CHAPTER 8

**Bacillus cereus** Food Poisoning

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**Disease:** *Bacillus cereus* food poisoning.

**Etiologic Agents:** *Bacillus cereus* and possibly *Bacillus thuringiensis* bacteria or toxic substances.

**Source:** Soil; widely distributed in the environment; a frequent contaminant in many foods.

**Clinical Manifestations:** Acute abdominal cramps and diarrhea (diarrheal type), which occur within 4 to 16 h, or nausea and vomiting (emetic type), which occur within 1 to 5 h after consumption of contaminated foods. Some patients experience symptoms of both types.

**Laboratory Diagnosis:** Quantitative bacteriologic examination of implicated foods to demonstrate presence of *B. cereus* strains with enterotoxigenic activity; serologic or biological assays to confirm enterotoxigenic activity of isolates from food, vomitus, or feces.

**Epidemiology:** Associated with consumption of foods containing excessive populations of *B. cereus* organisms or preformed material with enterotoxic activity; symptoms are similar to intoxication caused by enterotoxins of other bacteria such as *Clostridium perfringens* and *Staphylococcus aureus*.

**Treatment:** Symptomatic; no specific treatment is presently available.

**Prevention and Control:** Limiting preventable contamination by good food handling practices and proper holding of prepared foods (especially adequate refrigeration) to minimize proliferation of the organism.

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### Description of Disease

#### Foodborne Intoxications

Although *Bacillus cereus* was long considered to be a harmless saprophyte, its role as a food poisoning organism has been known since the 1950s (Goepfert et al., 1972; Hauge, 1955). Consumption of foods containing millions of *B. cereus* cells per gram frequently results in food poisoning. Two types of illness have been attributed to consumption of foods contaminated with *B. cereus*. The first and best known type is characterized by abdominal pain and diarrhea, not unlike the symptoms produced by consumption of foods containing large numbers of viable enterotoxigenic cells of *Clostridium perfringens* (Hobbs et al., 1953; McClung, 1945). The diarrheal illness caused by *B. cereus* has an incubation period of 4 to 16 h; symptoms usually last for 12 to 24 h.

The second type of illness is characterized by an acute attack of vomiting, which commences 1 to 5 h after a meal. Diarrhea is not a common feature, but it is known to occur (Melling et al., 1976). Most investigators consider *B. cereus* food poisoning to be a true intoxication rather than a foodborne infection.

#### Diarrheal Activity

The diarrheal strains produce an extracellular protein that elicits diarrhea in monkeys and can be detected in culture fluids by using serological assays (Bennett, 1985). Although it has not been completely
characterized, this toxin is reported to be a protein with a molecular weight of approximately 55,000 to 60,000 (Ezepcuk and Fluer, 1973). For use in diagnostic tests, specific antibodies can be raised against the protein in rabbits. The diarrheal component is heat-labile and is inactivated by heating for 5 min at 56°C. Recent studies have shown that it is also produced by some strains of *Bacillus thuringiensis* (Bennett and Harmon, 1986).

**Emetic Activity**

Less is known about the emetic component than the diarrheal entity, but apparently it is not produced by all strains of *B. cereus*. When fed to monkeys with rice, large populations of strains implicated in outbreaks with symptoms of vomiting elicited a vomiting response (Melling et al., 1976). The emetic activity appears to be associated with a peptide of low molecular weight, which is extremely resistant to heat (withstanding 120°C for more than 1 h) and is produced as a cell-free component in broth cultures. Besides the emetic response in monkeys, heat-treated culture fluids of emetic strains injected intravenously induced vomiting in cats (Bennett, unpublished observations). A similar response in cats is produced by injection of heated culture fluid of certain *Bacillus subtilis* and *Bacillus licheniformis* cultures (Bennett, 1987) that have been implicated epidemiologically in food poisoning (Gilbert et al., 1981; Kramer et al., 1982). It is not known whether the toxin (or toxins) produced by these species is the same as that produced by emetic *B. cereus* strains.

**Diagnostic Features**

Traditionally, examination of implicated foods for the presence of large numbers (10⁶ per g) of *B. cereus* has indicated involvement of the organism in foodborne disease. The culture techniques are simple and can be performed in most food hygiene laboratories; however, until recently there were no reliable means of demonstrating the enterotoxigenicity of isolates. A variety of biological assays, including the rabbit ligated ileal loop (Spira and Goepfert, 1972) and the vascular permeability skin test (Glatz and Goepfert, 1973), have been used by different investigators to imply the enterotoxigenicity of strains, but correlation of these results with diarrheagenic activity in monkeys has not been demonstrated. At present, there are two reliable assays for these foodborne *B. cereus* metabolites: the microslide gel diffusion test for the diarrheal metabolite (Bennett, 1985) and the kitten test for demonstrating emetic activity of culture fluids heated for 1.5 h at 100°C (Bennett, unpublished observations). The monkey feeding test is a possible but impractical alternative (Goepfert, 1974; Melling et al., 1976).

**Epidemiologic Aspects**

Foods implicated in past outbreaks include vanilla puddings, cooked meat and vegetable dishes, boiled and fried rice, certain dairy products, and vegetable sprouts. In most instances, the causative strain was found to be present in large numbers in the implicated food. One or sometimes both categories of symptoms (i.e., vomiting and diarrhea) are experienced by the victims. Because symptoms of these intoxications mimic those caused by enterotoxins of other bacteria such as *C. perfringens* (diarrheal type) and *Staphylococcus aureus* (emetic type), laboratory confirmation is essential before a definite diagnosis can be made.

**Etiologic Agent**

**Taxonomic Position of *B. cereus***

Within the genus *Bacillus*, a great diversity of species and strains exists. The work of Gordon (1973), Gordon et al. (1973), and Smith et al. (1946) has brought a measure of order to the classification of bacilli and greatly facilitated the identification of the more common species. *B. cereus* is classified as a large-celled member of Group 1 (i.e., those species that have a cell wall greater than 0.9 μm and whose spores do not appreciably swell the sporangium). There has been considerable argument about whether *Bacillus anthracis*, *B. thuringiensis*, and *Bacillus mycoides* should be accorded species status or considered as varieties of the parent species *B. cereus*. Certainly, they are closely related and, for all practical purposes, the other members of this group differ from *B. cereus* by only a single characteristic, namely, 1) the pathogenicity of *B. anthracis* for animals, 2) the production of endotoxin crystals by *B. thuringiensis*, and 3) rhizoid growth by *B. mycoides*. Loss of the specific property of each variety has been reported. Thus, absolute separation of this group into separate species may not be possible in all instances. Nevertheless, the typical characteristics of *B. cereus* strains appear to be quite stable, and the other biotypes can be readily distinguished from them when the variant properties are evident (Harmon, 1982). Therefore, for the purposes of this chapter, each will be considered as a separate species (except the rhizoid strains, which have been accepted as merely a variant of *B. cereus*). In addition, procedures will be described for differentiating the other biotypes from typical *B. cereus* strains.