Bacillus

General Characteristics of Bacillus

- ~ 60 species; Gram-positive or Gram-variable bacilli
  - Large (0.5 x 1.2 to 2.5 x 10 um)
  - Most are saprophytic contaminants or normal flora
  - ***Bacillus anthracis*** is most important member
- Produce **endospores**
- Aerobic or facultatively anaerobic
- **Catalase positive** (most)
  - Rapidly differentiates from *Clostridium*
  - *Bacillus* spp. are **ubiquitous**
    - Soil, water, and airborne dust
    - Thermophilic ($\leq$ 75°C) and psychrophilic ($\geq$5-8°C)
    - Can flourish at extremes of acidity & alkalinity (pH 2 to 10)

Diseases Associated with Bacillus

Organism	Diseases
*B. anthracis**	Anthrax (cutaneous, gastrointestinal, inhalation)
*B. cereus**	Gastroenteritis (emetic, diarrheal), ocular infections, catheter-related sepsis, opportunistic infections
*B. mycoides**	Gastroenteritis, opportunistic infections
*B. thuringiensis**	Gastroenteritis, opportunistic infections
Other *Bacillus* species	Opportunistic infections

Laboratory Characteristics of Bacillus

- On blood agar
  - Large, spreading, gray-white colonies, with irregular margins
  - Many are beta-hemolytic (helpful in **differentiating various *Bacillus* species from *B. anthracis***)
- Spores seen after several days of incubation, but not typically in fresh clinical specimens

Bacillus anthracis

Summary of *B. anthracis* Infections

Physiology and Structure

Spore-forming gram-positive bacilli.

Facultative anaerobe.

Nonfastidious growth of nonhemolytic colonies that are firmly adherent to the agar surface.

Polypeptide capsule consisting of poly-D-glutamic acid observed in clinical specimens.

Virulence

The capsule is present in virulent stains.

Virulent strains also produce three exotoxins that combine to form edema toxin (combination of protective antigen and edema factor) and lethal toxin (protective antigen with lethal factor).

Spores can survive in soil for years.

Epidemiology

B. anthracis primarily infects herbivores with humans as accidental hosts.

Rarely isolated in developed countries but is prevalent in impoverished areas where vaccination of animals is not practiced.

Individuals at risk include people in endemic areas in contact with infected animals or contaminated soil, people who work with animal materials imported from endemic

Summary of *B. anthracis* Infections (cont.)

areas, and military and nonmilitary people exposed to infectious aerosols.

There is significant concern that the spores will be used in bioterrorism.

Diseases

Cutaneous anthrax is the most common form.

Inhalation anthrax is the most deadly form.

Gastrointestinal anthrax is a rare but commonly fatal disease.

Diagnosis

Isolation of the organism from clinical specimens (e.g., papule or ulcer, blood).

Treatment, Prevention, and Control

Ciprofloxacin is the drug of choice; penicillin, doxycycline, erythromycin, or chloramphenicol can be used (if susceptible), but the bacteria are resistant to sulfonamides and extended-spectrum cephalosporins.

Vaccination of animal herds and people in endemic areas can control disease, but spores are difficult to eliminate from contaminated soils.

Animal vaccination is effective, but human vaccines have limited usefulness.

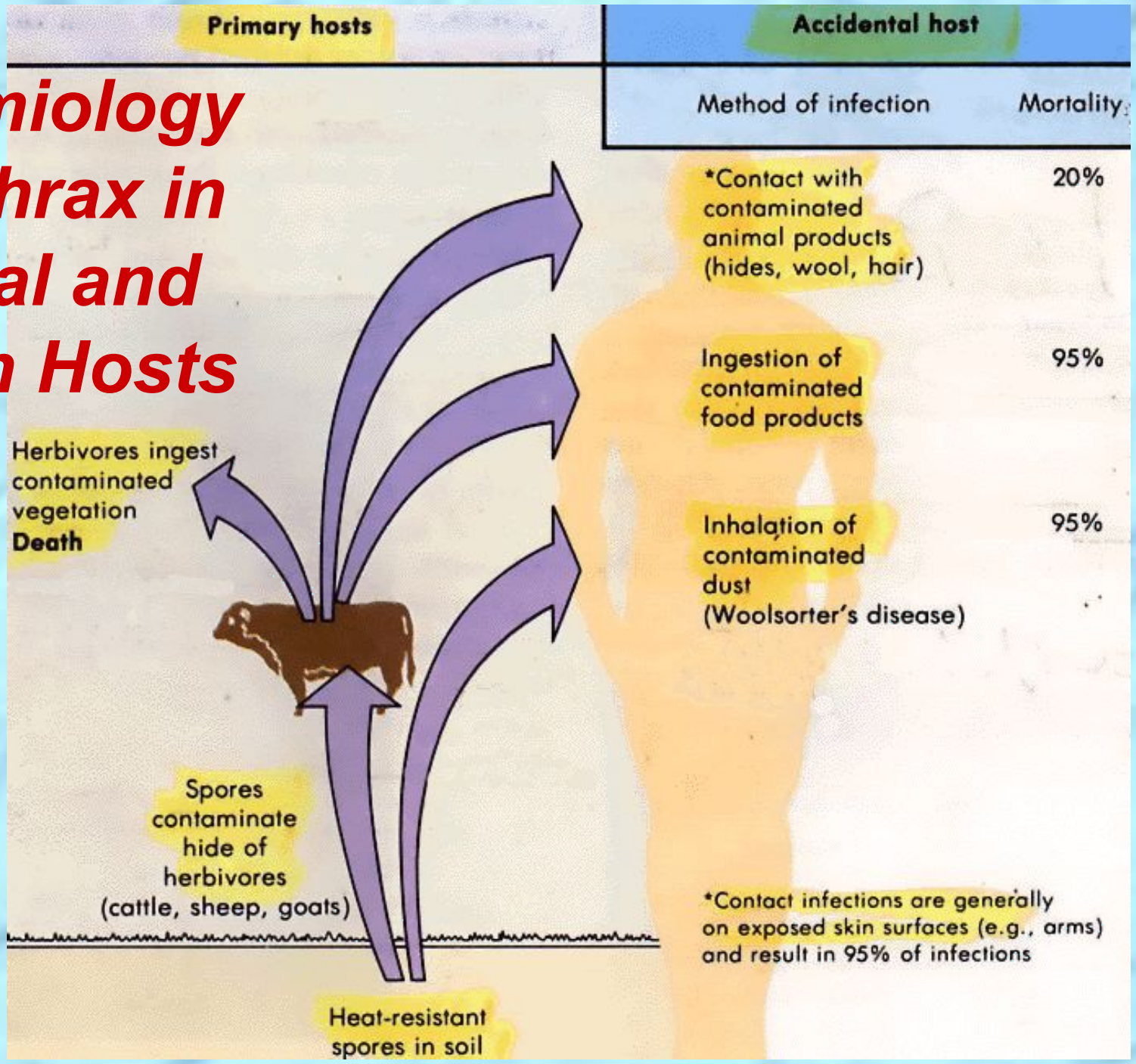
Epidemiology of Bacillus anthracis

- **Rare in the US** (1974-1990, 17 cases reported by CDC)
- Enzootic in certain foreign countries (e.g., Turkey, Iran, Pakistan,and Sudan)
- Anthrax **spores infectious for decades**
  - Biologic warfare experiments (annual tests for 20 years)
    - ✔ Gruinard, off western coast of Scotland
    - ✔ 4 x 10e14 fully virulent spores exploded
    - ✔ Eliminated in 1987 (formaldehyde & seawater)
- **Three well-defined cycles**
  - Survival of spores in the **soil**
  - **Animal** infection
  - Infection in **humans**

Epidemiology of Bacillus anthracis (cont.)

- Primarily a **disease of herbivorous animals**
- Most commonly transmitted to humans by **direct contact with animal products** (e.g., wool and hair)
- Also acquired via **inhalation & ingestion**
  - **Increased mortality** with these portals of entry
- Still poses a threat
  - Importing materials contaminated with spores from these countries (e.g., bones, hides, and other materials)
  - Usually encountered as an occupational disease
  - Veterinarians, agricultural workers

Epidemiology of Anthrax in Animal and Human Hosts



Clinical Presentation of Anthrax

Cutaneous Anthrax

- **95% human cases** are cutaneous infections
- 1 to 5 days after contact
- Small, pruritic, non-painful papule at inoculation site
- Papule develops into hemorrhagic vesicle & ruptures
- Slow-healing **painless ulcer** covered with **black eschar** surrounded by edema
- Infection may spread to lymphatics w/ local adenopathy
- Septicemia may develop
- **20% mortality** in **untreated** cutaneous anthrax

Clinical Presentation of Anthrax

Inhalation Anthrax

- **Virtually 100% fatal (pneumonic)**
- Meningitis may complicate cutaneous and inhalation forms of disease
- **Pharyngeal anthrax**
  - Fever
  - Pharyngitis
  - Nneck swelling

Clinical Presentation of Anthrax

Gastrointestinal (Ingestion) Anthrax

- **Virtually 100% fatal**
- Abdominal pain
- **Hemorrhagic ascites**
- Paracentesis fluid may reveal gram-positive rods

Treatment & Prophylaxis

- **Treatment**
  - **Penicillin** is drug of choice
  - Erythromycin, chloramphenicol acceptable alternatives
  - **Doxycycline** now commonly recognized as **prophylactic**

- **Vaccine (controversial)**
  - **Laboratory workers**
  - Employees of mills handling goat hair
  - Active duty **military** members
  - Potentially entire populace of U.S. for herd immunity

Key Characteristics to Distinguish between B anthracis & Other Species of Bacillus

Characteristic	***Bacillus anthracis***	**Other *Bacillus* spp.**
Hemolysis	Neg	Pos
Motility	Neg	Pos (usually)
Gelatin hydrolysis	Neg	Pos
Salicin fermentation	Neg	Pos
Growth on PEA blood agar	Neg	Pos

Bacillus cereus

Summary of B. cereus Infections

Physiology and Structure

Spore-forming gram-positive bacilli.
Facultative anaerobe.
Nonfastidious growth requirements.

Virulence

Heat-stable enterotoxin.
Heat-labile enterotoxin.
Spores can survive in soil.
Tissue destruction is mediated by cytotoxic enzymes, including cereolysin and phospholipase C.

Epidemiology

Ubiquitous in soils throughout the world.
People at risk include those who consume food contaminated with the bacterium (e.g., rice, meat, vegetables, sauces), those with penetrating injuries (e.g., to eye), and those who receive intravenous injections.

Summary of B. cereus Infections (cont.)

Diseases

Infections include emetic (vomiting) and diarrheal forms of gastroenteritis; ocular infection following trauma to eye; and other opportunistic infections.

Diagnosis

Isolation of the organism in implicated food product or nonfecal specimens (e.g., eye, wound).

Treatment, Prevention, and Control

Gastrointestinal infections are treated symptomatically.

Ocular infectious or other invasive diseases require removal of foreign bodies and treatment with vancomycin, clindamycin, ciprofloxacin, or gentamicin.

Gastrointestinal disease is prevented by proper preparation of food (e.g., foods should be consumed immediately after preparation or refrigerated).

Gram-Variable Stain of B. cereus with Endospores

Foodborne Diseases of B. cereus

(Intoxication) (Foodborne Infection)

	Emetic Form	Diarrheal Form
Implicated food	Rice	Meat, vegetables
Incubation period (hours)	<6 (mean, 2)	>6 (mean, 9)
Symptoms	Vomiting, nausea, abdominal cramps	Diarrhea, nausea, abdominal cramps
Duration (hours)	8–10 (mean, 9)	20–36 (mean, 24)
Enterotoxin	Heat-stable	Heat-labile

Other Bacillus spp.

- ***Bacillus thurigensis***
  - **BT corn; Other GMO's (genetically modified organisms)**
- ***Bacillus stearothermophilus***
  - **Spores used to test efficiency of killing in autoclaves**

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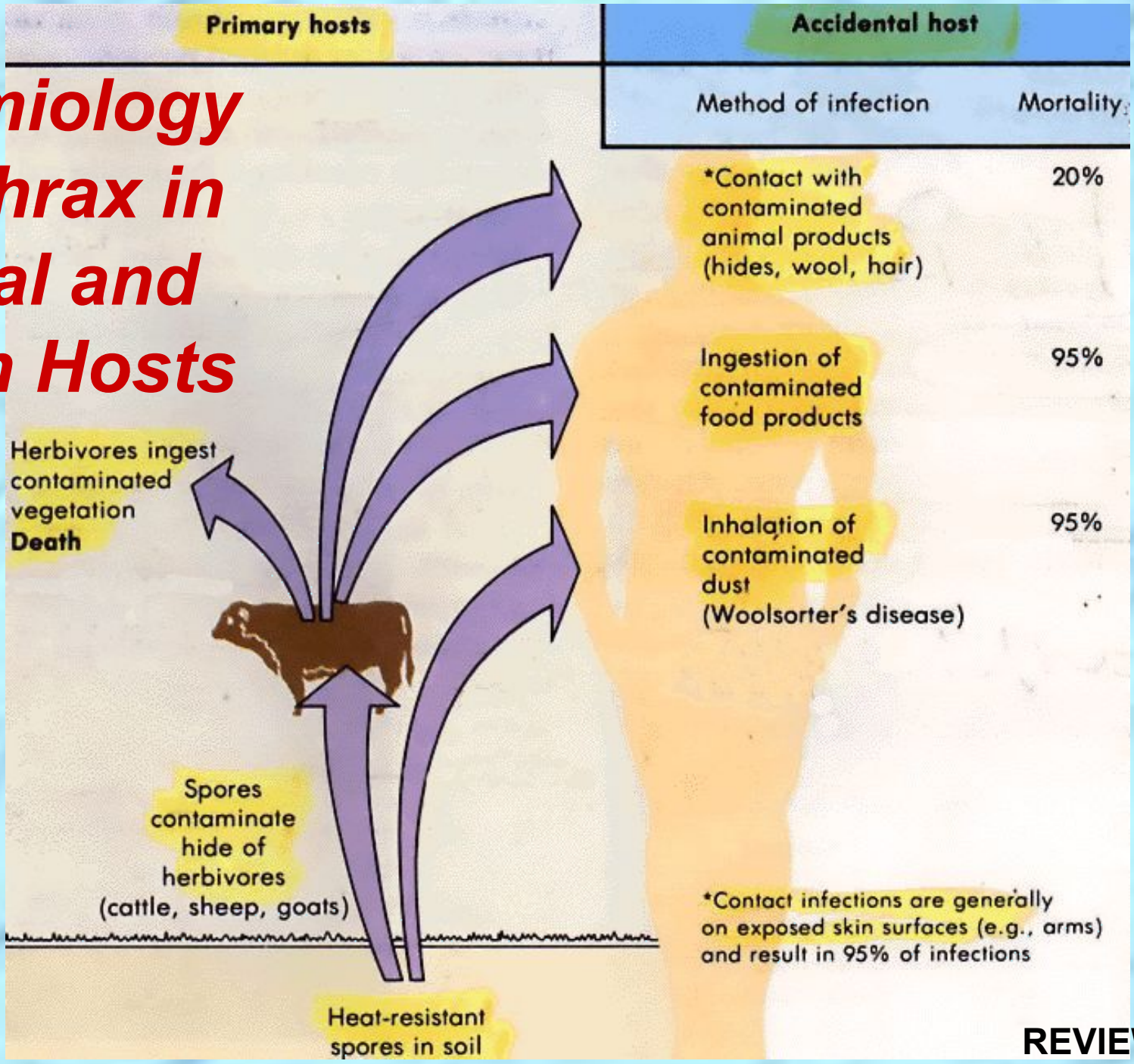

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