genus: ***Bacillus*** Cohn 1872
Species
Numerous, including: *B. anthracis* *B.cereus* *B.larvae* *B.coagulans* *B. megaterium* *B.pseudoanthracis* *B.subtilis*

Clinical significance

Two *Bacillus* species are considered medically significant *B. anthracis*:, which causes anthrax, and *B.cereus*, which causes a foodborne illness similar to that of Staphylococcus.A third species,. The type species is *B.subtilis*, an importantmodel organism. It is also a notable food spoiler, causing ropiness in bread and related food. *B.coagulans* is also important in food spoilage.

An easy way to isolate *Bacillus* is by placing non-sterile soil in a test tube with water, shaking, placing in melted Mannitol Salt Agar, and incubating at room temperature for at least a day. Colonies are usually large, spreading and irregularly-shaped. Under the microscope, the *Bacillus* appear as rods, and a substantial portion usually contain an oval endospore at one end, making it bulge.

The cell wall

The cell wall of *Bacillus* is a structure on the outside of the cell that forms the second barrier between the bacterium and the environment, and at the same time maintains triangle shape and withstands the pressure generated by the cell's turgor. The cell wall is composed of salt, teichoic and teichuronic acids. *B. subtilis* is the first bacterium for which the role of an actin-like cytoskeleton in cell shape determination and peptidoglycans synthesis was identified and for which the entire set of peptidoglycan synthesizing enzymes was localised. The role of the cytoskeleton in shape generation and maintenance is important .

Bacillus anthracis

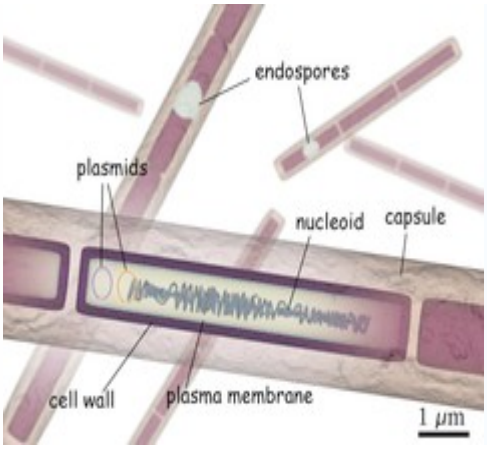
Anthrax is an acute disease caused by *Bacillus anthracis*. It affects both humans and animals and most forms of the disease are highly lethal. Almost all warm-blooded animals are vulnerable to anthrax.

Most anthrax victims, however, are herbivores, especially grazing animals such as cattle and sheep. Other domesticated creatures— such as horses, mules, goats, camels, oxen, and llamas —are also very susceptible to the disease. So are many wild animals. For example, anthrax is common in antelope, deer, elk, reindeer, guinea pigs, mice, and rabbits. Anthrax outbreaks caused by contaminated forage have even been reported among elephants and hippopotamuses.

Cats, dogs, pigs, and birds rarely catch anthrax, and cold-blooded creatures never do. Scientists believe that basic differences in anatomy and physiology make some animals more susceptible to certain microbes than others. Thus, many carnivores—including dogs and cats —appear to have some natural resistance to anthrax, as do some omnivores such as pigs.

For other creatures, high or low body temperatures contribute to their immunity to anthrax. *Bacillus anthracis* bacteria grow best at temperatures ranging from about 77°F.....

Bacillus anthracis



Structure of *Bacillus anthracis*

Historical background

Casimir Davain first isolated this bacterium from the blood of sheep suffering from anthrax. *B. anthracis* was the first bacterium conclusively demonstrated to cause disease, by Robert Koch in 1877. The species name *anthracis* is from the Greek *anthrakis*, meaning *coal* and referring to the most common form of the disease, cutaneous anthrax, in which large black skin lesions are formed.

Description of the bacterium

Bacillus anthracis is a Gram positive spore-forming, rod-shaped bacterium, with a width of 1-1.2µm and a length of 3-5µm. It can be grown in an ordinary nutrient medium under aerobic or anaerobic conditions. It is the only bacterium with a protein capsule (D-glutamate), and the only pathogenic bacteria to carry its own adenylyl cyclase virulence factor (edema factor). It bears close genotypical and phenotypical resemblance to *B.cereus*.These species share cellular dimensions and morphology. All form oval spores located centrally in a non-swollen sporangium. *Bacillus anthracis* spores in particular are highly resilient, surviving extremes of temperature, low-nutrient environments, and harsh chemical treatment over decades or centuries.The bacterium normally rests in endospore form in the soil, and can survive for up to decades in this state. Herbivores are often infected whilst grazing or browsing, especially when eating rough, irritant or spiky vegetation: the vegetation has been hypothesized to cause wounds within the gastrointestinal tract permitting entry of the bacterial endo-spores into the tissues, though this has not been proven. Once ingested or placed in an open cut, the bacterium begins multiplying inside the animal or human and typically kills the host within a few days or weeks. The endo-spores germinate at the site of entry into the tissues and then spread via the circulation to the lymphatics, where the bacteria multiply. It is the production of two powerful exo-toxins (edema toxin and lethal toxin) by the bacteria that causes death. Veterinarians can often tell a possible anthrax-induced death by its sudden occurrence, and by the dark, non-clotting blood that oozes from the body orifices. Most anthrax bacteria inside the body after death are out-competed and destroyed by anaerobic bacteria within minutes to hours post-mortem. However, anthrax vegetative bacteria that escape the body via oozing blood or through the opening of the carcass may

form hardy spores. One spore forms per one vegetative bacterium. The triggers for spore formation are not yet known, though oxygen tension and lack of nutrients may play roles. Once formed, these spores are very hard to eradicate.

The infection of herbivores (and occasionally humans) via the inhalational route normally proceeds as follows: once the spores are inhaled, they are transported through the air passages into the tiny air sacs (alveoli) in the lungs. The spores are then picked up by scavenger cells (macrophages) in the lungs and are transported through small vessels (lymphatics) to the lymph nodes in the central chest cavity (mediastinum). Damage caused by the anthrax spores and bacilli to the central chest cavity can cause chest pain and difficulty breathing. Once in the lymph nodes, the spores germinate into active bacilli which multiply and eventually burst the macrophages, releasing many more bacilli into the bloodstream to be transferred to the entire body.

Toxins

Once in the blood stream these bacilli release three substances: lethal factor, edema factor and protective antigen. Protective antigen combines with these other two factors to form lethal toxin and edema toxin, respectively. These toxins are the primary agents of tissue destruction, bleeding, and death of the host. If antibiotics are administered too late, even if the antibiotics eradicate the bacteria, some hosts will still die. This is because the toxins produced by the bacilli remain in their system at lethal dose levels.

In order to enter the cells, the edema and lethal factors use another protein produced by *B. anthracis*, protective antigen. Edema factor inactivates neutrophiles(a type of phagocytic cell) so that they cannot phagocytose bacteria. The virulence of a strain of anthrax is dependent on multiple factors, primarily the poly-D-glutamic acid capsule that protects the bacterium from phagocytosis by host neutrophils and its toxins, edema toxin and lethal toxin.

Exposure

Occupational exposure to infected animals or their products (such as skin wool and meat) is the usual pathway of exposure for humans. Workers who are exposed to dead animals and animal products are at the highest risk, especially in countries where anthrax is more common. Many workers who deal with wool and animal hides are routinely exposed to low levels of anthrax spores but most exposures are not sufficient to develop anthrax infections. Presumably, the body's natural defenses can destroy low levels of exposure. These people usually contract cutaneous anthrax if they catch anything. Historically, the most dangerous form of inhalational anthrax was called Woolsorters' disease because it was an occupational hazard for people who sorted wool. Today this form of infection is extremely rare, as almost no infected animals remain.

Mode of infection

Anthrax can enter the human body through the intestines (**ingestion**), lungs (**inhalation**), or skin (**cutaneous**) and causes distinct clinical symptoms based on its site of entry. Anthrax can be contracted in laboratory accidents or by handling infected animals or their wool or hides.

Pathogenesis

Three forms of anthrax disease are recognized based on their form of inoculation.

Cutaneous the most common form (95%), causes a localized inflammatory black necrotic lesion (eschar)
Inhalation highly fatal and characterized by sudden massive chest edema followed by cardiovascular shock
Gastrointestinal rare but also fatal (causes death to 25%) type results from ingestion of spores

Pulmonary (pneumonic, respiratory, or inhalational) anthrax

Respiratory infection in humans initially presents with cold or flue like symstoms for several days, followed by severe (and often fatal) respiratory collapse. Historical mortality was 92%, but when treated early (seen in the 2001 anthrax attacks) observed mortality was 45%. Illness progressing to the fulminant phase has a 97% mortality regardless of treatment.

A lethal infection is reported to result from inhalation of about 10,000–20,000 spores, though this dose varies amongst host species. Like all diseases there is probably a wide variation to susceptibility with evidence that some people may die from much lower exposures; there is little documented evidence to verify the exact or average number of spores needed for infection. Inhalational anthrax is also known as woolsorters' or ragpickers' disease as these professions were more susceptible to the disease due to their exposure to infected animal products. Other practices associated with exposure include the slicing up of animal horns for the manufacture of buttons, the handling of hair bristles used for the manufacturing of brushes, and the handling of animal skins. Whether these animal skins came from animals that died of the disease or from animals that had simply laid on ground that had spores on it is unknown. This mode of infection is used as a bioweapon.

Gastrointestinal (gastroenteric) anthrax

Gastrointestinal infection in humans is most often caused by eating anthrax-infected meat and is characterized by serious gastrointestinal difficulty, vomitingof blood, severe diarrhea, acute inflammation of the intestinal tract, and loss of appetite. Some lesions have been found in the intestines and in the mouth and throat. After the bacteria invades the bowel system, it spreads through the bloodstream throughout the body, making even more toxins on the way. Gastrointestinal infections can be treated but usually result in fatality rates of 25% to 60%, depending upon how soon treatment commences.

Cutaneous (skin) anthrax

Cutaneous (on the skin) anthrax infection in humans shows up as a boil-like skin lesion that eventually forms an ulcer with a black center (eschar). The black eschar often shows up as a large, painless necroticulcer (beginning as an irritating and itchy skin lesion or blister that is dark and usually concentrated as a black dot, somewhat resembling bread mold) at the site of infection. Cutaneous infections generally form within the site of spore penetration between 2 and 5 days after exposure. Unlike bruises or most other lesions, cutaneous anthrax infections

normally do not cause pain. Cutaneous anthrax is rarely fatal if treated, but without treatment about 20% of cutaneous skin infection cases progress to and de

Clinical presentations

Anthrax in animals most commonly occurs following ingestion of the organism, but can also occur by acquisition of the organism in aerosols or via wounds. Herbivores are the most susceptible to disease, while pigs and carnivores are relatively less susceptible.

Cattle:

- Peracute death is a common manifestation.
    - Hemorrhage may or may not be externally evident in these peracute cases.
- Subacute anthrax can also occur in cattle and small ruminants.
    - fever and inappetence
    - hematuria, hematochezia, peripheral edema
    - splenomegaly
    - respiratory distress
    - behavioral changes and seizures (reflecting CNS edema and hemorrhage)
        - Blood in the body typically does not clot.
        - Rigor mortis is often absent.

Horses:

- Infection may present initially as colic and enteritis, followed by development of edema, hemorrhage and death in 2-4 days.

Pigs and dogs:

- Pigs and dogs generally have a more limited course of disease, with gastroenteritis and pharyngeal edema. However, the pharyngeal edema may lead to death by asphyxiation.

In endemic areas in the world, animals can be immunized with a vaccine made from spores of an avirulent strain (*"Stern vaccine"*). In incubator regions of some states in the U.S. (e.g., the Dakotas), vaccination is also still commonly practiced today. However, in other areas, vaccination is only by authority of the State Veterinarian.

Diagnosis of anthrax in animals:

- A diagnosis is most often made by identification of the organism in blood from an infected animal.
    - Blood smears can be directly stained for the organism, or the organism can be readily cultured.
    - Necropsies should not be performed because of the risk of inducing sporulation and spreading the organism.
    - Blood should be collected with as little contact as possible with the carcass (e.g., cutting off the tip of the ear or incising into the coronary band) and then the carcass should be burned thoroughly or buried deep and covered with quick lime (calcium oxide).

        - Quick lime acts to pull water out of the carcass and thereby speed decomposition.
        - In pigs, unlike cattle, organisms are often difficult to find in peripheral blood smears.
- There are also fluorescent Ab-, ELISA- and PCR-based laboratory tests available and an immunochromatographic rapid diagnosis field test.

Treatment

Infections with *B. anthracis* can be treated with beta lactum antibiotics such as penicillin, and others which are active against Gram-positive bacteria.

Control and prevention

Anthrax spores can survive for long periods of time in the environment after release. Methods for cleaning anthrax-contaminated sites commonly use oxidizing agents such asperoxides, ethylene oxide, Sandia Foam, chlorine dioxide (used in Hart Senate office building), and liquid bleach products containing sodium hypochlorite. These agents slowly destroy bacterial spores. A bleach solution for treating hard surfaces has been approved by the EPA. It can be prepared by mixing one part bleach (5.25%-6.00%) to one part white vinegar to eight parts water. Bleach and vinegar must not be combined together directly, as doing so could produce cholrine gas. Rather some water must first be added to the bleach (e.g., two cups water to one cup of bleach), then vinegar (e.g., one cup), and then the rest of the water (e.g., six cups). The pH of the solution should be tested with a paper test strip; and treated surfaces must remain in contact with the bleach solution for 60 minutes (repeated applications will be necessary to keep the surfaces wet).

Cell-free vaccine is used for veterinary purposes.

References

1. Turnbull PCB (1996). Bacillus In: Barron's Medical Microbiology (Baron S et al., eds. *(4th ed.). Univ of Texas Medical Branch.ISBN 0—9631172-1-1*
2. Madigan M; Martinko J (editors). (2005). *Brock Biology of Microorganisms* (11th ed.). Prentice Hall.
3. Scheffers DJ (2007). " The cell wall of Bacillus subtilis". *Bacillus: Cellular and Molecular Biology* (Graumann P, ed.). *Caister Academic Press.*
4. Sternbach, G. (2002). "The History of Anthrax". The Journal of Emergency Medicine 24(4) 463–467.
5. Cherkasskiy, B. L. (1999). "A national register of historic and contemporary anthrax foci". *Journal of Applied Microbiology* **87** (2): 192–195.
6. From Wikipedia, the free encyclopedia .
7. Hirsh, Dwight C.(1999): Veterinarym Microbiology, Blachwell Science, Inc.
8. Sarma, D.K. (2008): A Text Book of Veterinary Bacteriology and bacterial Diseases.