Bacterial Diseases in Humans & Animals

Contents

- **AIR BORN DISEASES**
  Diphtheria, Legionnaires' disease and Pontiac fever, Tuberculosis, Streptococcal diseases, and Mycoplasmal pneumonia etc.
- **ARTHROPOD BORN DISEASES**
  Plague. Lyme disease, Typhus etc.
- **DIREACT CONTACT DISEASES**
  Vaginosis, Chancroid, Gas Gangrene, Leprosy, Peptic ulcer Staphylococcal diseases, Syphilis etc.
- **ZOONOTIC DIDEASES**
  Anthrax, Brucellosis , Psitticosis, Tularemia etc
- **FOOD AND WATER BORN DISEASES**
  Botulism, Cholera, and Staphylococcal food poisoning Typhoid etc.
- **DENTAL DISEASES**
  Dental plaque, Dental Decay (Caries) etc.

AIR BORNE DISEASES

RESPIRATORY

- Most of the airborne diseases caused by bacteria involve the respiratory system

Examples

- Diphtheria
- Legionnaires' disease
- Pontiac fever
- Tuberculosis infections
- *Pertussis*
- Streptococcal diseases
- Mycoplasmal pneumonia

SKIN DISEASES

Some airborne bacteria can cause skin diseases

EXAMPLES

- Cellulitis
- Erysipelas

SYSTEMIC DISEASES

cause systemic or visceral damage

- Meningitis
- Glomerulonephritis
- Rheumatic fever

Diphtheria

Transmission

- *Corynebacterium diphtheriae*
- Airborne; contact with infected persons
- Pseudomembrane Formation
- May Spread into Bloodstream
- Cardiovascular and visceral damage

- This toxin is an exotoxin that causes an inflammatory response and the formation of a grayish pseudomembrane on the pharynx and respiratory mucosa
- **The pseudomembrane** consists of dead host cells and cells of *C. diphtheriae*.
- Diphtheria toxin is absorbed into the circulatory system and distributed throughout the body, where it may
- Cause destruction of cardiac, kidney, and nervous tissues by inhibiting protein synthesis.

- The toxin is composed of two polypeptide subunits: A and B.

- A subunit consists of the catalytic domain;
- B subunit is composed of the receptor and transmembrane domains

- *The receptor domain binds to the heparin-binding epidermal* growth factor receptor on the surface of various eucaryotic cells.

The transmembrane domain of the toxin embeds itself into the target cell membrane causing the catalytic domain to be cleaved and translocated into the cytoplasm.

The cleaved catalytic domain becomes an active enzyme, catalyzing the attachment of ADP-ribose (from NAD) to elongation factor-2 (EF-2).

A single enzyme (i.e., catalytic domain) can exhaust the entire supply of cellular EF-2 within hours, resulting in protein synthesis inhibition and cell death.

Typical symptoms

Diphtheria include a thick mucopurulent (containing both mucus and pus) nasal discharge, pharyngitis, fever, cough, paralysis, and death.

(*C. diphtheriae can also* infect the skin, usually at a wound or skin lesion, causing a slow healing ulceration termed **cutaneous diphtheria.)**

Diagnosis

Observation of the pseudomembrane in the throat and by bacterial culture. Diphtheria antitoxin is given to neutralize any unabsorbed exotoxin in the patient's tissues; penicillin and erythromycin are used to treat the infection.

Prevention

active immunization with **DPT (*diphtheria-pertussis-tetnus) vaccine;***

and then boosted with DTap **(*diphtheria toxoid, tetanus toxoid,* *acellular B. pertussis vaccine); or*

Tdap ***(tetanus toxoid, reduced*** *diphtheria toxoid, acellular pertussis vaccine, adsorbed), approved* in 2005

ARTHROPOD-BORNE DISEASES

Ancient

plague, typhus

Newly introduced into humans

ehrlichiosis, Q fever, Lyme disease

Arthropod Vectors

- fleas
- lice
- ticks

Plague

Yersinia pestis

Gram-negative, facultatively anaerobic rods

In the southwestern part of the United States, **plague** occurs primarily in wild ground squirrels, chipmunks, mice, and prairie dogs.

massive human epidemics occurred in Europe during the Middle Ages, where the disease was known as the **Black Death** due to black-colored, subcutaneous hemorrhages.

Transmission

- *Y. pestis* secretes *plasmid-encoded yersinal outer membrane proteins* (YOPS) into phagocytic cells to counter-act natural defense mechanisms

- help the bacteria multiply and disseminate in the host

Types of plague

Pneumonic plague occurs when Y. pestis is either inhaled directly or reaches the lungs via the blood or lymphatic circulation.

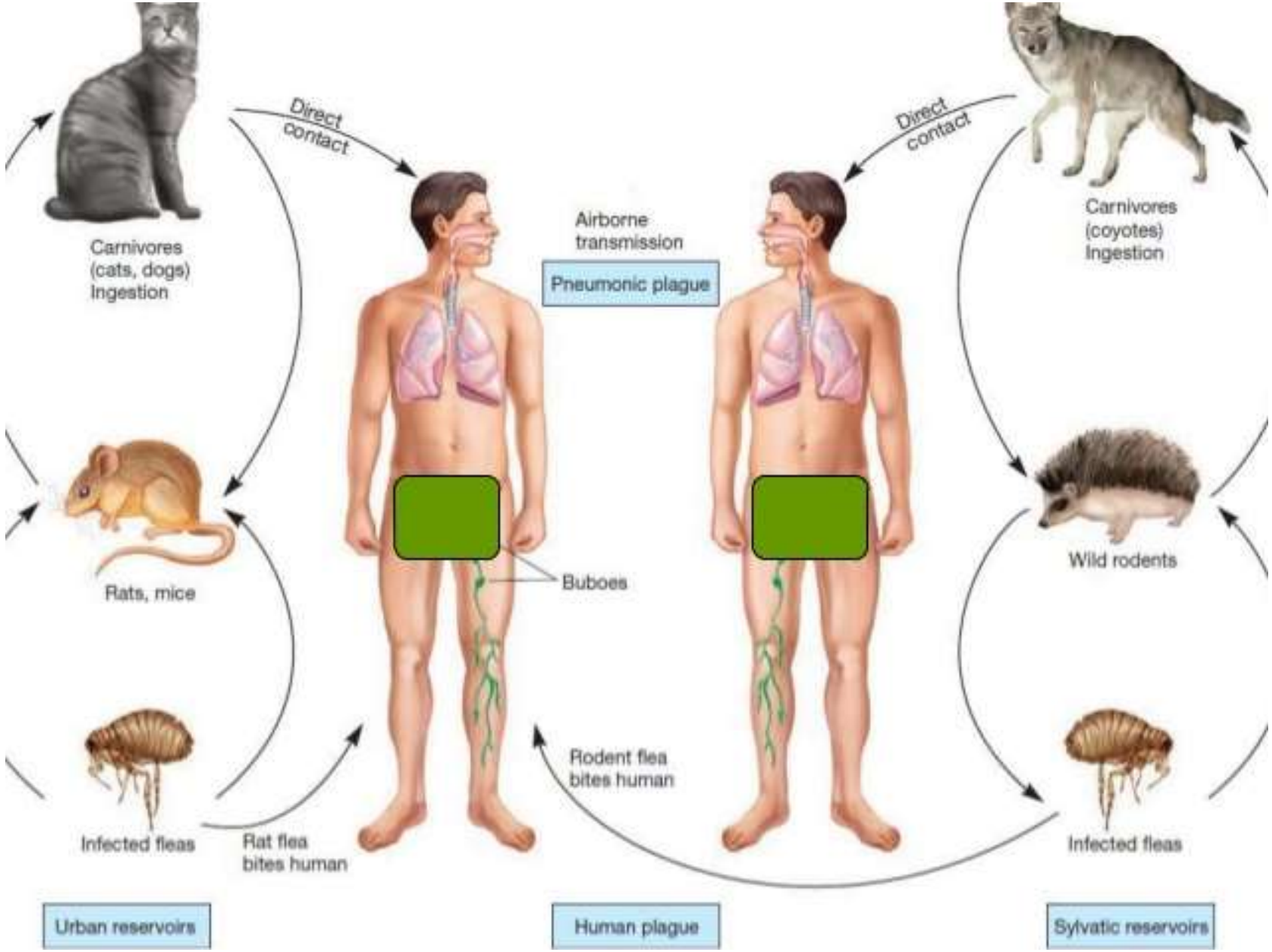
- Symptoms are usually absent until the last day or two of the disease when large amounts of bloody sputum are produced.

- Untreated individuals rarely survive more than 2 days. Pneumonic plague is highly contagious and can spread rapidly via the person-to-person respiratory route if infected individuals are not immediately quarantined.

Septicemic plague is the rapid spread of *Y. pestis* throughout the body via the bloodstream without the formation of buboes and usually causes death before a diagnosis can be made.

Bubonic plague

Symptoms—besides the subcutaneous hemorrhages—include fever, chills, headache, extreme exhaustion, and the appearance of enlarged lymph nodes called **buboes (hence another** old name**)**


Carnivores
(cats, dogs)
Ingestion
Direct
contact
Direct
contact
Carnivores
(coyotes)
Ingestion
Airborne
transmission
Pneumonic plague
Rats, mice
Buboes
Wild rodents
Infected fleas
Rat flea
bites human
Rodent flea
bites human
Infected fleas
Urban reservoirs
Human plague
Sylvatic reservoirs

Prevention and control

- Prevention and control involve flea and rodent control, isolation of human patients, prophylaxis or abortive therapy of exposed persons, and vaccination (Plague vaccine) of persons at high risk.

- *Y. pestis* infection is treated with streptomycin or gentamicin.

- Alternatively, doxycycline, ciprofloxacin, or chloramphenicol may be given intravenously.

DIRECT CONTACT DISEASES

Most of the direct contact bacterial diseases involve the skin, mucous membranes, or underlying tissues.

Examples

Vaginosis

Chancroid

Gas gangrene

Leprosy

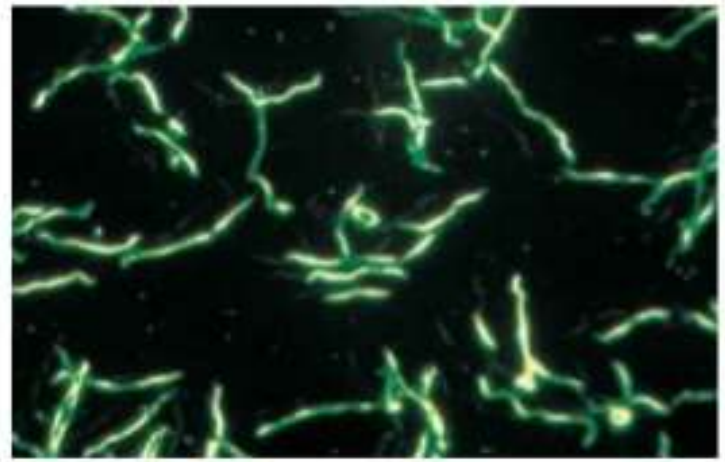
Peptic ulcer disease and gastritis,

Staphylococcal diseases

Syphilis

Syphilis

Sexually transmitted disease caused by the spirochete *Treponema pallidum*



Stages of Syphilis

Three recognizable stages of syphilis occur in untreated adults.

In the **primary stage,** after an incubation period of about 10 days to 3 weeks or more, the initial symptom is a small, painless, reddened ulcer, or **chancre** **[French *canker, a destructive sore]*** with a hard ridge that appears at the infection site and contains spirochetes

Contact with the chancre during sexual contact may result in disease transmission.

The spirochetes typically enter the bloodstream and are distributed throughout the body. Within 2 to 10 weeks after the primary lesion appears, the disease may enter the **secondary stage**, which is characterized by a highly variable skin rash

Both the chancre and the rash lesions are infectious.

After several weeks the disease becomes latent.

After many years a **tertiary stage** develops in about 40% of untreated individuals with secondary syphilis. During this stage degenerative lesions called **gummas** form in the skin, bone, and nervous system as the result of hypersensitivity reactions.

Involvement of the central nervous system may result in tissue loss that can lead to cognitive deficits, blindness, a "shuffle"walk (tabes), or insanity.

Treatment

- In the early stages of the disease is easily accomplished with long-acting benzathine penicillin G or aqueous procaine penicillin.
- Later stages of syphilis are more difficult to treat with drugs and require much larger doses over a longer period.
- For example, in neurosyphilis cases, treponemes occasionally survive such drug treatment.

FOOD-BORNE AND WATER BORNE DISEASES

- Humans contract the food-borne and water-borne bacterial diseases when they ingest contaminated food or water.

These diseases are essentially of two types:

- **Infections and intoxications.** An infection occurs when a pathogen enters the gastrointestinal tract and multiplies.

Examples include Campylobacter gastroenteritis, salmonellosis, listerosis, shigellosis, *Escherichia coli* infections and typhoid etc.

- *An **intoxication*** occurs because of the ingestion of a toxin.
- Examples include botulism, cholera, and staphylococcal food poisoning.
- Because these toxins disrupt the functioning of the intestinal mucosa, they are called **enterotoxins.**

Botulism

Cause: *Clostridium botulinum*

- Properties of the *Clostridium*
  - Gram-positive rod
  - Strictly anaerobic
  - Spore-former
  - Widely distributed, especially in soil and water

Transmission

- A neurotoxin that binds to the synapses of motor neurons
- **It selectively cleaves the synaptic** vesicle membrane protein **synaptobrevin,** thus preventing exocytosis and release of the neurotransmitter acetylcholine.
- As a consequence, muscles do not contract in response to motor neuron activity, and flaccid paralysis results

Symptoms and Diagnosis

- Symptoms of botulism occur within 12 to 72 hours of toxin ingestion and include blurred vision, difficulty in swallowing and speaking, muscle weakness, nausea, and vomiting.

- Laboratory diagnosis is restricted to Laboratory Response Network facilities and is by demonstration of the toxin in the patient's serum or vomitus.

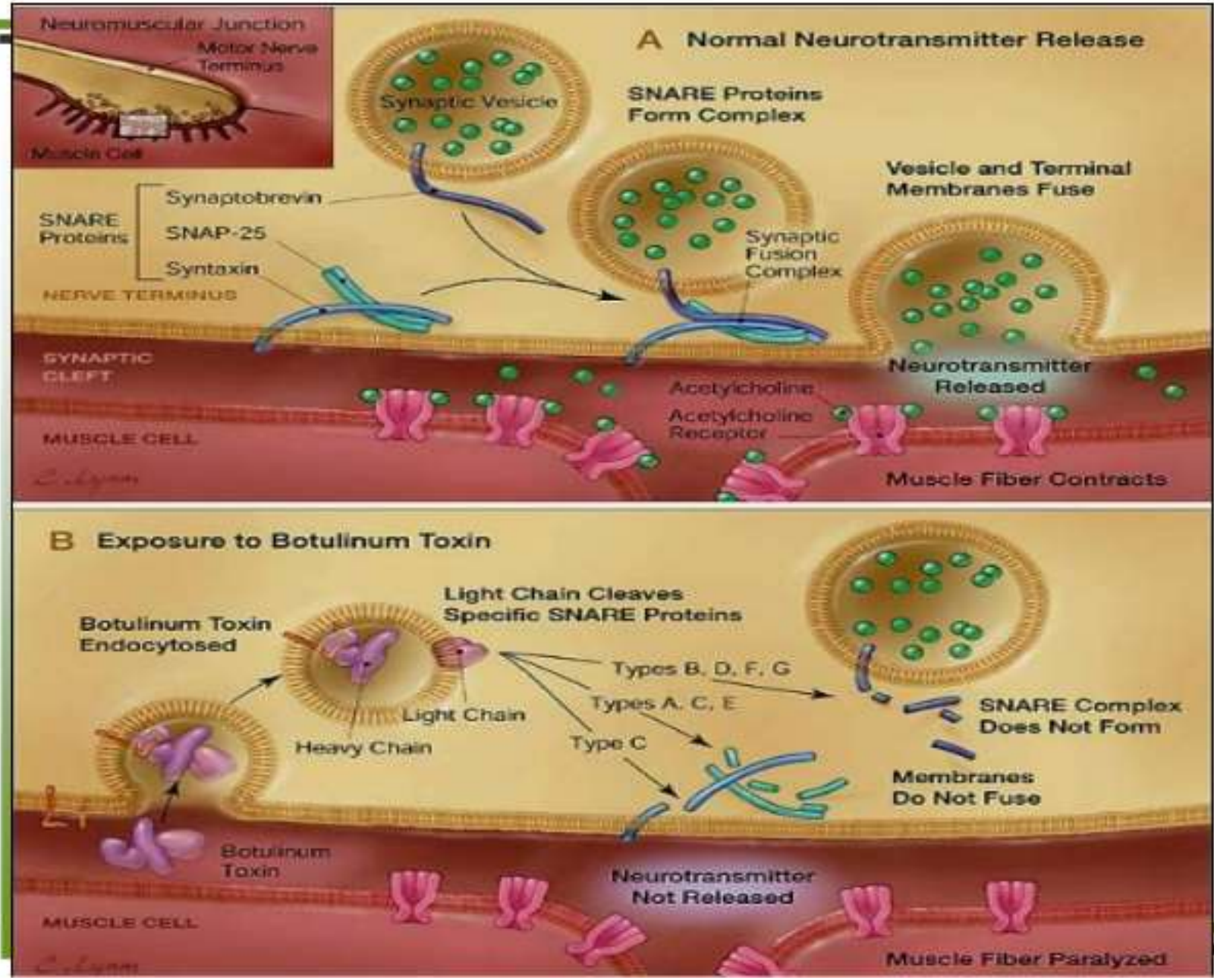
Prevention & Control

Prevention and control of botulism involves

(1) strict adherence to safe food-processing practices by the food industry

(2) educating the public on safe home-preserving (canning) methods for foods,

(3) not feeding honey to infants younger than 1 year of age.


Neuromuscular Junction
Motor Nerve Terminus
Muscle Cell
A Normal Neurotransmitter Release
Synaptic Vesicle
SNARE Proteins Form Complex
Vesicle and Terminal Membranes Fuse
SNARE Proteins
Synaptobrevin
SNAP-25
Syntaxin
NERVE TERMINUS
Synaptic Fusion Complex
SYNAPTIC CLEFT
Acetylcholine
Acetylcholine Receptor
Neurotransmitter Released
MUSCLE CELL
Muscle Fiber Contracts
B Exposure to Botulinum Toxin
Botulinum Toxin Endocytosed
Light Chain Cleaves Specific SNARE Proteins
Types B, D, F, G
Types A, C, E
Type C
Light Chain
Heavy Chain
SNARE Complex Does Not Form
Membranes Do Not Fuse
Botulinum Toxin
Neurotransmitter Not Released
MUSCLE CELL
Muscle Fiber Paralyzed

ZOONOTIC DISEASES

- Diseases transmitted from animals to humans are called Zoonotic diseases.

Examples

- Anthrax
- Brucellosis
- Psitticosis
- Tularemia

Anthrax

- The causative bacterium is the relatively large, gram-positive, aerobic, endospore-forming *Bacillus anthracis*

Human infection is usually

- **cutaneous anthrax**

  through a cut or abrasion of the skin

- **pulmonary anthrax (woolsorter's disease)**

  inhaling spores

- **gastrointestinal anthrax**

  spores reach the gastrointestinal tract

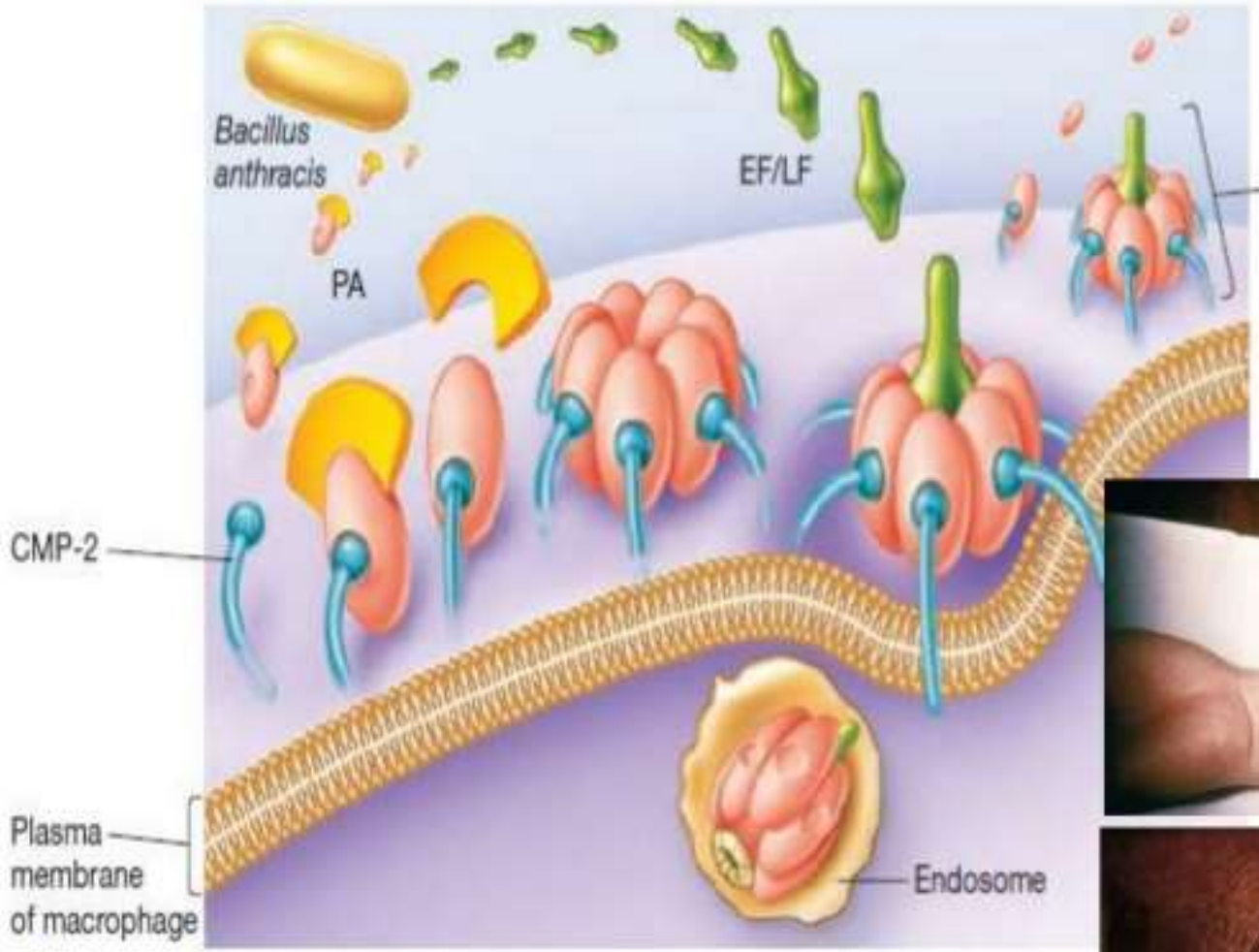
Cutaneous Anthrax

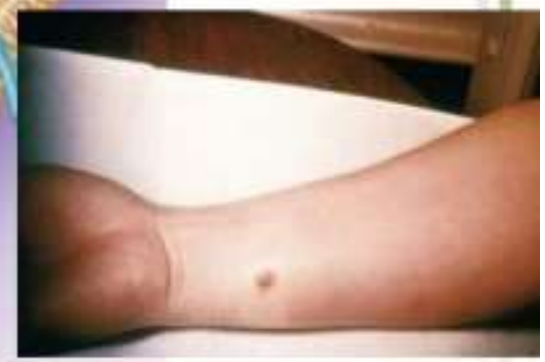
(a) A protein called protective antigen (PA) delivers two other proteins, edema factor (EF) and lethal factor (LF), to the capillary morphogenesis protein-2 (CMP-2) receptor on the cell membrane of a target macrophage where

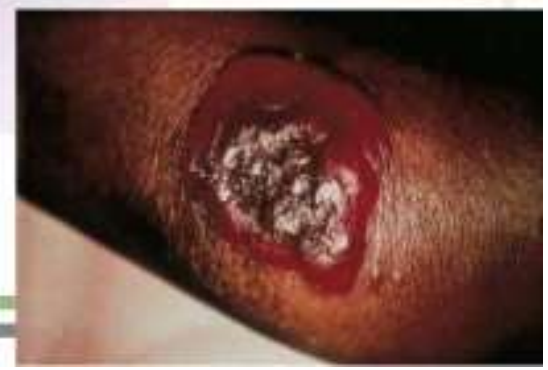
PA, EF, and LF are transported to an endosome. PA then delivers EF and LF from the endosome into the cytoplasm of the macrophage where they exert their toxic effects.

(b) A cutaneous anthrax papule will ulcerate and necrose

(c) an eschar will form







Killing Macrophages

Role of EF and LF

- EF has adenylate cyclase activity, similar to diphtheria toxins; increasing intracellular cAMP releases fluid or the formation of edema.

- Additionally, LF interferes with a transcription factor, **nuclear factor B (NFB),** which regulates numerous cytokine and other immunity genes, promoting macrophage survival.

As thousands of macrophages die, they release their lysosomal contents, leading to fever, internal bleeding, septic shock, and rapid death.

Treatment

- The incubation period for cutaneous anthrax is 1 to 15 days
- The eschar dries and falls off in 1 to weeks with little scarring

Antibiotics

Ciprofloxacin

Penicillin

Doxycycline

Pulmonary Anthrax

- In inhalation anthrax, the spores (1 to 2 μm in diameter) are inhaled and lodge in the alveolar spaces where they are engulfed by alveolar macrophages.
- Pulmonary anthrax results in massive pulmonary edema, hemorrhage, and respiratory arrest.
- The medial lethal inhalation dose for humans has been estimated to be about 8,000 spores.

Two phase Illness

- In the **initial phase**, which follows an incubation period of 1 to 6 days, the disease appears as a nonspecific illness characterized by mild fever, malaise, nonproductive cough, and some chest pain.

- The **second phase** begins abruptly and involves a higher fever, acute dyspnea (shortness of breath), and cyanosis (oxygen deficiency).

- This stage progresses rapidly, with septic shock, associated hypothermia, and death occurring within 24 to 36 hours from respiratory failure.