Bacillus cereus and other Bacillus spp.

1. Name of the Organism:
Bacillus cereus and other Bacillus spp.

Bacillus cereus is a Gram-positive, facultatively aerobic sporeformer whose cells are large rods and whose spores do not swell the sporangium. These and other characteristics, including biochemical features, are used to differentiate and confirm the presence B. cereus, although these characteristics are shared with B. cereus var. mycoides, B. thuringiensis and B. anthracis. Differentiation of these organisms depends upon determination of motility (most B. cereus are motile), presence of toxin crystals (B. thuringiensis), hemolytic activity (B. cereus and others are beta hemolytic whereas B. anthracis is usually nonhemolytic), and rhizoid growth which is characteristic of B. cereus var. mycoides.

2. Name of Illness:

B. cereus food poisoning is the general description, although two recognized types of illness are caused by two distinct metabolites. The diarrheal type of illness is caused by a large molecular weight protein, while the vomiting (emetic) type of illness is believed to be caused by a low molecular weight, heat-stable peptide.

3. Nature of Illness:

The symptoms of B. cereus diarrheal type food poisoning mimic those of Clostridium perfringens food poisoning. The onset of watery diarrhea, abdominal cramps, and pain occurs 6-15 hours after consumption of contaminated food. Nausea may accompany diarrhea, but vomiting (emesis) rarely occurs. Symptoms persist for 24 hours in most instances.

The emetic type of food poisoning is characterized by nausea and vomiting within 0.5 to 6 h after consumption of contaminated foods. Occasionally, abdominal cramps and/or diarrhea may also occur. Duration of symptoms is generally less than 24 h. The symptoms of this type of food poisoning parallel those caused by Staphylococcus aureus foodborne intoxication. Some strains of B. subtilis and B. licheniformis...
have been isolated from lamb and chicken incriminated in food poisoning episodes. These organisms demonstrate the production of a highly heat-stable toxin which may be similar to the vomiting type toxin produced by *B. cereus*.

The presence of large numbers of *B. cereus* (greater than $10^6$ organisms/g) in a food is indicative of active growth and proliferation of the organism and is consistent with a potential hazard to health.

4. Diagnosis of Human Illness: Confirmation of *B. cereus* as the etiologic agent in a foodborne outbreak requires either (1) isolation of strains of the same serotype from the suspect food and feces or vomitus of the patient, (2) isolation of large numbers of a *B. cereus* serotype known to cause foodborne illness from the suspect food or from the feces or vomitus of the patient, or (3) isolation of *B. cereus* from suspect foods and determining their enterotoxigenicity by serological (diarrheal toxin) or biological (diarrheal and emetic) tests. The rapid onset time to symptoms in the emetic form of disease, coupled with some food evidence, is often sufficient to diagnose this type of food poisoning.

5. Foods Incriminated: A wide variety of foods including meats, milk, vegetables, and fish have been associated with the diarrheal type food poisoning. The vomiting-type outbreaks have generally been associated with rice products; however, other starchy foods such as potato, pasta and cheese products have also been implicated. Food mixtures such as sauces, puddings, soups, casseroles, pastries, and salads have frequently been incriminated in food poisoning outbreaks.

6. Relative Frequency of Illness: In 1980, 9 outbreaks were reported to the Centers for Disease Control and included such foods as beef, turkey, and Mexican foods. In 1981, 8 outbreaks were reported which primarily involved rice and shellfish. Other outbreaks go unreported or are misdiagnosed because of symptomatic similarities to *Staphylococcus aureus* intoxication (*B. cereus* vomiting-type) or *C. perfringens* food poisoning (*B. cereus* diarrheal type).

7. Complications: Although no specific complications have been associated with the diarrheal and vomiting toxins produced by *B. cereus*, other clinical manifestations of *B. cereus* invasion or contamination have been observed. They include bovine mastitis, severe systemic and pyogenic infections, gangrene,
septic meningitis, cellulitis, panophthalmitis, lung abscesses, infant death, and endocarditis.

8. Target Populations:
All people are believed to be susceptible to *B. cereus* food poisoning.

9. Food Analysis:
A variety of methods have been recommended for the recovery, enumeration and confirmation of *B. cereus* in foods. More recently, a serological method has been developed for detecting the putative *enterotoxin* of *B. cereus* (diarrheal type) isolates from suspect foods. Recent investigations suggest that the vomiting type toxin can be detected by animal models (cats, monkeys) or possibly by cell culture.

10. Selected Outbreaks:
On September 22, 1985, the Maine Bureau of Health was notified of gastrointestinal illness among patrons of a Japanese restaurant. Because the customers were exhibiting symptoms of illness while still on the restaurant premises, and because uncertainty existed as to the etiology of the problem, the local health department, in concurrence with the restaurant owner, closed the restaurant at 7:30 p.m. that same day.

Eleven (31%) of the approximately 36 patrons reportedly served on the evening of September 22, were contacted in an effort to determine the etiology of the outbreak. Those 11 comprised the last three dining parties served on September 22. Despite extensive publicity, no additional cases were reported.

A case was defined as anyone who demonstrated vomiting or diarrhea within 6 hours of dining at the restaurant. All 11 individuals were interviewed for symptoms, time of onset of illness, illness duration, and foods ingested. All 11 reported nausea and vomiting; nine reported diarrhea; one reported headache; and one reported abdominal cramps. Onset of illness ranged from 30 minutes to 5 hours (mean 1 hour, 23 minutes) after eating at the restaurant. Duration of illness ranged from 5 hours to several days, except for two individuals still symptomatic with diarrhea 2 weeks after dining at the restaurant. Ten persons sought medical treatment at local emergency rooms on September 22; two ultimately required hospitalization for rehydration.

Analysis of the association of specific foods with illness was
not instructive, since all persons consumed the same food items; chicken soup, fried shrimp, stir-fried rice, fried zucchini, onions, bean sprouts, cucumber, cabbage, and lettuce salad, ginger salad dressing, hibachi chicken and steak, and tea. Five persons ordered hibachi scallops, and one person ordered hibachi swordfish. However, most individuals sampled each other's entrees. One vomitus specimen and two stool specimens from the three separate individuals yielded an overgrowth of *B. cereus*, although an accurate bacterial count could not be made because an inadequate amount of the steak remained for laboratory analysis. No growth of *B. cereus* was reported from the fried rice, mixed fried vegetables, or hibachi chicken.

According to the owner, all meat was delivered 2-3 times a week from a local meat supplier and refrigerated until ordered by restaurant patrons. Appropriate-sized portions for a dining group were taken from the kitchen to the dining area and diced or sliced, then sauteed at the table directly in front of restaurant patrons. The meat was seasoned with soy sauce salt and white pepper, open containers of which had been used for at least 2 months by the restaurant. The hibachi steak was served immediately after cooking.

The fried rice served with the meal was customarily made from leftover boiled rice. It could not be established whether the boiled rice had been stored refrigerated or at room temperature.

Fresh, rapidly cooked meat, eaten immediately, seems an unlikely vehicle of *B. cereus* food poisoning. The laboratory finding of *B. cereus* in a foodstuff without quantitative cultures and without accompanying epidemiologic data is insufficient to establish its role in the outbreak. Although no viable *B. cereus* organisms were isolated from the fried rice eaten with the meal, it does not exclude this food as the common vehicle. Reheating during preparation may have eliminated the bacteria in the food without decreasing the activity of the heat-stable toxin. While the question of the specific vehicle remains incompletely resolved, the clinical and laboratory findings substantially support *B. cereus* as the cause of the outbreak.

Most episodes of food poisoning undoubtedly go unreported, and in most of those reported, the specific pathogens are never identified. Alert recognition of the
clinical syndrome and appropriate laboratory work permitted identification of the role of *B. cereus* in this outbreak.

For a report on a *B. cereus* outbreak in northern Virginia see this [MMWR 43(10):1994 Mar 18](https://www.cdc.gov/mmwr/). For more information on recent outbreaks see the [Morbidity and Mortality Weekly Reports](https://www.cdc.gov/mmwr/) from CDC.