



US007303874B1

(12) **United States Patent**  
**Bavykin et al.**

(10) **Patent No.:** **US 7,303,874 B1**  
(45) **Date of Patent:** **\*Dec. 4, 2007**

(54) **DISCRIMINATION OF *BACILLUS ANTHRACIS* FROM CLOSELY RELATED MICROORGANISMS BY ANALYSIS OF 16S AND 23S RRNA WITH OLIGONUCLEOTIDE MICROCHIPS**

(75) Inventors: **Sergei G. Bavykin**, Darien, IL (US); **Andrei D. Mirzabekov**, deceased, late of Westmont, IL (US); by **Natalia V. Mirzabekova**, legal representative, Westmont, IL (US)

(73) Assignee: **The University of Chicago**, Chicago, IL (US)

(\* ) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 418 days.

This patent is subject to a terminal disclaimer.

(21) Appl. No.: **10/647,423**

(22) Filed: **Aug. 25, 2003**

**Related U.S. Application Data**

(63) Continuation-in-part of application No. 10/287,455, filed on Nov. 4, 2002.

(60) Provisional application No. 60/336,319, filed on Nov. 2, 2001.

(51) **Int. Cl.**  
**C12Q 1/68** (2006.01)  
**C07H 21/02** (2006.01)  
**C12M 3/00** (2006.01)

(52) **U.S. Cl.** ..... **435/6; 536/23.1; 435/287.2**

(58) **Field of Classification Search** ..... None  
See application file for complete search history.

(56) **References Cited**

**U.S. PATENT DOCUMENTS**

5,580,971 A \* 12/1996 Mitsuhashi ..... 536/24.32

**OTHER PUBLICATIONS**

Ash et al. Comparative analysis of *Bacillus anthracis*, *Bacillus cereus* and related species on the basis of reverse transcriptase sequencing of 16s rRNA. 1991. Int. J. Systematic Bacteriology. vol. 41, No. 3, pp. 343-346.\*

Ash et al. Comparative analysis of 23s ribosomal RNA gene sequences of *Bacillus anthracis* and emetic *Bacillus cereus* determined by PCR-direct sequencing. 1992. FEMS Microbiol Lett. vol. 94, pp. 75-80.\*

Chee et al. Accessing genetic information with high-density DNA arrays. 1996. Science. vol. 274, No. 5287, pp. 610-614.\*

Genbank accession No. GI:3929652, Dec. 4, 1998.\*

Genbank accession No. GI:8452887, Jun. 11, 2000.\*

Genbank accession No. GI:3929664, Dec. 4, 1998.\*

Genbank accession No. GI:3929662, Dec. 4, 1998.\*

Genbank accession No. GI:927390, Jul. 28, 1995.\*

Genbank accession No. GI:1149455, Jan. 5, 1996.\*

Ash, C., et al. 1992. "Comparative analysis of 23S ribosomal RNA gene sequences of *Bacillus anthracis* and emetic *Bacillus cereus* determined by PCR-directsequencing." FEMS Microbiol. Lett. 94:75-80.

Ash, C., et al. 1991. "Comparative analysis of *Bacillus anthracis*, *Bacillus cereus*, and related species on the basis of reverse transcriptase sequencing of 16S rRNA." Int. J. Syst. Bacteriol. 41:343-346.

Ash, C., et al. 1991. "Phylogenetic heterogeneity of the genus *Bacillus* revealed by comparative analysis of small-subunit-ribosomal RNA sequences." Lett. Appl. Microbiol. 3:202-206.

Bavykin, S. G. et al. 2001. "Portable system for microbial sample preparation and oligonucleotide microarray analysis." Appl. Environ. Microbiol., 67: 922-928.

Beyer, W., et al. 1996. "A nested PCR and DNA-amplification-fingerprinting method for detection and identification of *Bacillus anthracis* in soil samples from former tanneries." Salisbury Medical Bulletin. Special Supplement No. 87:47-49.

Chee, M., et al. 1996. "Accessing genetic information with high-density DNA arrays." Science 274: 610-614.

Daffonchio, D., et al. 2000. "Homoduplex and heteroduplex polymorphisms of the amplified ribosomal 16S-23S internal transcribed spacers describe genetic relationships in the '*Bacillus cereus* Group.'" Appl. Environ. Microbiol. 66:5460-5468.

Giffel, M.C., et al. 1997. "Discrimination between *Bacillus cereus* and *Bacillus thuringiensis* using specific DNA probes based in variable regions of 16S rRNA. FEMS Microbiol." Lett. 146:47-51.

Guschin, D., et al. 1997. "Manual manufacturing of oligonucleotide, DNA, and protein microchips." Anal. Biochem. 250:203-211.

Gushin, D. Y., et al. 1997. "Oligonucleotide microchips as genosensors for determinative and environmental studies in microbiology." Appl. Environ. Microbiol. 63:2397-2402.

Harrell, L. J., et al. 1995. "Genetic variability, of *Bacillus anthracis* and related species." J. Clin. Microbiol. 33:1847-1850.

Helgason, E., et al. 2000. "*Bacillus anthracis*, *Bacillus cereus*, and *Bacillus thuringiensis*-one species on the basis of genetic evidence." Appl. Environ. Microbiol. 66:2627-2630.

(Continued)

*Primary Examiner*—Jeffrey Fredman  
*Assistant Examiner* Samuel Woolwine

(74) *Attorney, Agent, or Firm*—Barnes & Thornburg LLP; Alice O. Martin

(57) **ABSTRACT**

The present invention relates to methods and compositions for using nucleotide sequence variations of 16S and 23S rRNA within the *B. cereus* group to discriminate a highly infectious bacterium *B. anthracis* from closely related microorganisms. Sequence variations in the 16S and 23S rRNA of the *B. cereus* subgroup including *B. anthracis* are utilized to construct an array that can detect these sequence variations through selective hybridizations and discriminate *B. cereus* group that includes *B. anthracis*. Discrimination of single base differences in rRNA was achieved with a microchip during analysis of *B. cereus* group isolates from both single and in mixed samples, as well as identification of polymorphic sites. Successful use of a microchip to determine the appropriate subgroup classification using eight reference microorganisms from the *B. cereus* group as a study set, was demonstrated.

**15 Claims, 10 Drawing Sheets**

## OTHER PUBLICATIONS

- Henderson, I. 1996. "Fingerprinting *Bacillus anthracis* strains." Salisbury Medical Bulletin, Special Supplement No. 87:55-58.
- Henderson, I., et al. 1994. "Differentiation of *Bacillus anthracis* from other *Bacillus cereus* group bacteria with the PCR." Int. J. Syst. Bacteriol. 44:99-105.
- Henderson, I., et al. 1995. "Differentiation of *Bacillus anthracis* and other *Bacillus cereus* group bacteria using IS231-derived sequences." FEMS Microbiol. Lett. 128:113-118.
- Hutson, R. A., et al. 1993. "The development and assessment of DNA and oligonucleotide probes for the specific detection of *Bacillus anthracis*." J. Appl. Bacteriol. 75:463-472.
- Jackson, P. J., et al. 1999. "Genetic comparison of *Bacillus anthracis* and its close relatives using amplified fragment length polymorphism and polymerase chain reaction analysis." J. Appl. Microbiol. 87:263-269.
- Kiem, P., et al. 1997. "Molecular evolution and diversity in *Bacillus anthracis* as detected by amplified fragment length polymorphism markers." J. Bacteriol. 179:818-824.
- Longchamp, P., et al. 1999. "Molecular recognition specificity of *Bacillus anthracis* spore antibodies." J. Appl. Microbiol. 87:246-249.
- Patra, G., et al. 1996. "DNA fingerprinting *Bacillus anthracis* strains." Salisbury Medical Bulletin, Special Supplement No. 87:59.
- Patra, G., et al. 1996. "Isolation of a specific chromosomal DNA sequence of *Bacillus anthracis* and its possible use in diagnosis." EMS Immunol. Med. Microbiol. 15:223-231.
- Priest, F. G., et al. 1994. "Characterization of *Bacillus thuringiensis* and related bacteria by ribosomal RNA gene restriction fragment length polymorphisms." Microbiology 140:1015-1022.
- Proudnikov, D., et al. 1998. "Immobilization of DNA in polyacrylamide gel for the manufacture of DNA and DNA-oligonucleotide microchips." Anal. Biochem. 259:34-41.
- Ramisse, V., et al. 1996. "Identification and characterization of *Bacillus anthracis* by multiplex PCR analysis of sequences on plasmids pX01 and pX02 and chromosomal DNA." FEMS Microbiol. Lett. 145:9-16.
- Ryzhov, V., et al. 2000. "Rapid characterization of spores of *Bacillus cereus* group bacteria by matrix-assisted laser desorption-ionization time-of-flight mass spectrometry." Appl Environ. Microbiol. 66:3828-3834.
- Shangkuan, Y.-H., et al. 2000. Comparison of PCR-RFLP, ribotyping and ERIC-PCR for typing *Bacillus anthracis* and *Bacillus cereus* strains. J. Appl. Microbiol. 89:452-462.
- Strizhkov, B. N., et al. 2000. "PCR amplification on a microarray of gel-immobilized oligonucleotides: detection of bacterial toxin- and drug-resistant genes and their mutations." BioTechniques 29:844-857.
- Wunschel, D., et al. 1994. "Discrimination among the *Bacillus cereus* group, in comparison to *B. subtilis*, by structural carbohydrate profiles and ribosomal RNA spacer region PCR." Syst. Appl. Microbiol. 17:625-635.
- Yershov, G., et al. 1996. "DNA analysis and diagnostics on oligonucleotide microchips." Proc. Natl. Acad. Sci. USA. 93:4913-4918.
- Zlatanova, J., et al. 2001. "Gel immobilized microarrays of nucleic acids and proteins." In J. B. Rampal (ed.), Methods in Molecular Biology: DNA Arrays, Methods, and Protocols, in press, Human Press, Inc., Totowa, NJ.

\* cited by examiner

FIG. 1

A

Subgroups

	76	93	133	180	209	286	1014	1046	1462
Anthraxis (SEQ ID NO: 1)	TAAGAGCTTGCTCTTATG	G	(NO: 8)	AACATTTTGAACCGCATGGTTCGAAATTGA	A	(NO: 15)	ACAACCCCTAGAGATAGGGCTTCTCCTTCGGGAG	T	
Cereus A (SEQ ID NO: 2)			(NO: 9)			(NO: 16)			
Cereus B (SEQ ID NO: 3)			(NO: 10)			(NO: 17)	a		
Thuringiensis (SEQ ID NO: 4)			(NO: 11)			(NO: 18)	a		
Thuringiensis (SEQ ID NO: 5)	g	c a	(NO: 12)	t	g	(NO: 19)	a	a	
Mycoides A (SEQ ID NO: 6)			(NO: 13)	t	g	(NO: 20)	a	a	a
Mycoides B (SEQ ID NO: 7)			(NO: 14)	c	g	(NO: 21)		c	g

B

Reference microorganisms

SIQ ID NO: 22) <i>B. anthracis str. Ames</i>	TAAGAGCTTGCTCTTATG	(SEQ ID NO: 30)	AACATTTTGAACCGCATGGTTCGAAATTGA	(SEQ ID NO: 38)	ACAACCCCTAGAGATAGGGCTTCTCCTTCGGGAG
SIQ ID NO: 23) <i>B. thuringiensis str. B8</i>		(SEQ ID NO: 31)		(SEQ ID NO: 39)	
SIQ ID NO: 24) <i>B. cereus str. NCTC9620</i>		(SEQ ID NO: 32)		(SEQ ID NO: 40)	a
SIQ ID NO: 25) <i>B. cereus str. T</i>		(SEQ ID NO: 33)		(SEQ ID NO: 41)	a
SIQ ID NO: 26) <i>B. thuringiensis str. 4Q281</i>	g	(SEQ ID NO: 34)	t	(SEQ ID NO: 42)	a
SIQ ID NO: 27) <i>B. medusa str. ATCC25621</i>	g	(SEQ ID NO: 35)	t	(SEQ ID NO: 43)	a
SIQ ID NO: 28) <i>B. mycooides str. ATCC6462m</i>		(SEQ ID NO: 36)	c	(SEQ ID NO: 44)	
SIQ ID NO: 29) <i>B. mycooides str. ATCC10206</i>		(SEQ ID NO: 37)	c	(SEQ ID NO: 45)	

- c-ps1\_GAGCGAATGGATTAAGAGCT c-SB1 (SEQ ID NO: 46)
- c-ps2\_GAGCGAATGGATTgAGAGCT c-#41 (SEQ ID NO: 47)
- Thuringiensis B {
  - c-ps3\_\_AGCTTGCTCTTATGAAGTTA c-SB15 (SEQ ID NO: 48)
  - c-ps4\_\_AGCTTGCTCTcAaGAAGTTA c-SB16 (SEQ ID NO: 49)
  - c-ps5\_\_TGCTCTTATGAAGTTAGCGG c-SB4 (SEQ ID NO: 50)
  - c-ps6\_\_TGCTCTcAaGAAGTTAGCGG c-SB4-1 (SEQ ID NO: 51)
- Thuringiensis A + B {
  - c-ps7\_\_CATTITGAACCGCATGGTTC c-SB12 (SEQ ID NO: 52)
  - c-ps8\_\_CATTITGAACCTGCATGGTTC c-#44 (SEQ ID NO: 53)
  - c-ps9\_\_CATTITGAACCGCATGGTTC c-SB12 (SEQ ID NO: 54)
  - c-ps10\_\_CATTITGcACCGCATGGTgC c-SB17 (SEQ ID NO: 55)
- Mycoides B {
  - c-ps11\_\_AACCGCATGGTTCGAAATTG c-SB9 (SEQ ID NO: 56)
  - c-ps12\_\_cACCGCATGGTgCGAAATTG c-SB8 (SEQ ID NO: 57)
  - c-ps13\_\_ATGGTgCGAAATTcAAAGGC c-SB10 (SEQ ID NO: 58)
  - c-ps14\_\_ATGGTgCGAAATTcAAAGGC c-SB11 (SEQ ID NO: 59)
  - c-ps15\_\_GAAATTGAAAGGCGGCTTCG c-#54 (SEQ ID NO: 60)
  - c-ps16\_\_GAAATTcAAAGGCGGCTTCG c-SB25 (SEQ ID NO: 61)
- Anthraxis, Cereus A + Mycooides B {
  - c-ps17\_\_CATCCTCTGACACCCTAGA c-SB23 (SEQ ID NO: 62)
  - c-ps18\_\_CATCCTCTGaaAACCCCTAGA c-SB22 (SEQ ID NO: 63)
- Mycoides B {
  - c-ps19\_\_GCTTCTCCTTCGGGAGCAGA c-SB26 (SEQ ID NO: 64)
  - c-ps20\_\_GCTTcCCTTCGGGgGCAGA c-SB27 (SEQ ID NO: 65)

REPLACEMENT SHEET

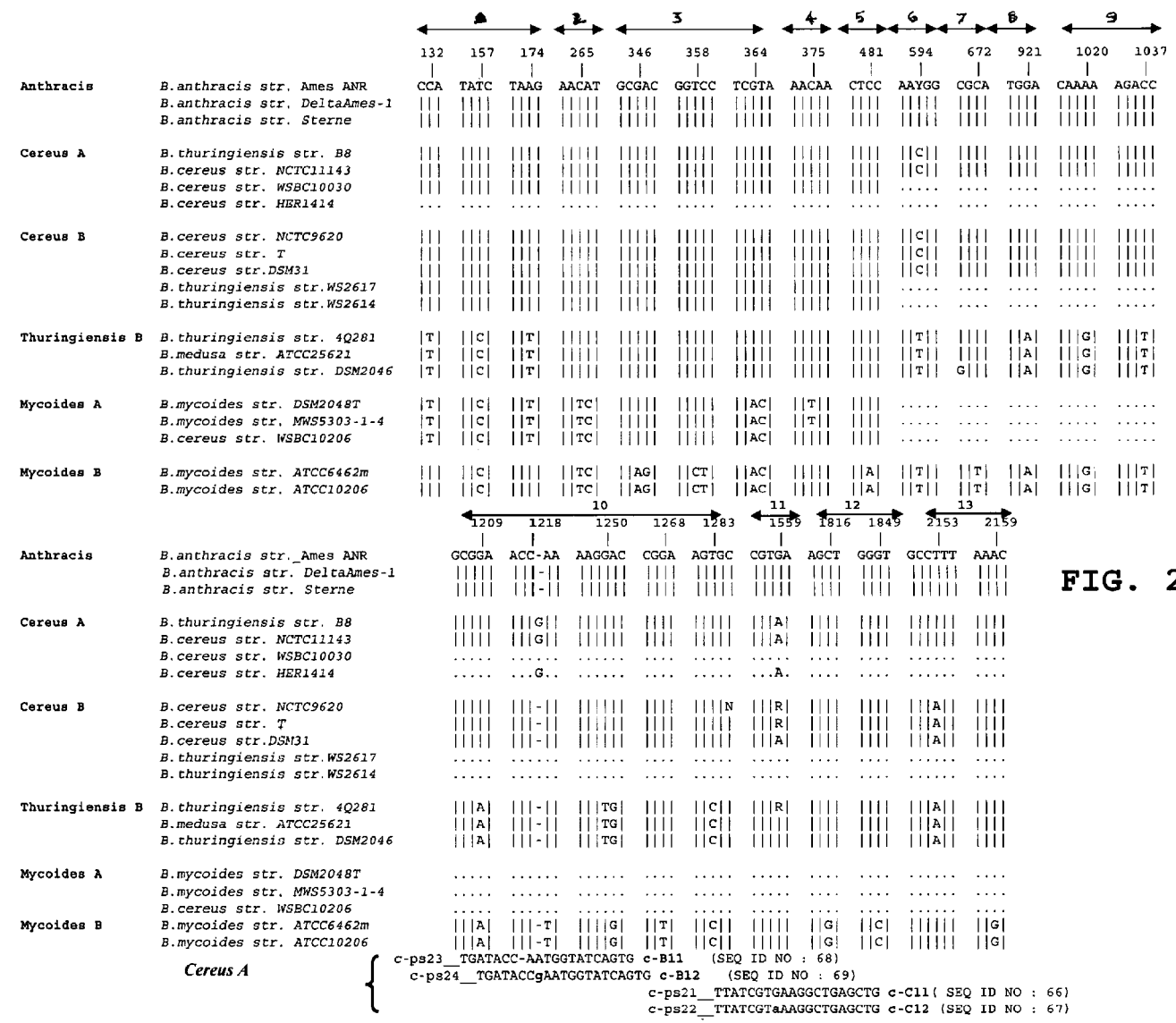
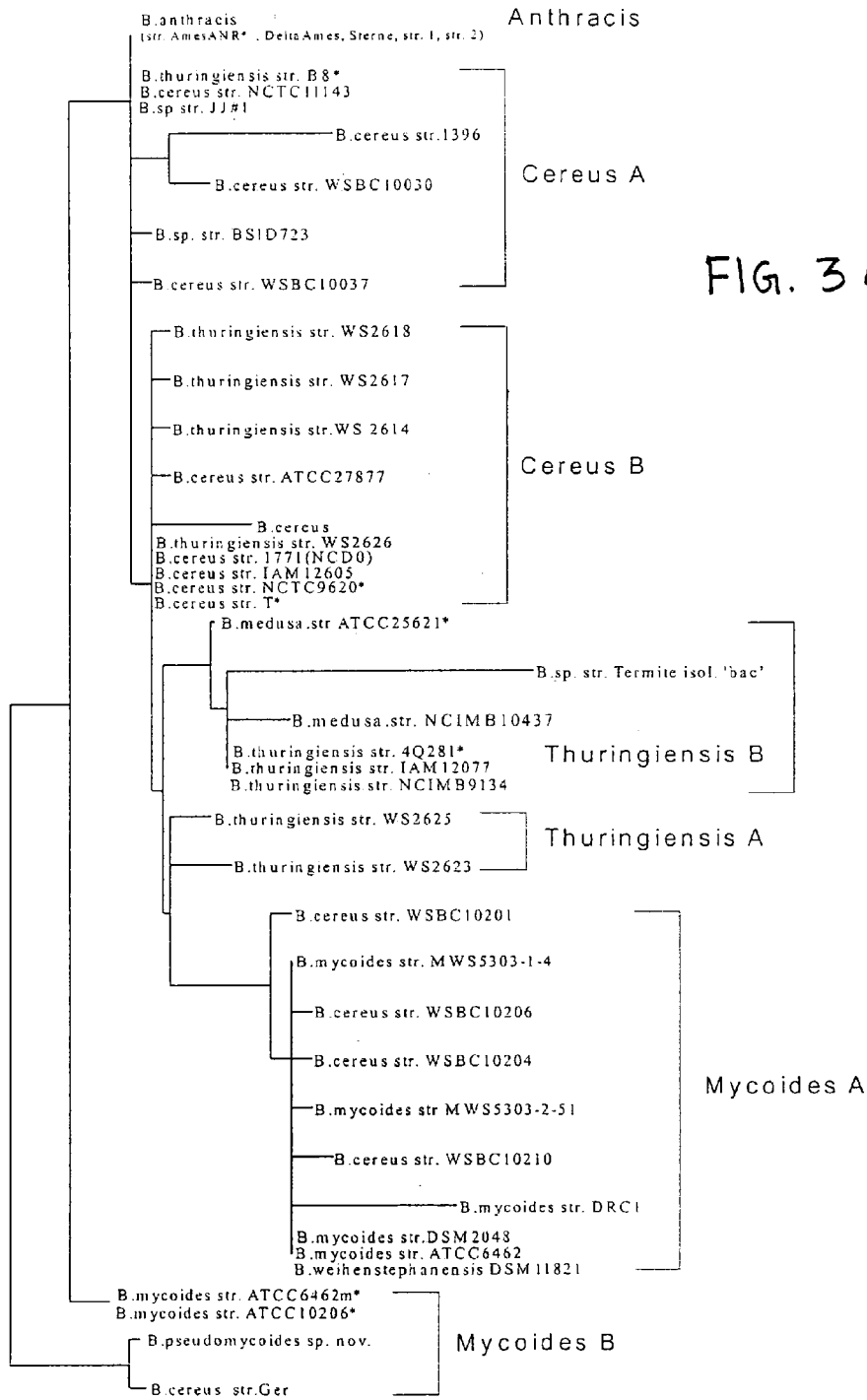


FIG. 2



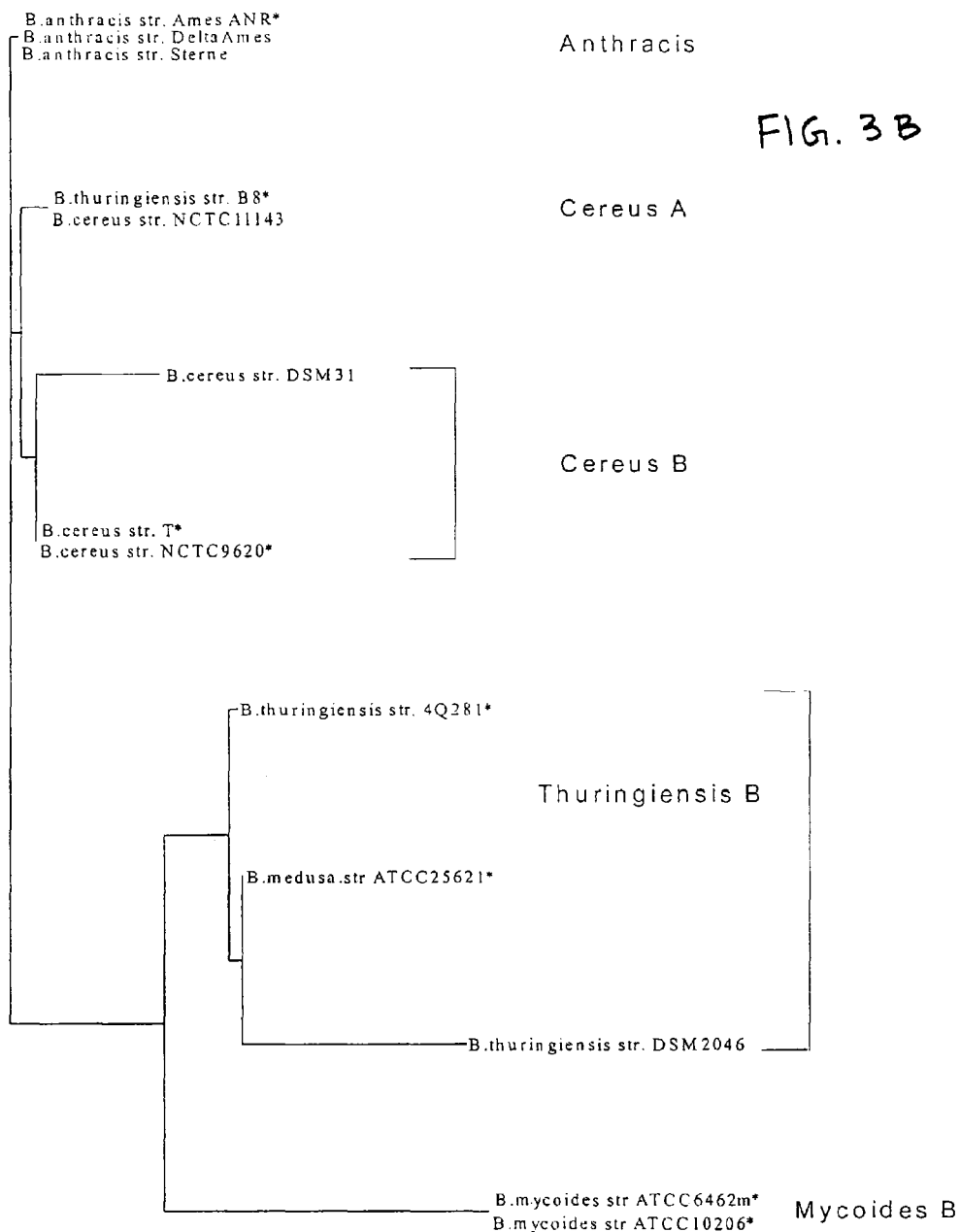
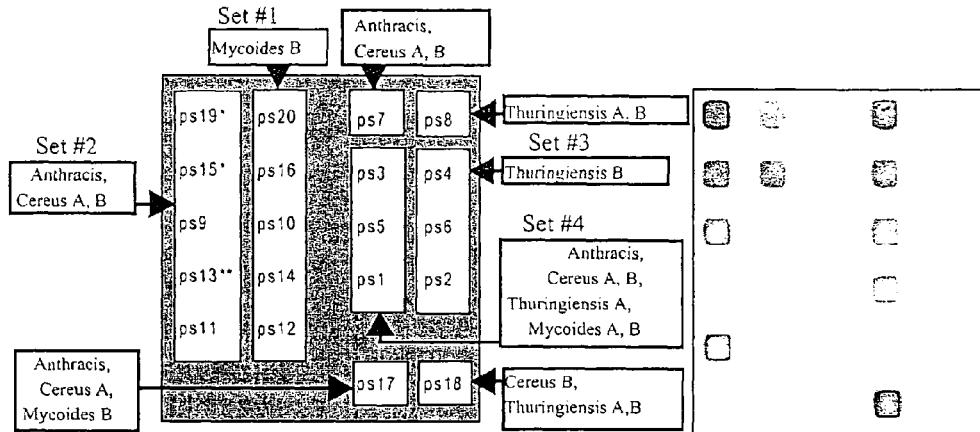
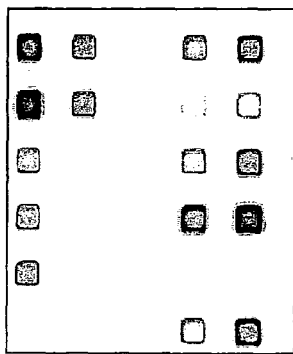


FIG. 4

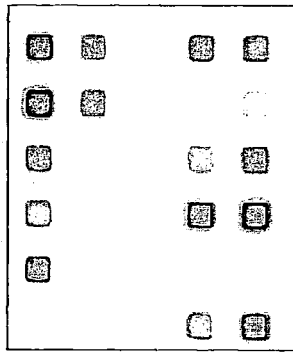


\* - also gives perfect with Thuringiensis A,B and Mycooides A  
 \*\*-also gives perfect with Thuringiensis A,B

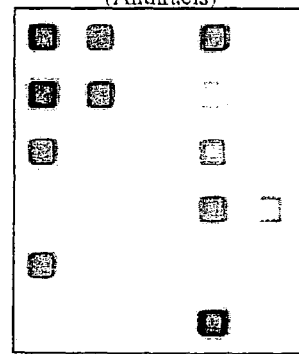
B,anthracis AMES  
 (Anthracis)



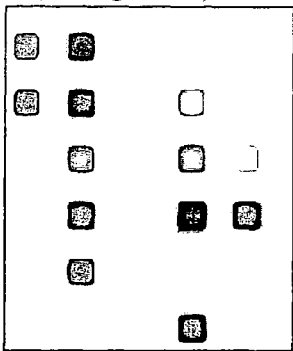
B.thuringiensis 4Q281  
 (Thuringiensis B)



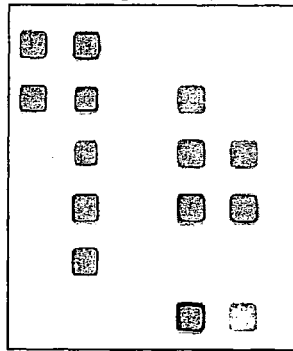
B.medusa ATCC25621  
 (Thuringiensis B)



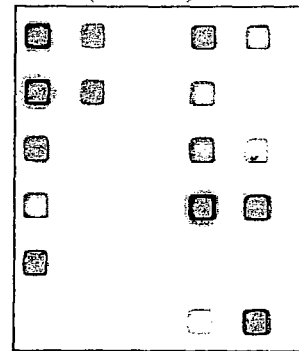
B.thuringiensis B8  
 (Cereus A)



B.mycooides ATCC6462  
 (Mycooides B)



B.mycooides ATCC10206  
 (Mycooides B)



B.cereus T  
 (Cereus B)

FIG. 5A

	ps21/ps22	ps21/ps22 signal ratio	site 1559 in 23S rRNA	G/A ratio in site 1559
<i>B. anthracis</i> Ames (Anthraxis)		1.80	G	-
<i>B. mycoides</i> ATCC10206 (Mycooides B)		1.50	G	-
<i>B. cereus</i> T (Cereus B)		1.00	R	1.5
<i>B. thuringiensis</i> 4Q281 (Thuringiensis B)		0.72	R	1
<i>B. cereus</i> NCTC9620 (Cereus B)		0.64	R	0.3
<i>B. thuringiensis</i> B8 (Cereu A)		0.45	A	-

FIG. 5B










Subgroup		ps21/ps22 signal ratio	ps23/ps24 signal ratio	ps18/ps17 signal ratio
Cereus A	<i>B. cereus</i> HER 1414	 0,7	 0,7	 0,2
	<i>B. thuringiensis</i> B8	 0,4	 0,4	 0,2
Anthracis	<i>B. anthracis</i> Sterne	 2,2	 1,7	 0,2

FIG. 6

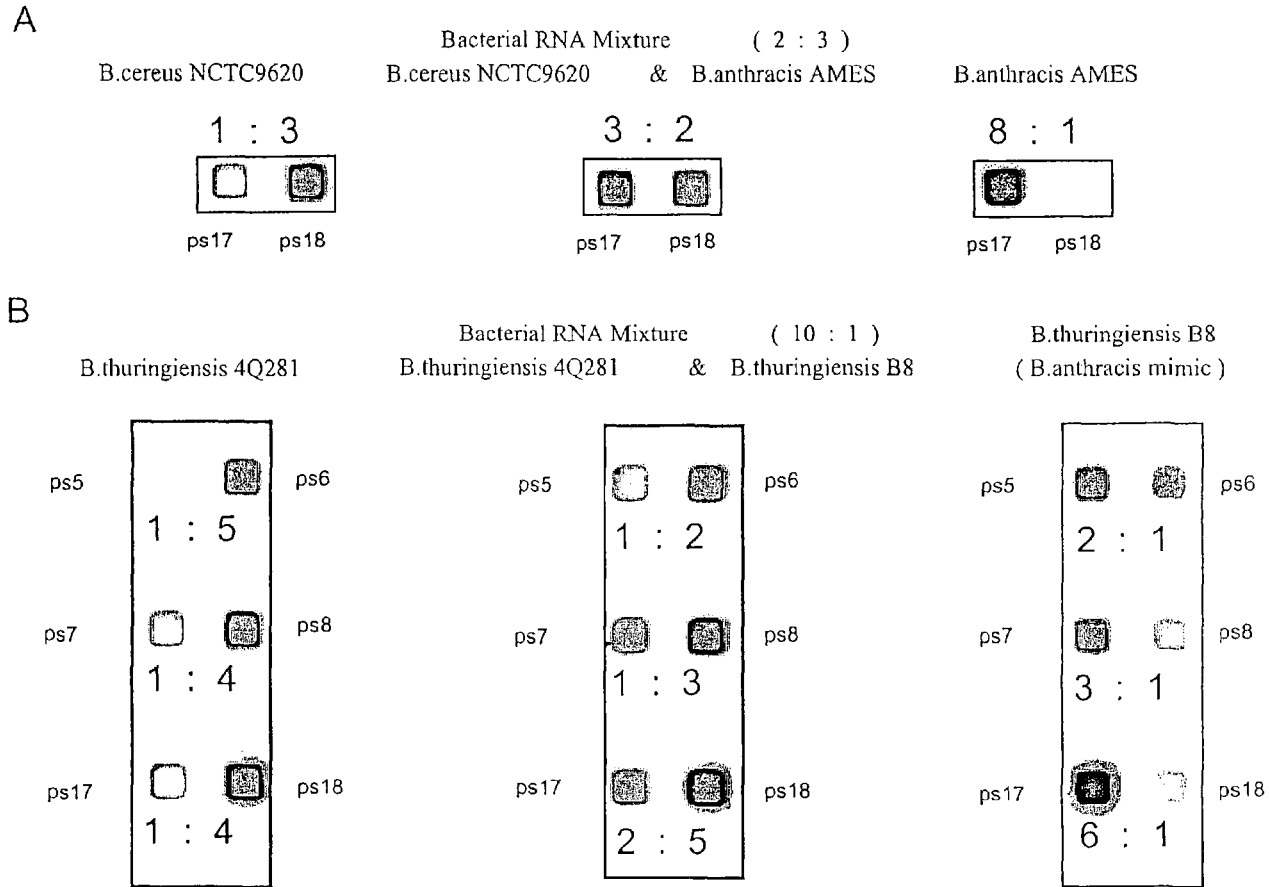












FIG. 7

Microorganism	group		Signal ratio
	Cereus	Subtilis	
B.anthraxis AMES			9.5
B.cereus T			8.3
B.mycoides ATCC6462m			7.8
B.thuringiensis 4Q281			8.1
B.subtilis B-459			0.4

ps 25

ps 26

FIG. 8

23F1 not Myc A B	23F2 Myc A B	#54 not Myc B	SB25 Myc B	B1 Antr. Cer A B	B2 Thur B Myc B	SB22 not Antr. Cer A Myc B	SB23 Antr. Cer A Myc B	A1 not Thur B Myc A
23F5 not Myc A	23F6 Myc A	SB10 not Myc B	SB11 Myc B	B7 Antr. Cer A B	B8 Thur B Myc B	B11 Antr.	B12 Cer A	A2 Thur B Myc A
23F7 not Myc A	23F8 Myc A		E7 Hybrid Marker	C5 Antr. Cer A B	C6 Thur B Myc B	C9 Antr.	C10 Cer A	A5 not Thur B Myc A
16A1 not Myc A	16A2 Myc A	A7 not Myc B	A8 Myc B	C7 Antr. Cer A B	C8 Thur B Myc B		E7 Hybrid Marker	A6 Thur B Myc A
16A3 not Myc A	16A4 Myc A	23F3 not Myc B	23F4 Myc B	A3 Antr. Cer A B	A4 Thur B Myc B	C11 Antr.	C12 Cer A	A9 not Thur B Myc B
16A5 not Myc A	16A6 Myc A	E7 Hybrid Marker				SB12 B med not Thur A B	#44 Thur A B	A10 not Thur B Myc B
16A7 not Myc A	16A8 Myc A	SB23 Antr. Cer A Myc B	SB22 not Antr. Cer A Myc B	23F13 Antr.	23F14 Cer A	SB15 not Thur B	SB16 Thur B	A11 not Thur B Myc B
16A9 not Myc A	16A10 Myc A	D1 Antr. Cer A Myc B	D2A not Antr. Cer A Myc B	23F15 Antr.	23F16 Cer A	SB4 not Thur B	SB4-1 Thur B	A12 Thur B Myc B

**DISCRIMINATION OF *BACILLUS ANTHRACIS* FROM CLOSELY RELATED MICROORGANISMS BY ANALYSIS OF 16S AND 23S RRNA WITH OLIGONUCLEOTIDE MICROCHIPS**

This application is a continuation-in-part of U.S. Ser. No. 10/287,455 filed Nov. 4, 2002, which claims priority to U.S. Ser. No. 60/336,319 filed Nov. 2, 2001.

The United States Government has rights in this invention under Contract No. W-31-109-ENG-38 between the U.S. Department of Energy and the University of Chicago representing Argonne National Laboratory.

FIELD OF THE INVENTION

Methods and compositions are provided for the detection of *Bacillus anthracis* from closely related microorganisms of the *B. cereus* group, and to distinguish and classify the *B. cereus* group. A customized, analytical oligonucleotide microchip incorporating 16S and 23S rRNA-targeted nucleic acid probes, is used for the detection of *B. anthracis* and discrimination.

BACKGROUND

*Bacillus anthracis*, the causative agent of the highly infectious disease anthrax, belongs to the *Bacillus cereus* group, which also contains six other closely related species: *Bacillus cereus*, *Bacillus thuringiensis*, *Bacillus mycoides*, *Bacillus pseudomycooides*, *Bacillus weihenstephanensis* and *Bacillus medusa*. A variety of methods have been reported for the selective identification of *B. anthracis*. These include direct testing of bacterial DNA with specific probes, PCR amplification followed by an in-tube assay, PCR with subsequent electrophoretic analysis of length variation among ribosomal operons, ribotyping, amplified fragment length polymorphisms, methods of analysis using plasmid and chromosomal sequences, PCR-ELISA, on chip PCR amplification of anthrax toxin genes, detection of unique polysaccharides and other biomarkers on *B. anthracis* cell surface with mass spectrometry, immunological recognition of spores and vegetative cells and determination of phenotypic characteristics. The main goal of the various methods is rapid and inexpensive detection of this extremely pathogenic microorganism so that containment, destruction of the pathogens and treatments are facilitated.

Hybridization analysis of 16S rRNA is a method of microbial identification. The 16S rRNA molecule is suitable for use as a target for microbial identification and detection. Although conserved in sequence overall, the 16S rRNAs exhibit significant sequence variation in some regions. These differences in 16S rRNA sequences provide the basis for the design of nucleic acid probes of varying specificity, ranging from probes targeting all living organisms, to group-specific and species-specific probes. Another advantage of using the rRNAs as a target is the fact that these molecules are naturally amplified within the cell. In general, rRNA represents about 80% of total nucleic acids in microbial cells, and thus is present in many hundreds and thousands of copies per cell. This natural amplification allows for direct detection of rRNA sequences without the need for intermediate amplification via PCR.

The main limitations of current hybridization techniques in general are that they are time consuming and limited in terms of the number of probes which can be analyzed simultaneously. Oligonucleotide microchip technology is a

rapid and high throughput platform for nucleic acid hybridization reactions. Moreover, a universal mini-column (syringe-operated silica mini-column) for nucleic acid isolation, fractionation, fragmentation, fluorescent labeling, and purification, as well as an inexpensive, portable fluorescent analyzer for hybridization imaging was reported. Using the prototype mini-column, oligonucleotide microchip and portable imager, hybridization patterns from both microbial and human cells were detected in less than 60 minutes.

Current detection techniques for *B. anthracis* identification such as PCR, electrophoretic analysis, PCR-ELISA, and mass-spectrometry require a considerable amount of time, are expensive, and are generally limited by the number of probes analyzed. Moreover, some of these detection techniques are incapable of discriminating closely related isolates, especially isolates that are differentiated by as little as a single base change in DNA or RNA. In addition to being expensive and time-consuming, many of these methods are not portable. The present invention is designed to address many of the problems mentioned above.

SUMMARY OF THE INVENTION

A method for detecting a particular isolate of *B. cereus* subgroups, including *B. anthracis*, in a sample includes the steps of:

- (a) Placing on a microchip oligonucleotide probes targeted to rRNA sequences that discriminate the *B. cereus* subgroups.
- (b) Providing conditions for hybridization of the probes with rRNA from the sample.
- (c) Analyzing hybridization signals in the microchip from which the particular isolate is detected.

The oligonucleotide probes on the microchip are directed to 16S rRNA or 23S rRNA of various *B. cereus* subgroups organisms. The rRNA samples are labeled with fluorescent dyes or radio isotopes, or immunological labels or immunochemical labels or gold particles and the like. The oligonucleotide probes, whose sequences are listed in Table 5, discriminate subgroups *Anthraxis*, *Cereus A*, *Cereus B*, *Thuringiensis A*, *Thuringiensis B*, *Mycoides A* and *Mycoides B*.

An aspect of the invention is a microarray with oligonucleotide probes that bind to the target sequences designated: (SEQ ID NOS 46-69 respectively in order of appearance)

Target Name	5' to 3' Target Sequence
c-ps1	GAGCGAATGGATTAAGAGCT
c-ps2	GAGCGAATGGATTgAGAGCT
c-ps3	AGCTTGCTCTTATGAAGTTA
c-ps4	AGCTTGCTCTcAaGAAGTTA
c-ps5	TGCTCTTATGAAGTTAGCGG
c-ps6	TGCTCTcAaGAAGTTAGCGG
c-ps7	CATTTTGAACCGCATGGTTC
c-ps8	CATTTTGAACIGCATGGTTC
c-ps9	CATTTTGAACCGCATGGTTC
c-ps10	CATTTTGAACCGCATGGTgC
c-ps11	AACCGCATGGTTCGAAATTG
c-ps12	cACCGCATGGTgCGAAATTc
c-ps13	ATGGTTCGAAATTGAAAGGC
c-ps14	ATGGTgCGAAATTcAAAGGC
c-ps15	GAAATTGAAAGCGCGCTTCG
c-ps16	GAAATTcAAAGCGCGCTTCG
c-ps17	CATCCTCTGACAACCCTAGA
c-ps18	CATCCTCTGAaAACCCTAGA
c-ps19	GCTTCTCCTTCGGGAGCAGA

-continued

Target Name	5' to 3' Target Sequence
c-ps20	GCTTCcCCTTCGGGgGCAGA
c-ps21	TTATCGTGAAGGCTGAGCTG
c-ps22	TTATCGTaaAAGGCTGAGCTG
c-ps23	TGATACC-AAATGGTATCAGTG
c-ps24	TGATACCgAATGGTATCAGTG

Lower case letters refer to positions of mismatches among the *B. cereus* subgroups (see FIGS. 1 and 2).

This invention also includes a microarray with oligonucleotide probes, whose sequences are designated: (SEQ ID NOS 70-95 respectively in order of appearance)

Oligonucleotide Name	5' to 3' Sequence
ps1	AGC TCT TAA TCC ATT CGC TC
ps2	AGC TCT eAA TCC ATT CGC TC
ps3	TAA CTT CAT AAG AGC AAG CT
ps4	TAA CTT Ctt gAG AGC AAG CT
ps5	CCG CTA ACT TCA TAA GAG CA
ps6	CCG CTA ACT Tct TgA GAG CA
ps7	GAA CCA TGC GGT TCA AAA TG
ps8	GAA CCA TGC aGT TCA AAA TG
ps9	GAA CCA TGC GGT TCA AAA TG
ps10	GcA CCA TGC GGT gCA AAA TG
ps11	CAA TTT CGA ACC ATG CGG TT
ps12	gAA TTT CGc ACC ATG CGG Tg
ps13	GCC TTT CAA TTT CGA ACC AT
ps14	GCC TTT gAA TTT CGc ACC AT
ps15	CGA AGC CGC CTT TCA ATT TC
ps16	CGA AGC CGC CTT TgA ATT TC
ps17	TCT AGG Gtt GTC AGA GGA TG
ps18	TCT AGG Gtt tTC AGA GGA TG
ps19	TCT GCT CCC GAA GGA GAA GC
ps20	TCT GCc CCC GAA GGg GAA GC
ps21	CAG CTC AGC CTT CAC GAT AA
ps22	CAG CTC AGC CTT tAC GAT AA
ps23	CAC TGA TAC CAT TG GTA TCA
ps24	CAC TGA TAC CAT TcG GTA TCA
ps25	CGGTCTTGcAGCTCTTTGTA
ps26	ATTCCAGCTTcACGCAGTC

Lower case letters refer to positions where mismatches are present in the target sequences (see FIGS. 1 and 2).

This invention further includes an arrangement of the oligonucleotide probes in a microarray. The probes may be arranged in pairs. The pairs can be arranged in such a way that the presence or absence of a particular subgroup can be interpreted easily. For example, a customized microchip wherein I, II, III and IV are columns and A, B, C, D, E, and F are rows in the microchip design as follows:

	I	II	III	IV
A	ps19	ps20	ps7	ps8
B	ps15	ps16	ps3	ps4
C	ps9	ps10	ps5	ps6
D	ps13	ps14	ps1	ps2
E	ps11	ps12	—	—
F	—	—	ps17	ps18

This invention further includes an arrangement of the oligonucleotide probes as pairs in a microarray. The oligonucleotide probes are arranged in pairs in the following fashion: ps19 and ps20; ps15 and ps16; ps9 and ps10; ps13 and ps14; ps11 and ps12; ps7 and ps8; ps3 and ps4; ps5 and

ps6; ps1 and ps2; ps17 and ps18. The pairs can be arranged in such a way that the presence or absence of a particular subgroup can be interpreted easily. One such arrangement is shown in FIG. 4.

5 A microarray represented in FIG. 8 is also an aspect of this invention.

Arrangement of the oligonucleotide probes as pairs in the microarray as in FIG. 8: 23F1 and 23F2; 23F5 and 23F6; 23F7 and 23F8; 16A1 and 16A2; 16A3 and 16A4; 16A5 and 16A6; 16A7 and 16A8; 16A9 and 16A10; #54 and SB25; SB10 and SB11; A7 and A8; 23F3 and 23F4; SB23 and SB22; D1 and D2A; B1 and B2; B7 and B8; C5 and C6; C7 and C8; A3 and A4; 23F13 and 23F14; 23F15 and 23F16; SB22 and SB23; B11 and B12; C9 and C10; C11 and C12; SB12 and #44; SB15 and SB16; SB4 and SB4-1; A1 and A2; A5 and A6; A9 and A10; A11 and A12. The pairs can be arranged in such a way that the presence or absence of a particular subgroup can be interpreted easily. A representative example of one such arrangement is shown in FIG. 8.

20 This invention includes a diagnostic kit to detect *B. anthracis* target rRNA in a sample. This kit includes in separate compartments:

(a) A microchip that comprises at least one oligonucleotide probe to distinguish variations among *B. cereus* group isolates.

(b) Means for detecting hybridization between the probes and a target rRNA by which *B. anthracis* is detected.

This invention also includes a method for taxonomically classifying *B. cereus* group. This method includes the steps of:

(a) developing strain- and subgroup-specific signature profiles of 16S and 23S rRNA sequences for *B. cereus* group isolates; and

(b) using the signature profiles to construct phylogenetic trees in order to classify the various *B. cereus* group isolates.

This invention includes a microarray with oligonucleotide probes, whose sequences are listed in Table 5.

This invention includes oligonucleotide probes, whose sequences are listed in Table 5.

Array, Microarray: molecules connected to the matrix or support in a specific arrangement relative to each other.

Biochip: also known as a chip, DNA chip, DNA microarray, DNA array, microchip, peptide chip or peptide array; includes array of biological molecules such as DNA fragments, peptides, proteins, lipids, and tissues connected to a matrix.

Biological Sample: a biological material obtained from blood, liver, skin, tissues, saliva, tears, bodily fluids or bodily secretions.

Isolate: a particular genetic variant of a species. If one isolate is known, then it defines the species. However, there can be many different isolates of one species, isolated for example, from different patients or different parts of the world.

Sample: includes biological samples such as blood, skin, bodily fluids and tissues and environmental samples such as air, food, water and soil.

Placing on a Microchip: refers to a process by which oligonucleotides are attached to a microarray.

Providing Conditions for Hybridization: refers to experimental setup that includes as appropriate buffers, temperature, and time that are essential for hybridization of nucleic acids.

Analyzing Hybridization Signals:  
a method of detecting and interpreting  
Signature Profiles:  
a compilation of mismatches of nucleotide sequence that  
is specific for a particular strain or subgroup of microorgan-  
isms.

#### BRIEF DESCRIPTION OF THE FIGURES

FIG. 1 illustrates the positions of subgroup-specific  
sequence differences in the 16S rRNA gene of *B. cereus*  
subgroups (A) (SEQ ID NOS 1-21) and reference microorgan-  
isms used for microchip testing (B) (SEQ ID NOS  
22-45). The sequence of *B. anthracis* Ames ANR was used  
as the consensus sequence. Sequences c-ps1 through c-ps20  
which are complementary to the probes ps1 through ps20 on  
a microchip (see page 3-5, 52-53) and their locations on the  
16S rRNA are also shown (bold letters denote target nucle-  
otides). The names of the target sequences (example, c-ps1)  
are shown to the left of each of the sequences and the  
corresponding probe sequences (example, SB1) are shown  
to the right of the sequences. The probe sequences (ps1-  
ps20) for the target sequences are listed in Table 5.

FIG. 2 illustrates the positions of subgroup-specific  
sequence differences in the 23S rRNA. The sequence of *B.*  
*anthracis* Ames ANR was used as the consensus sequence.  
Arrows indicate regions containing subgroup-specific sig-  
natures. Target sequences (c-ps21 through c-ps24) comple-  
mentary to the probes (ps21 through ps24) (SEQ ID NOS  
66-69) and their locations on the 23S rRNA are also shown  
(bold letters denote target nucleotides). The corresponding  
probe sequences (example, ps21) are listed in Table 5.  
R=G, or A; Y=T, or C.

FIG. 3 illustrates the phylogenetic trees of (A) 16S and  
(B) 23S rRNA genes of bacteria in *B. cereus* group.  
Sequence analysis was performed using the multiple  
sequence alignment computer programs "Clustalx" ([ftp://  
ftp-igbmc.u-strausbg.fr/pub/clustal/x](ftp://ftp-igbmc.u-strausbg.fr/pub/clustal/x)), and "Clustlaw"  
(<http://www.ebi.ac.uk/clustlaw>). Asterisks indicate the refer-  
ence microorganisms which were used.

FIG. 4 illustrates the identification of reference microor-  
ganisms and subgroups to which they belong in the *B. cereus*  
group with a 16S rRNA oligonucleotide microchip. Total  
RNA from reference microorganisms was isolated, fluores-  
cently labeled with Texas Red, and hybridized with a micro-  
chip bearing 20 bases of oligonucleotides as described in  
MATERIALS AND METHODS. Positions of the probes  
and targeted subgroups (in rectangles) are indicated in the  
upper left corner. Members of the targeted subgroup form  
perfect matches with probes indicated with arrows. For  
probe abbreviations see FIG.

FIG. 5 illustrates the identification of single-base poly-  
morphisms (A) and differentiation of *Cereus* A subgroup  
bacteria (*B. thuringiensis* B8 and *B. cereus* 1414) from  
organisms of *Anthraxis* subgroup (*B. anthracis* Ames) (B),  
using hybridization of fluorescently labeled total RNA from  
*B. cereus* group bacteria to probes targeting the 23S rRNA.  
R=G, or A. Probe signal ratio represents an average from 2-4  
experiments.

FIG. 6 illustrates the identification of 16S rRNA of (A) *B.*  
*anthracis* Ames in a mixture (3:2) with *B. cereus*  
NCTC9620 16S rRNA and (B) *B. thuringiensis* B8 (*B.*  
*anthracis* mimic) 16S rRNA mixed with *B. thuringiensis*  
4Q281 16S rRNA in the ratio 1:10. Total RNA of the studied  
bacteria was isolated, fluorescently labeled as described in  
MATERIALS AND METHODS, mixed in the above men-  
tioned proportions, and hybridized with an oligonucleotide

microchip. For probe abbreviations shown on the left and  
right sides of panels, see FIG. 1. Bold numbers indicate the  
ratio of integrated fluorescent signals after hybridization.

FIG. 7 illustrates the identification of microbial groups  
using a 16S rRNA oligonucleotide microchip. A microchip  
containing oligonucleotides ps25 and ps26 targeting the *B.*  
*cereus* group (5'-CGGTCTTGCAGCTCTTTGTA-3') (SEQ  
ID NO: 94) and the *B. subtilis* group (5'-ATTCCAGCT-  
TCACGCAGTC-3') (SEQ ID NO: 95), respectively is  
shown. Microchips were hybridized with fluorescently  
labeled total RNA of the corresponding microorganisms.  
Ratios of integrated fluorescent signals are shown in the far  
right column.

FIG. 8 is a map of a microchip with oligonucleotide  
probes (for example, 23F1) whose sequences and target  
names (for example, *Mycoides* B) are listed in Table 5. The  
positions of oligonucleotides are designated by squares and  
the brief description inside the square indicates name of the  
oligonucleotide probe and the targeted subgroups.

#### DETAILED DESCRIPTION OF THE INVENTION

Methods and compositions are presented for using nucle-  
otide sequence variations of 16S and 23S rRNA within the  
*B. cereus* group to discriminate *B. anthracis* from closely  
related microorganisms. The existence of sequence variabil-  
ity within the *B. cereus* group was useful to consistently  
determine the identity of *B. cereus* isolates including *B.*  
*anthracis*. To accomplish this goal a set of 16S and 23S  
rRNA targeted oligonucleotide probes was designed to dis-  
criminate among the seven subgroups within *B. cereus*, and  
in particular to discriminate *B. anthracis* from other mem-  
bers in the *B. cereus* group. The sequences for these probes  
were selected so that they are complementary to target rRNA  
sequences. These probes were incorporated into an oligo-  
nucleotide microchip. Feasibility of discrimination of single  
base differences in rRNA was demonstrated with this micro-  
chip during analysis of *B. cereus* group isolates from both  
single and mixed cultures. Rapid, selective identification of  
*B. anthracis* from a mixture of closely related microorgan-  
isms has valuable application in diagnosis and epidemio-  
logical monitoring.

Aspects of the invention include:

1. microchips designed to detect a particular isolate of *B. cereus* subgroup, including *B. anthracis* based on sequence variations in the 16S and 23S rRNAs; the sequence variations are chosen so that hybridization signals discriminate a particular isolate from other closely related organisms; using at least one mis-matched sequence; and
2. methods for improved taxonomic classification and detection of *B. cereus* group isolates based on individual strain variations of 16S and 23S rRNA sequences.

The microchips of the present invention overcome some  
of the limitations of current hybridization techniques to  
detect *B. anthracis*. The microchip-based detection of vari-  
ations in rRNA sequences is rapid, reliable, and capable of  
high throughput. Additionally, small sequence variations  
such as single nucleotide polymorphisms (SNPs) among  
closely related isolates can be effectively discriminated with  
the microchip disclosed in the present invention. Because  
rRNA-based hybridization does not require PCR amplifica-  
tion, a direct and efficient method of detection is possible  
with microchips. Hybridization signals can be analyzed by  
an inexpensive fluorescent analyzer, which is also portable.

This portability coupled with the ease of detecting *B. anthracis*, a highly infectious agent renders the current invention a valuable tool for public health safety measures.

The present invention also discloses variations of 16S and 23S rRNA sequences among *B. cereus* isolates. These sequence variations are essential to correctly classify closely related microorganisms. Analysis of 16S and 23S rRNA sequence variations in *B. cereus* group isolates revealed certain subgroup- and strain-specific signatures that aid in the grouping of closely related isolates. Correct classification of these isolates is important to identify the close relationships and to develop better analytical methods to discriminate among the isolates. For example, appropriate clustering of subgroup-specific sequence variants of the present invention provides the basis for the design of a number of diagnostic oligonucleotide probes to discriminate each of the subgroups within the *B. cereus* group.

Diagnostic kits to discriminate *B. anthracis* from closely related microorganisms include:

- (a) At least one microchip that includes at least one oligonucleotide probe that is discriminating, usually distinguishing among related organisms by at least one mismatch between target rRNA sequences. Suitable probes are those in Table 5;
- (b) Means for detecting hybridization signals between labeled RNA and oligonucleotides on the microchip.

Means for detecting hybridization signals include a fluorescence microscope equipped with a CCD camera or a laser scanner. Reagents for isolating total RNA include nucleic acid spin columns (Bavykin et al., 2001) and GITC-based RNA extraction reagents. Fluorescent dyes such as Liss-Rhod (Lissamine™ rhodamine B ethylenediamine; Cat #L2424 and Texas Red cadaverine; Cat #T2425 (Molecular Probes Eugene, Oreg.) can be used to label rRNA molecules isolated from microorganisms.

Customized oligonucleotide microchips are aspects of the invention. The microchip includes a matrix support, which can be made from elements such as glass, and polyacrylamide. An embodiment of a microchip is:

- (a) ten pairs of oligonucleotide probes that target 16S rRNA sequences and two pairs of oligonucleotide probes targeting 23S rRNA sequences; the oligonucleotides are synthesized to include a 5'-amino-modifier;
- (b) microchips containing polyacrylamide gel pads with aldehyde groups; and
- (c) one to six nl of individual amino-oligonucleotide solutions in each gel pad element.

An embodiment of a customized microchip includes an array wherein oligonucleotides are arranged in a specific pattern as in FIG. 8 and sequences of the oligonucleotides are selected from Table 5. Another embodiment of a customized microchip is an array wherein oligonucleotide probes are immobilized in a specific pattern as in FIG. 4 and the probe sequences are selected from Table 1 (ps1 through ps20). Using these customized microchips, *B. anthracis* can be discriminated from other closely related isolates.

Identification of Subgroups and Strains in *B. cereus* Group with rRNA Probes

Based on 16S rRNA sequence analysis, the *B. cereus* group was divided into seven subgroups (*Anthraxis*, *Cereus* A and B, *Thuringiensis* A and B and *Mycoides* A and B) each containing microorganisms with similar 16S rRNA gene sequences (FIG. 3A and Table 2). The strains within each subgroup contained all of the sequence variants specific for that subgroup. The 23S rRNA sequencing confirmed these subgroup classifications (FIG. 3B and Table 3). Some of the subgroup-specific signatures, indicated in Table 2, have

already been reported for identification of certain *Bacillus* strains. For example, *B. thuringiensis* was differentiated from *B. cereus* based on a sequence difference in region 77-92. However, only isolates from subgroup *Thuringiensis* B, and not isolates from subgroup *Thuringiensis* A (FIG. 1 and Table 2), could be differentiated based on this sequence difference. Psychrotolerant strains of *B. cereus* or *B. mycooides* have been identified based on differences in regions 182-197 and 1019-1030 of their 16S rRNA sequences, but these signatures describe organisms from subgroup *mycooides* A only, and not isolates from subgroup *mycooides* B (FIG. 1 and Table 2). Therefore, systematic analysis of all *B. cereus* group microorganisms had not been done.

A set of 16S rRNA targeted oligonucleotide probes (FIG. 1) is constructed for use in 3-D gel pads. These probes were immobilized within a oligonucleotide microchip. This microchip enabled differentiation of *B. anthracis* Ames (subgroup *Anthraxis*) and *B. thuringiensis* B8 (subgroup *Cereus* A) from six reference strains of closely related organisms (*B. cereus* T, *B. thuringiensis* 4Q281, *B. medusa* ATCC25621, *B. mycooides* ATCC 6462m, *B. mycooides* ATCC 10206, *B. cereus* 9620) representing three different subgroups, *Cereus* B, *Thuringiensis* B and *Mycoides* B, respectively. An embodiment of the present invention is a customized microchip capable of identifying organisms of subgroups *Thuringiensis* A. Comparison of hybridization signals from probe pairs ps1/ps2, ps3/ps4 and ps5/ps6 with signals from pair ps7/ps8 on the microchip (FIG. 1) demonstrated that *B. thuringiensis* str. 4W1, 4T1, 4F1 and 4D1 belong to subgroup *Thuringiensis* A, whereas *B. thuringiensis* str.4Q1, 4Q2, 4A1 and 4A7 belong to subgroup *Thuringiensis* B.

Because the RNA sequences of bacteria from the *Mycoides* A subgroup became available only recently, specific probes for this subgroup are present only on a microarray as shown in FIG. 8 and not as shown in FIG. 4. However, the microchip, whose configuration is disclosed in FIG. 4 also has the capability to recognize organisms of *Mycoides* A subgroup. Results of microchip hybridization is similar with subgroup *Thuringiensis* A organisms, but signals from pairs ps7/ps8, ps9/ps10, and ps11/ps12 (FIG. 1) are considerably decreased in comparison with that one for *Thuringiensis* A, because of the forming of two additional mismatches for ps7/ps8 and ps9/ps10, and one additional mismatch in the middle of the probes, ps11/ps12. Signals from the probes ps13/ps14 and ps17/18 may be also decreased because of the presence of one additional mismatch in the terminal end of these probes. However, discrimination is easily achieved using regions 120-145, 166-188, 1015-1035 on 16S rRNA and region 366-390 on the 23S rRNA genes as probe targets. Probes for these regions have also been selected and applied on the second generation of microchips for identification of *B. cereus* group microorganisms (FIG. 8, Table 5).

Another embodiment of the present invention is a method for differentiating microbial strains that differ by only one base in their 16S rRNA molecule both separately (FIG. 4) and in mixtures (FIG. 6). Thus it is possible to identify all strains within the *B. cereus* group that differ by as little as a single nucleotide change in their rRNA sequences. Based on 16S rRNA sequence differences (Table 2), the microchip also serves to differentiate isolates of subgroup *Anthraxis* and subgroup *Cereus* A from all other thirty-two studied strains of bacteria in the *B. cereus* group and to identify which subgroup (Table 2) each microorganism belongs (FIG. 4), even in a 1:10 mixture (FIG. 6).

Another embodiment of the present invention is to be able to identify *B. cereus* isolates by the sequence variations in their 23S rRNA. The 23S rRNA gene was sequenced for a selected set of reference strains of the *B. cereus* group. Isolates from subgroup *Cereus* A, which has the same 16S rRNA sequence as *B. anthracis* Ames (FIG. 1 and Table 2), have three changes in the 23S rRNA sequence in comparison with *B. anthracis* Ames (FIG. 2 and Table 3). *B. thuringiensis* B8 and *B. cereus* HER1414 were used to demonstrate that these sites may be utilized for discrimination between subgroups *Anthraxis* and *Cereus* A (FIG. 5).

Study of site 1559 on the 23S rRNA, where a number of strains revealed single-base changes, demonstrated that the microchip also enabled a single-base polymorphism to be detected (FIG. 5A).

Previous work has shown that 16S rRNA sequences for *B. anthracis* Sterne (subgroup *Anthraxis*), as well as *B. cereus* NCDO1771 and *B. cereus* NCTC 11143 (subgroup *Cereus* A) have 99.9-100% similarity (Table 1). However, all the organisms that belong to *Cereus* A and *Anthraxis* subgroups, are differentiated using subgroup-specific signatures, or strain-specific variations and a combination of 16S and 23S rRNA-targeted probes (Tables 2 and 3). False negative identifications, are not expected i.e. the methods will effectively recognize the presence of *B. anthracis*. Very seldom, some false positive identifications occurred, i.e. mistaken identification of *B. anthracis* strains that lost one or both of their plasmids, and therefore, lost their virulence as *B. anthracis*. However, for the identification of a species, which produces a toxin as hazardous as anthrax, a small number of false positive reactions is preferable to any false negative signals.

Therefore, the microchips (FIG. 4 and FIG. 8) is capable of discriminating all seven subgroups of the *B. cereus* group, and thus microchip analysis of ribosomal RNA serves as a powerful tool for identification of *B. cereus* group bacteria.

#### Taxonomy of the *B. cereus* Group

The results of analysis of 16S and 23S rRNA sequences show some disagreement with the current taxonomic classification of species within the *B. cereus* group. Traditionally, classification of microorganisms in the *B. cereus* group has been based on morphological, physiological, and immunological data. However, some data suggests that there may be some difficulties with these classification schemes. *B. thuringiensis* has been traditionally distinguished from *B. cereus* by the production of a parasporal crystal of a protein that is toxic for Lepidoptera, Diptera and Coleoptera larvae. The capacity to form crystals is plasmid-encoded, however, the plasmid may be lost by laboratory culturing. Moreover, authentic cultures of *B. cereus* can acquire the ability to produce crystals as a result of growing in mixed culture with *B. thuringiensis*. Thus, the discrimination of *B. cereus* from *B. thuringiensis* is a difficult task by any method, and the fact that they have grouped together in the present analysis is not surprising. At the same time, some *B. thuringiensis* strains may be moved (reassigned) after resequencing their 16S rRNA from subgroup *Cereus* B to subgroup *Thuringiensis* B, which differ from each other by only one subgroup-specific signature C/T(192) (Table 2).

Sporadic loss of the ability to form rhizoid colonies has been observed in several strains of *B. mycooides*, indicating an instability of morphology in this species. DNA relatedness studies have indicated that the species *B. mycooides* actually consists of two genetically distinct groups. The fact that methods and compositions of the present invention place *B. mycooides* strains into two subgroups, *Mycooides* A and *Mycooides* B, supports this finding. Bacterial strains can

also undergo physiological changes after the loss or acquisition of plasmids coding for toxins, sporulation, or antibiotic resistance.

According to the present classification scheme (Table 2), four representatives of psychrotolerant strains of *B. cereus* (WSBC10201, WSBC10204, WSBC10206 and WSBC10210), which were recently named as the new species *B. weihenstephanensis*, fall under subgroup *Mycooides* A. This finding suggests that species *B. weihenstephanensis* may be one of the *B. mycooides* strains that belongs to the subgroup *Mycooides* A. This suggestion is confirmed by the high degree of similarity of genomic DNA sequences (85-88%) between *B. cereus* strains WSBC10201, WSBC10204, and WSBC10206 and *B. mycooides* DSM2048, which is also located in subgroup *Mycooides* A. In addition, based on the ability to grow at low temperature, *B. mycooides* is the most closely related species to *B. weihenstephanensis* in the *B. cereus* group.

## EXAMPLES

### Example 1

#### Sequencing of 16S and 23S rRNA Genes of *B. cereus* Group Microorganisms

Twelve 16S rRNA and ten 23S rRNA genes were sequenced (Tables 2, 3). There are published sequences available for two of the strains that were sequenced, *B. medusa* NCIMB 10437 (ATCC 25621) and *B. anthracis* Sterne. There were some discrepancies between the present sequences and the previously published sequences. The published 16S rRNA sequences of *B. anthracis* Sterne (GenBank AC: X55059) and *B. medusa* NCIMB 10437 (GenBank AC X60628) have a deletion of C (942) in comparison with other strains of *B. anthracis* and *B. medusa* that were sequenced later (Table 2). This deletion was found neither in the present resequencing of *B. anthracis* Sterne (GenBank AC: AF176321) and *B. medusa* ATCC25621 (GenBank AC AF155958), nor in the present and in TIGR sequencing of *B. anthracis* Ames (GenBank AC:AF267734 and website <http://www.tigr.org>, respectively). It is likely that the reported deletion was a compression artifact of sequencing of the GC-rich region, i.e.-GGGGCCCG- instead of -GGGGCCCC-. The same compression artifact may also have compromised the 16S rRNA sequences of *B. cereus* NCDO 1771, *B. cereus* NCTC 11143, *B. mycooides* DSM 2048 and *B. thuringiensis* NCIMB 9134 (GenBank AC:X55060 to X55063).

In addition, resequencing of the 16S rRNA gene for *B. medusa* ATCC 25621, did not reveal the C to T transition at position 192 (presence of T instead of C found in *B. anthracis*), or the A to G transversion at position 1383 previously reported for *B. medusa* NCIMB 10437 16S rRNA (Table 2).

Differences were also found in the previously published 23S rRNA sequence of *B. anthracis* Sterne (GenBank AC: S43426) and the present resequencing of this strain (GenBank AC: AT267877). The differences found were the following: T instead of C in position 491, deletion of CG(1413, 1414), and T instead of C in position 2651. These changes were not found in any other 23S rRNA sequence in *B. cereus* group, including *B. anthracis* Ames and *B. anthracis* DeltaAmes (Table 3). Therefore, it is likely that these differences in *B. anthracis* Sterne and also the same differences in *B. cereus* 11143 (GenBank AC X64646) are due to errors in the previously reported sequence.

## Example 2

Comparison of 16S and 23S rRNA Sequences in the *B. cereus* Group

The present analysis indicated that in terms of known 16S and 23S rRNA sequences, *B. anthracis* was the most homogeneous species within the *B. cereus* group. This finding confirms PCR fingerprinting studies that demonstrated almost complete homogeneity of *B. anthracis* bulk DNA. In this work no reliably established variation in the 16S or 23S rRNA sequences was observed within any of the five *B. anthracis* strains characterized (Tables 2 and 3, FIGS. 1 and 2). Because of this homogeneity, and because *B. anthracis* is a target organism for the present invention, the *B. anthracis* 16S and 23S rRNA sequences were used as a reference for reporting differences among closely related bacteria within the *B. cereus* group (FIGS. 1 and 2, Tables 2 and 3).

The present analysis of 16S rRNA sequences for the other *B. cereus* group organisms identified six characteristic regions which contained the majority of the sequence differences among members of the groups: position(s) 77-92, 133, 182-208, 286, 1015-1045 and 1464 (FIG. 1 and Table 2). Because sequence variation in these regions can be used to divide the *B. cereus* group organisms into several large subgroups, the differences located within these regions were termed subgroup-specific signatures. Eighty percent of the strains of *B. cereus*, *B. thuringiensis*, *B. medusa*, *B. mycoides*, *B. pseudomycoides* and *B. weihenstephanensis* (32 of 40 sequences) analyzed contained some subgroup-specific signatures (Table 2) in their 16S rRNA sequences. The most common were C/A (1015) and C/T (192). In addition, a number of other differences were observed, which were termed strain-specific signatures (Table 2). These strain-specific signatures were unique to each strain and were located randomly along the 16S rRNA molecule, i.e., they did occur within the same sites as the subgroup-specific alterations. *B. anthracis* differed from 37 of the 40 other organisms within the *B. cereus* group by at least one sequence difference in the 16S rRNA.

Analysis of the 23S rRNA sequences for the *B. cereus* group organisms revealed thirteen regions within which the majority of the sequence variation occurred (FIG. 2 and Table 3). The differences within these regions are analogous to the subgroup-specific signatures found in the 16S rRNA.

However, due to the limited number of 23S rRNA sequences in the GenBank database, it may be that not all of these differences are subgroup specific. Some of the regions, which appear to contain subgroup-specific variants, may actually contain only strain-specific regions. For example, the *Mycoides* B subgroup showed five subgroup-specific differences in the 16S rRNA and eleven subgroup-specific differences in 23S rRNA sequences that were not found in other subgroups (FIG. 2). However, available rRNA sequences for the *Mycoides* B subgroup currently contain only four strains for which 16S rRNA sequences were determined and two strains for 23S rRNA sequences (Table 2, 3). Among them, *B. mycoides* ATCC6462m and *B. mycoides* ATCC10206, have identical 16S and 23S rRNA sequences (FIGS. 1 and 2), as well as 16S-23S rRNA spacer, however differed with their colony morphology. If additional members of the *Mycoides* B subgroup are sequenced and added to the GenBank database, some of the subgroup-specific signatures may be actually strain-specific.

Both the 16S and 23S rRNA sequence sets showed alterations, which were present in a majority of the subgroups. Subgroups *Cereus* B, *Thuringiensis* A, *Thuringien-*

*sis* B, and *Mycoides* A all contained a C/A difference at position 1015 in their 16S rRNA sequences. The most common subgroup specific differences in 23S rRNA sequence occurred at positions 157 and 594 (Table 3, FIG. 2). The presence of these common variants among the subgroups supports a phylogenetic relationship among them.

## Example 3

Grouping of Microorganisms in *B. cereus* Group According to 16S rRNA Sequences

The *B. cereus* group can be divided into seven subgroups based on 16S rRNA sequence differences (Table 2). Each of these subgroups were identified according to the name of the most common member of the subgroup: *Anthraxis*, *Cereus* A and B, *Thuringiensis* A and B, and *Mycoides* A and B. Based on 16S rRNA sequences, an unrooted phylogenetic tree was also inferred for the *B. cereus* group using the computer program "Clustalx" (FIG. 3A). Although the affiliations in the tree are generally consistent with those defined by signature analysis (Table 2), these groupings do not correspond exactly to the current taxonomy, which divides the *B. cereus* group into seven species: *B. anthracis*, *B. cereus*, *B. thuringiensis*, *B. medusa*, *B. mycoides*, *B. pseudomycoides* and *B. weihenstephanensis*.

The following subgroups were described according to the 16S rRNA sequences (Table 2):

Subgroup *Anthraxis* includes five strains of *B. anthracis*. These organisms do not contain any reliably established subgroup-specific or strain-specific sequence differences in comparison with the *B. anthracis* consensus sequence. Subgroup *Cereus* A includes eight members, which do not contain any subgroup-specific sequence differences from the *B. anthracis* consensus sequence, however were not classified as *B. anthracis* by conventional taxonomic methods. Of these strains, four were found to contain strain-specific sequence differences in their 16S rRNA sequences. However, three of other four strains, *B. sp.* strain JJ#1, *B. cereus* NCTC11143, and *B. thuringiensis* B8, were found to have sequences identical to subgroup *Anthraxis* in the region of the 16S rRNA compared (about 100 nucleotides at the 3'-end of the 16S rRNA have not yet been sequenced for two of these three strains (Table 2)). Two strains of the subgroup *Cereus* A, *B. cereus* WSBC10037 and *B. cereus* 10030, have been characterized as mesophilic. As the result of the present invention, *B. cereus* HER1414, whose 16S rRNA genes are not yet sequenced, was also included in *cereus* A subgroup on the basis of hybridization with the microchip represented on FIG. 5B.

Subgroup *Cereus* B includes strains of *B. cereus* and *B. thuringiensis* that differ from *B. anthracis* by a C to A change at position 1015. The strains *B. cereus* NCTC9620, *B. cereus* T, *B. cereus* IAM12605, also named *B. cereus* 1771, and *B. thuringiensis* WS2626 do not differ from one another in the 16S rRNA sequence, and thus they would be indistinguishable based on 16S rRNA hybridization.

Subgroups *Thuringiensis* A and *Thuringiensis* B include strains which contain two and five subgroup-specific sequence differences respectively, C/A (1015) and C/T (192) being shared among the two subgroups. These two subgroups include mainly *B. thuringiensis* strains. Two strains in the subgroup *Thuringiensis* B (*B. thuringiensis* 4Q281 and *B. thuringiensis* IAM12077 which was also named *B. thuringiensis* NCIM9134 or *B. thuringiensis* OSM2046) have identical 16S rRNA sequences. Two other strains within this subgroup, *B. medusa* ATCC25621 and *B. medusa*

NCIMB10437, should be identical according to Bergey's Manual. However, according to sequencing (Table 2) and hybridization studies (FIG. 4), strain *B. medusa* ATCC25621 does not contain the subgroup-specific signature C/T(192), whereas according to published sequences, *B. medusa* NCIMB10437 does contain this sequence variant.

In the last two subgroups, *Mycooides* A and *Mycooides* B, five *B. mycooides* strains group in subgroup *Mycooides* A, and four fall under subgroup *Mycooides* B. Psychrotolerant strains *B. weihenstephanensis* DSM11821 and *B. cereus* str. WSBC 10201, 10204, 10206 and 10210, which have been characterized as *B. weihenstephanensis*, were also included in subgroup *Mycooides* B. Subgroup *Mycooides* B contains *B. cereus* ki21 and *B. pseudomycooides*, which may have split off from the other two isolates (*B. mycooides* ATCC-10206 and *B. mycooides* ATCC 6462m) in this subgroup rather early in their evolution, as they have a large number of strain-specific sequence differences (Table 2).

#### Example 4

##### Grouping of Microorganisms in *B. cereus* Group According to 23S rRNA Sequences

Based on a similar analysis of 23S rRNA sequences (FIG. 2) the *B. cereus* group strains could be divided into six subgroups. These divisions were consistent with the phylogenetic tree inferred using the computer program "Clustalx" (FIG. 3B). These 23S-based subgroups correspond to six of the seven 16S-based subgroups, namely *Anthraxis*, *Cereus* A and B, *Thuringiensis* B and *Mycooides* A and B (Tables 2 and 3). There were no 23S rRNA sequences available for any of the organisms from the subgroup *Thuringiensis* A. Therefore, based on the available data, division of the *B. cereus* group members into the specified subgroups is supported by both the 16S and 23S rRNA. Also, as with the 16S rRNA sequences, all *B. anthracis* strains had identical 23S rRNA sequences.

Subgroup *Cereus* A (Table 3) contains *B. thuringiensis* B8 and *B. cereus* NCTC11143. The 23S rRNA sequences of these two organisms include alterations at positions 594, 1559 and an insertion G(1219) (FIG. 2 and Table 3). The third member of the subgroup, *B. cereus* HER1414, whose rRNA operon is not sequenced yet, contains subgroup-specific signatures in positions 1218 and 1559. These signatures were found in the hybridization experiments disclosed herein. The third subgroup-specific signature, at position 594, was not tested for this strain. The 23S rRNA sequence of *B. cereus* WSBC10030 was sequenced only partially (FIG. 2, Table 3). It does not contain any signatures that are specific for any other subgroups, but also does not cover subgroup-specific sites for *Cereus* A subgroup. For this reason *B. cereus* WSBC10030 (Table 2 and 3) and other five strains, *B. cereus* str. BSID723, WSBC10037, 1396 and *B. sp.*JJ#1 (Table 2) were placed into *Cereus* A subgroup conditionally. Final discrimination of these isolates from *Anthraxis* subgroup bacteria awaits testing of the 23S rRNA sequences of these microorganisms.

*B. cereus* T, *B. cereus* NCTC9620, *B. cereus* DSM31 (also named *B. cereus* IAMI2605, *B. cereus* NCD01771) *B. thuringiensis* WS2614, and *B. thuringiensis* WS2617 were placed in subgroup *Cereus* B based on both the 16S and 23S sequence comparisons. Unfortunately, 23S rRNA sequences available for both *B. thuringiensis* strains do not extend beyond position 527 from the 5'-end of the gene.

Subgroup *Thuringiensis* B consists of three strains, *B. thuringiensis* 4Q281, *B. medusa* ATCC25621 and *B. thur-*

*ingiensis* DSM2046 (also named *B. thuringiensis* IAMI207 or *B. thuringiensis* NCM9134). Sequences of the 16S rRNAs are available for all three bacteria, (Table 2). A finding from the 23S rRNA sequence analysis was the relationship between subgroups *Thuringiensis* B and *Mycooides* B. According to the 16S rRNA sequences, subgroups *Thuringiensis* B and *Mycooides* B do not share any subgroup-specific sequence signatures (FIG. 1, Table 2). However, subgroups *Thuringiensis* B and *Mycooides* B do share eight positional variants in their 23S rRNA sequences (FIG. 2, Table 3). This 23S rRNA data suggests that the organisms in these two groups may be phylogenetically related (FIG. 3B).

*B. mycooides* 2048T, *B. mycooides* MWS5303-1-4 and *B. cereus* WSBC10206 according to their 16S rRNA sequences belongs to subgroup *Mycooides* A. Unfortunately, only 527 nucleotides of sequence from the 5'-end of these 23S rRNAs are available for the last two organisms, however, they revealed enough variations to be discriminated from members of all other subgroups (Table 3, FIG. 2).

The clustering of subgroup-specific sequence variants demonstrated by the present invention provided the basis for the design of a number of diagnostic oligonucleotide probes for the identification of each of the different subgroups within the *B. cereus* group. In addition, some of the sequence variants were useful for the design of probes for the identification of individual strains.

#### Example 5

##### Design of Subgroup-Specific Probes

Results of the 16S and 23S rRNA gene sequencing indicated that microorganism identification within the *B. cereus* group would require single base mismatch discrimination. The optimal probe length was determined, taking into account the increased efficiency of mismatch discrimination which results from decreased probe length, and the increased specificity of hybridization, duplex stability, and hence hybridization signal intensity, which results from longer probes. Computer analysis of rRNA sequences available from the Ribosomal Data Project website (<http://www.cmc.msu.edu/RDP>) indicated that 10-15 base long probes would not provide adequate specificity, the optimum probe length was determined to be 17-23 bases long.

The sequences complementary to the probes, which were selected are shown in FIGS. 1 and 2 and Table 5. The degree of matching between the probes and the rRNA sequences of the eight reference microorganisms is shown in Table 4. The location of the 16S rRNA probes on the microchip is shown in FIG. 4 and FIG. 5. The microchip on FIG. 4 includes three pairs of probes for identification of bacteria from subgroup *Thuringiensis* B (ps1/ps2, ps3/ps4 and ps5/ps6), one pair for identification of organisms from subgroups *Thuringiensis* A and B, five pairs for identification of *Mycooides* B subgroup bacteria (ps9/ps10, ps11/ps12, ps13/ps14, ps15/ps16 and ps19/ps20), and one pair for discrimination of subgroups *Anthraxis*, *Cereus* A, and *Mycooides* B from subgroups *Cereus* B and *Thuringiensis* A, B (ps17/ps18). The combined application of these probes provides a basis for distinguishing subgroup *Anthraxis* from all other subgroups except *Cereus* A. Most bacteria of subgroup *Cereus* A revealed strain-specific sequence variation. Although some isolates in this subgroup have 16S rRNA sequences identical to *B. anthracis* (Table 2), these organisms do differ from *B. anthracis* in 23S rRNA sequences (FIG. 2). Therefore, probe pairs designed were ps 21/ps22 and ps23/ps24 (FIG. 2) for

## 15

the discrimination of subgroups *Anthraxis* and *Cereus* A using a sequence difference located respectively at positions 1559 and 1219 in the 23S rRNA molecule (Table 3).

## Example 6

## Identification Strategy for Subgroups and Reference Microorganisms

Eight reference organisms were selected (*B. anthracis* Ames, *B. thuringiensis* B8, *B. cereus* T, *B. cereus* 9620, *B. thuringiensis* 4Q281, *B. medusa* 25621, *B. mycooides* 6462m and *B. mycooides* 10206) to demonstrate the ability of microchips to differentiate subgroups *Anthraxis*, *Cereus* A and *B. thuringiensis* B and *Mycooides* B. Objectives were to determine if organisms from these closely related subgroups could be discriminated (as determined by 16S and 23S rRNA analysis), to determine if bacteria whose rRNA sequences differed by only one base could be discriminated, and to determine if *B. anthracis* could be discriminated from closely related species in the *B. cereus* group. Results of hybridization of LissRhod labeled total RNA of the reference bacteria with a microchip containing selected probes are shown in FIG. 4 and FIG. 5B.

## Example 7

Identification of *B. mycooides* ATCC 6462m and *B. mycooides* ATCC 10206 (Subgroup *Mycooides* B)

The results from microchip hybridizations (FIG. 4) were identical for these two references *B. mycooides* strains. These results demonstrate the reproducibility of the microchip technique for characterizing independent isolates having identical rRNA sequences. The 16S rRNAs of *B. mycooides* 6462m and 10206 form perfect duplexes with probes ps10, ps12, ps14, ps16 and ps20 (set #1) but include mismatches with probes ps7(ps9), ps11, ps13, ps15 and ps19 (set #2). All other reference bacteria contain mismatches for set #1 probes and form perfect matches with set #2, except *B. thuringiensis* 4Q281 (subgroup *Thuringiensis* B), as well as organisms of *Thuringiensis* A subgroups, which contain one mismatch for probes ps7(ps9) and ps11 (FIG. 1 and Table 4). Microorganisms that belong to subgroup *Mycooides* A contain two mismatches with probes ps9 and ps11 and one mismatch with probe ps13 (FIG. 1).

## Example 8

Identification of *B. thuringiensis* 4Q281 (Subgroup *Thuringiensis* B)

Probe pair ps7(ps9)/ps8 is specific for subgroups *Thuringiensis* A, B (FIG. 1). Probe ps8 forms a perfect match with *B. thuringiensis* 4Q281 16S rRNA and contains one or three mismatches for 16S rRNAs of all other reference bacteria. In contrast, probe ps7(ps9) contains a mismatch for *B. thuringiensis* 4Q281, and forms perfect matches with all other reference bacteria except *B. mycooides* (strains 6462m and 10206), which have two mismatches with probe ps7 (FIG. 1 and Table 4). Organisms from subgroup *Mycooides* A have three mismatches with probe ps7(ps9) and two mismatches with probe ps8. Three probes from set #2, ps13, ps15 and ps19, form perfect match with 16S rRNA of *B. thuringiensis* 4Q281. In set #1 probe ps16 contains one mismatch, as well as probes ps14 and ps20 contain two mismatches for this bacteria.

## 16

## Example 9

Differentiation of *B. medusa* ATCC 25621 and *B. thuringiensis* 4Q281

Probe pairs ps1/ps2, ps3/ps4 and ps5/ps6 are subgroup-specific for subgroup *Thuringiensis* B (FIG. 1, Table 4). Probe set #3 (ps2, ps4, and ps6) forms perfect duplexes with the 16S rRNA of *B. medusa* ATCC 25621 and *B. thuringiensis* 4Q281 and mismatches with 16S rRNAs of all other reference microorganisms. In contrast, probe set #4 (ps1, ps3 and ps5) forms mismatches with RNA isolated from *B. medusa* 25621 and *B. thuringiensis* 4Q281 and perfect matches with 16S rRNA of all five other reference bacteria. *B. medusa* 25621 and *B. thuringiensis* 4Q281 can be discriminated based on probe ps8, which forms a perfect duplex only with *B. thuringiensis* 4Q281 (FIG. 4, Table 4).

Therefore, hybridization of 16S rRNA from bacteria of the *B. cereus* group with probes from region 77-92 can be used to discriminate microorganisms of subgroup *Thuringiensis* B from bacteria of all other subgroups, and it is especially important for the discrimination between subgroups *Thuringiensis* A and B.

## Example 10

Identification of *B. anthracis* Ames (Subgroup *Anthraxis*)

Probe ps17 is specific for subgroups *Anthraxis*, *Cereus* A, and *Mycooides* B, forming perfect duplexes with 16S rRNA from *B. anthracis* Ames, *B. thuringiensis* B8 and *B. mycooides* 6462 m/10206, and mismatches with all other reference microorganisms (FIG. 1 and Table 4). In contrast, probe ps 18 contains a mismatch for *B. anthracis* Ames, *B. thuringiensis* B8 and *B. mycooides* ATCC 6462/ATCC10206, and is a perfect match with all other references microorganisms. Discrimination of *B. anthracis* Ames and *B. thuringiensis* B8 from *B. mycooides* ATCC 6462/ATCC10206 can be based on a "perfect" signal for probe ps17 (compare with ps18) in combination with "mismatch" signal for probe set #1 (FIG. 4, Table 4). Microorganisms of subgroup *Mycooides* A have one additional mismatch with probes ps17 and ps18.

## Example 11

Identification of *B. cereus* T (subgroup *Cereus* B)

Identification of *B. cereus* (strain T) can be established based on perfect match signals for probes ps18, ps7(ps9), and for probe sets #2 and #4 (FIG. 1, 4 Table 4).

## Example 12

Identification of *B. thuringiensis* B8 (Subgroup *Cereus* A)

Organisms that belong to subgroup *Cereus* A contain 16S rRNA sequences that are identical to *B. anthracis* Ames (subgroup *Anthraxis*) or that differ from *B. anthracis* Ames by strain-specific sequence variation only (Table 2). Thus, 23S rRNA sequences were used to differentiate bacteria from subgroup *Cereus* A and *B. anthracis* Ames. The 23S rRNA sequences of *B. thuringiensis* B8 and *B. cereus* NCTC 11143 differ from *B. anthracis* Ames at three sites, Y/C (594), insertion G (1218-1219) and G/A (1559) (FIG. 2, Table 3). Two pairs of probes were used, ps21/ps22 and

ps23/ps24 (FIG. 2) to target sites 1559 and 1219, respectively. Probes ps21 and ps23 form a perfect duplex with the 23S rRNA of *B. anthracis* Ames but not *B. thuringiensis* B8 and *B. cereus* NCTC11143 23S rRNA. Probes ps22 and ps24 provide complementary information, by having a mismatch with *B. anthracis* Ames 23S rRNA and being complementary to *B. thuringiensis* B8 and *B. cereus* NCTC11143 23S rRNAs (FIGS. 2, 5A). The discriminative feasibility of 23S rRNA probes ps21/ps22 and ps23/ps24 was tested by using *B. cereus* HER1414, whose rRNA genes were not sequenced. *B. cereus* IIER1414 and *B. anthracis* Sterne revealed the same hybridization pattern after hybridization with a 16S rRNA microchip (FIG. 5B, ps18/ps17 shown only). A set of 23S rRNA probe pairs ps21/ps22 and ps23/ps24 successfully discriminated *B. cereus* HER1414 and *B. thuringiensis* B8 from *B. anthracis* Sterne with the hybridization signal ratio for these two pairs being 0.7, 0.4, 2.2 and 0.7, 0.4, 1.7, respectively (FIG. 5B).

#### Example 13

##### Identification of Polymorphic Sites

Partial (about 80% of total) sequencing of the *B. anthracis* Ames genome (TIGR website <http://www.tigr.org>) indicated that organisms from the *B. cereus* group may contain at least ten copies of the rRNA operon. Considerable polymorphism of these genes at some sites (for example 1:1 ratio of C:T at position 594 of 23S rRNA) has been demonstrated (TIGR website <http://www.tigr.org>). Sequencing revealed two polymorphic sites in the 23S rRNA molecule at positions 594 and 1559 for a number of microorganisms of the *B. cereus* group (FIG. 2 and Table 3). For example *B. cereus* T, *B. thuringiensis* 4Q281 and *B. cereus* 9620 have polymorphisms in their 23S rRNA genes at site 1559 with G:A ratios equal to 1.5:1, 1:1 and 1:3.5, respectively. At the same time, *B. anthracis* Ames and *B. mycooides* 10206 have a G in this site, and *B. thuringiensis* B8 has an A in this position (FIG. 2). The possibility of recognizing polymorphisms in this site was demonstrated by using a pair of probes, ps21/ps22. For these probes the hybridization signal ratio for *B. cereus* T, *B. thuringiensis* 4Q281 and *B. cereus* 9620 have been found to be intermediate (1.0, 0.72 and 0.64, respectively) between *B. anthracis* Ames, or *B. mycooides* 10206 (1.8 and 1.5, respectively) and *B. thuringiensis* B8 (0.45) (FIG. 5A).

#### Example 14

##### Identification of Mixtures

The 16S rRNA of *B. cereus* 9620 and *B. anthracis* Ames differ from each other in only one nucleotide. Nevertheless, not only homogeneous samples of these bacteria were discriminated, but also mixtures of RNA from these two microorganisms (FIG. 6A). The ratio of probes ps17/ps18, species-specific to these bacteria, is 1:3 for *B. cereus* 9620 and 8:1 for *B. anthracis* Ames. A 2:3 mixture of RNA from *B. cereus* 9620 and *B. anthracis* Ames, respectively, revealed 3:2 ratio (FIG. 6A). Identification of 10:1 mixture of *B. thuringiensis* B8 RNA and *B. thuringiensis* 4Q281 RNA were demonstrated. The identification of microorganisms and their relative content in the mixture was determined using three pairs, ps5/ps6, ps7/ps8, and ps17/ps18 (FIG. 6B). The signal changes were different for different probe pairs. For correct estimation of the percentage in the mixture, a calibration would be required for each pair separately. Even without quantitative interpretation of the

results variance from the expected hybridization ratios suggests the presence of both target groups.

#### Example 15

##### Cross-Hybridization of Selected Probes with Non-Target Bacteria

The number of subgroup-specific differences in rRNA sequences for bacteria from the *B. cereus* group are few and localized. This creates difficulties in the selection of probes specific to individual subgroups of bacteria. For example, the sequences of two of the twenty probes on the microchip (ps17 and ps20) (FIG. 1) selected for identification of *B. cereus* group reference microorganisms also match the 16S rRNA sequences of a number of bacteria that belong to other groups of the genus *Bacillus*. The use of probes targeting the entire *B. cereus* group and for some other groups may resolve this problem. To demonstrate this, probe ps25 was designed to match all known sequences of *B. cereus* microorganisms and probe ps26 to target the *B. subtilis* group (*B. subtilis*, *B. amiloliquifaciens*, *B. lentimorbus*, *B. popilliae*, and *B. atrophaeus*). Hybridization analysis indicated that these probes effectively differentiated *B. subtilis* B-459 from *B. anthracis* Ames, *B. cereus* T, *B. mycooides* 10206, and *B. thuringiensis* 4Q281 (FIG. 7). Thus, the *B. cereus* group probes can be used as an internal check to validate probes ps17 and ps20.

#### MATERIALS AND METHODS

##### Bacterial Strains

Ten strains belonging to the *B. cereus* group: *B. anthracis* str. Ames ANR, *B. anthracis* str. Delta Ames-1, *B. thuringiensis* str. B8, *B. cereus* str. NCTC9620, *B. cereus* str. T, *B. thuringiensis* str. 4Q281, *B. medusa* str. ATCC25621, *B. mycooides* str. ATCC6462m, and *B. mycooides* str. ATCC10206 (Table 2) were obtained from Dr. John Ezzell, USAMRIID (The U.S. Army Medical Research Institute of Infectious Diseases, Fort Detrick, Md.). Two of these strains were isolated as an occasional admixture from a culture previously identified as *B. mycooides* str. ATCC6462, revealed different colony morphology and received strain numbers, *B. mycooides* str. ATCC6462m and *B. mycooides* str. ATCC10206.

##### Sequencing of 16S and 23S rRNA Genes

Total DNA was isolated from frozen cell pellets by the guanidine extraction method. 16S rDNA and 23S rRNA were amplified from total genomic DNA for 10 strains. For each amplification reaction, 0.1 µg of bacterial DNA was subjected to PCR in a total volume of 100 µl, with 2.5 units of Taq polymerase (Perkin-Elmer, Boston, Mass.), 50 mM KCl, 10 mM Tris-HCl pH 8.3, 1.5 mM MgCl<sub>2</sub>, 0.01% (w/v) gelatin, 200 µM of each dNTP (dATP, dCTP, dGTP, TTP), and 6 µM of each of two primers. The primers used for 16S rDNA and 23S rDNA amplification are listed in Table 1. The thermal profile included denaturation at 94° C. for 2 min, primer annealing at 45° C. for 2 min, and extension at 72° C. for 2 min and then 35 cycles of denaturation at 94° C. for 15 sec, primer annealing at 45° C. for 15 sec, and extension at 72° C. for 4 min. DNA was purified using QIAquick PCR Purification Kit (QIAGEN Inc., Valencia, Calif.) and purified PCR products were directly sequenced by the cycle sequencing method using AmpliTaq DNA polymerase FS (Perkin-Elmer, Boston, Mass.), fluorescently labeled dye-terminators, and 373A fluorescent sequencer (ABI; Perkin-Elmer, Boston, Mass.). Sequencing primers are shown in Table 1.

## Development of Expanded Sequence Databases

All 16S and 23S rRNA sequences for members of the *B. cereus* group available in GenBank were retrieved. Thirty-three 16S rRNA sequences obtained from the GenBank database and one from "The Institute of Genomic Research (TIGR) were aligned with eleven 16S rRNA sequences independently determined herein, including one *B. anthracis* strain (Sterne) resequenced as part of the invention (Table 2). Software developed in the inventors' lab was used for comparative analysis and probe design.

Six complete and five partial sequences of 23S rRNA for *B. cereus* group bacteria were obtained from GenBank and TIGR. These were aligned with nine additional 23S rRNA sequences for the *B. cereus* group determined in this study and one *B. anthracis* strain (Sterne) resequenced as part of the invention (Table 3).

## Creation of Phylogenetic Tree

The 16S and 23S rRNA sequence databases were also used to create an unrooted phylogenetic tree for all of the strains in the database. These trees were created using the multiple sequence alignment computer program "Clustalx". All positions of nucleotides in analyzed alignment of sequences, where unidentified nucleotides N were found, were excluded from consideration for all microorganisms whose sequences were included in the alignment.

## Design of Oligonucleotide Probes

The following strategy was used for the probe design. Each unique 16S rRNA sequence was used to create a set of all 20-mer oligonucleotides possible for that sequence (the set consisted of L-19 overlapping oligonucleotides, where L denotes the length of the entire 16S rRNA sequence). Each of these 20-mer overlapping oligonucleotides was then considered as a potential probe. Each potential probe was tested against all available 16S rRNA sequences (GenBank and RDP) by an algorithm that estimates the relative duplex stability according to the number and position of mismatches. If the 16S rRNA of any microorganism that did not belong to the target group (genus, species, or subgroup) of interest formed stable duplexes with any oligonucleotide considered as a potential probe for the microchip, this oligonucleotide was excluded from the list of probes, except probes ps17 and ps20 specifically mentioned in Example 15.

## Oligonucleotide Microchip Design and Construction

DNA microchips were constructed with ten or 31 pairs of oligonucleotide probes targeting 16S rRNA and 23S rRNA sequences (see FIG. 1 and FIG. 8) and two group-specific probes (ps25 and ps26), two pairs of oligonucleotide probes targeting 23S rRNA sequences (ps21 and ps22, see FIG. 2) except probe ps26 which was 19 bases long. Each probe was 20 bases long. Oligonucleotides were synthesized on an automatic DNA/RNA synthesizer (Applied Biosystems 394) using standard phosphoramidite chemistry. 5'-Amino-Modifier C6 (Glen Research, Sterling, Va.) was linked to the 5'-end of the oligonucleotides. A micromatrix containing 100- by 100- by 20  $\mu$ m polyacrylamide gel pads fixed on a glass slide and spaced 200  $\mu$ m from each other was manufactured by photopolymerization, and activated as described herein. Six nl of individual 1 mM amino-oligonucleotide solutions was applied to each gel pad containing aldehyde groups according to the procedure described below.

## Determination of Relative Duplex Stability

To determine the relative duplex stability wherein the amount of positions where the microorganisms may be differentiated was restricted, and were tested all positions synthesizing all reasonable oligo pairs around each site of differentiation, oligos were applied onto the chip and

hybridized with labeled RNA from appropriate microorganisms. Pairs of oligos that revealed the highest signal in combination with highest perfect signal/mismatch signal ratio were selected.

## Preparation of Acrylamide Micro-Matrices by Photo-Polymerization

## Preparation of glass slides

1. Immerse 10 glass slides in 10 M sodium hydroxide in a Wheaton glass-slide container (volume 150 ml) for 30 minutes.
2. Rinse with five changes of double-distilled water in a container.
3. Immerse 10 slides in concentrated sulfuric acid in container for 30 minutes
4. Rinse five times in double-distilled water and allow to stand in double distilled water for 5 minutes then rinse again.
5. Remove water drops with nitrogen stream. Dry for 1 h at 60° C.

## Treatment of cleaned slide with Bind Silane.

Immerse slides in 3-(Trimethoxysilyl)propyl methacrylate and incubate for 40 h min at 37° C.

Rinse thoroughly with ethanol and then double-distilled water and dry under a nitrogen stream.

## Preparation of solutions for aldehyde matrices

1. Composition of 5% polyacrylamide solution 0.5 ml 40% Acrylamide/Bis solution (19:1)  
1.82 ml 0.2M sodium phosphate buffer (consists of equal volumes of 0.2M sodium phosphate monobasic monohydrate and 0.2M sodium phosphate dibasic anhydrous pH=6.8, store at 4° C.).  
1.6 ml glycerol  
0.08 ml monomer I solution (N-(5,6-di-O-isopropylidene) hexyl acrylamide). For monomer I solution add 1 ml MilliQ water to aliquot of monomer I stock (25 mg) located in -80° C. freezer. Aliquot and store these at -20° C. for approximately 1 month.

## 2. filter.

3. Prepare solution weekly and store at 4° C. Allow solution to reach room temperature before use.

## Assembly of gel-casting cassette.

1. Clean mask surface with ethanol.
2. Rinse thoroughly with distilled water stream rubbing briskly with lint-free tissue.
3. Dry under a nitrogen stream.
4. Place spacers (audio tape film) on chrome side of mask; two spacers from both sides and one in the center.
5. Place slide over mask and spacers with treated surface facing mask.
6. Clamp in place.

## Photo-polymerization (optimized for 4-cluster mask).

## Prepare mixture:

100  $\mu$ l of above polyacrylamide solution

0.4  $\mu$ l Methylene blue (0.04%)

1.2  $\mu$ l TEMED

Vortex 3 seconds

Degas solution 3 min

1. Pipette mixture between the slide and the mask allowing the solution to move between the space by capillary action. Take care that air does not enter the pipette or space. Pipette off excess solution.
2. Turn cassette over so that glass slide is underneath the mask.
3. Place in Oriel chamber.
3. Irradiate for 300 sec.

## 21

4. Carefully disassemble the cassette under water using the point of a scalpel to separate the slide and mask (the slide floats free without pressure being placed on the gel elements.) Take care not to scratch mask.
5. Rinse 30 seconds under running distilled water and soak in distilled water for 15 minutes
6. Air dry in a laminar-flow hood
7. Keep in dust-free slide box at room temperature. Matrices can be kept for at least 1 year.

Procedure for activation (deprotection) of aldehyde matrices

1. Place matrix in 2% trifluoro-acetic acid for 10 minutes at room temperature (prepare fresh solution after every 10 microchips).
2. Rinse well (5 or 6 times) with filtered distilled water for 1 min
3. Wash in distilled water X3 times then leave 3-5 mins in last rinse and dry 20 min in air.
4. Put slide into Repel Silane™ (use fresh solution for each treatment) for one minute.
5. Wash with acetone or dichloromethane (15 sec) and then thoroughly with tap-distilled water (15 sec under stream).
6. Load oligonucleotides.
7. Put microchip into freshly prepared solution of pyridine-borane complex in chloroform (0.1M)(80 ml chloroform/1 ml pyridine borane) and cover chloroform layer with water; (approx ¼ inch) hold 12 hours at room temperature (O. N.)
8. Wash microchip with distilled water.
9. Place microchip into 0.1M sodium borohydride on microchip for 20 min.
10. Wash with distilled water 1 min.
11. Heat microchip in 0.1×SSPE with 0.1% SDS at 60° C. for 1 h (50 ml).
12. Wash biochip in Hybridization Station for 15 min on a stirrer.
13. Wash with distilled water 1 min.
14. Dry microchip in a dust-free environment in the air for 20 min.
15. The chip is now ready for hybridization. The chip could be kept at room temperature.

Standardized Sources of Chemicals and Equipment

1. DEPC-Treated Water (Ambion, cat#9920)
2. 0.5M EDTA, pH 8.0 (Ambion, cat#9260G)
3. Eppendorf Centrifuge 5417C (Fisher, cat#05-406-11)
4. Eppendorf microcentrifuge tubes, 1.5 ml (Fisher, cat#05-402-24B)
5. Acetone (Sigma, cat#A4206)
6. Guanidine Thiocyanate (Fisher, cat#BP221-1)
7. 1M HEPES (Sigma, cat#H4034)
8. Hybridization chamber: Probe-Clip Press-Seal Incubation Chamber (Sigma, cat#Z36, 157-7)
9. Kimwipes (Fisher, cat#06-666A)
10. 20× SSPE (Sigma, cat#S2015)
11. Tween 20 (Fisher, cat#BP337-100)
12. Imaging Chamber (Sigma, cat#Z36, 585-8)
13. Ultrafree-MC 0.45 µm filter unit (Millipore, cat#UFC30HVNB)
14. Triton X-100 (Sigma, cat#T9284)
15. Ethyl Alcohol, absolute 200 proof, 99.5%, A.C.S. reagent (Aldrich, cat#45, 984-4)
16. QIAquick PCR Purification Kit (50) (Qiagen, cat#28104)
17. Taq DNA Polymerase (includes 10× PCR reaction buffer) (Amersham Pharmacia Biotech, cat#T0303Z)

## 22

18. PCR Nucleotide Mix: PCR nucleotide mix (10 mM each dATP, dCTP, dGTP, dTTP) (Amersham Pharmacia Biotech, cat#US77212)
19. Sonicated Salmon Sperm DNA, Phenol Extracted (Amersham Pharmacia Biotech, cat#27-4565-01)
20. Albumin from bovine serum, 20 mg/ml in water (Sigma, cat#B8667)
21. Luer Lok syringe, 60 cc/2 oz, B-D (Fisher cat#14-823-2D)
22. Millex-GN 0.20 filter units (Millipore, cat#SLGN025NS)

An example of a customized microchip is shown in FIG. 8 and Table 5.

## RNA Isolation

Total RNA was isolated from frozen cell pellets of eight *B. cereus* group bacteria: *B. anthracis* Ames, *B. thuringiensis* B8, *B. cereus* T, *B. cereus* 9620, *B. thuringiensis* 4Q281, *B. medusa* 25621, *B. mycoides* 6462m and *B. mycoides* 10206. Cells were lysed by bead beating the cell pellet (approx. 0.2 g) in the presence of 0.5 g baked zirconium oxide beads (0.1 mm), 500 µl phenol (pH 5.1), 500 µl 0.1 M sodium acetate, pH 5.1, and 50 µl 20% SDS at high speed for 2 min, followed by incubation at 65° C. for 10 minutes and an additional bead-beating step for 2 minutes at high speed. RNA was isolated by phenol extraction and precipitated by addition of 0.5 volumes of 7.5 M ammonium acetate and 2.5 volumes of ethanol. Following storage at -80° C. overnight the RNA was recovered by centrifugation at 14,000 rpm for 5 min, washing the RNA pellets two times with ethanol, and resuspending in diethyl pyrocarbonate (DEPC)-treated H<sub>2</sub>O.

Magnesium-Sodium Periodate Fragmentation of RNA and Dye Labeling

RNA (10 to 20 µg) and DEPC treated H<sub>2</sub>O were combined and preheated at 95° C. for 5 min. MgCl<sub>2</sub> was added to 60 mM (total volume 20 µl) and the reaction solution was heated at 95° C. for 40 min. Phosphatase treatment was carried out by addition of 3 µl 10× alkaline phosphatase buffer (Promega, Madison, Wis.) and 0.2 µl alkaline phosphatase (1 U/µl) (Promega, Madison, Wis.) and heating at 37° C. for 30 min. Oxidation of the 3'-end ribose moiety was conducted by addition of 6.5 µl of 100 mM sodium periodate and incubation at room temperature for 20 min. Labeling was carried out by addition of 3.5 µl of 100 mM Lissamine rhodamine B ethylenediamine (LissRhod) (Molecular Probes, Eugene, Oreg.), 1.65 µl of 1 M HEPES (pH 7.5) and heating at 37° C. for 1 h. Reduction of Schiff base was conducted by addition of 6.7 µl of 200 mM sodium cyanoborohydride and incubation at room temperature for 30 min. Labeled RNA was precipitated by addition of 15 volumes of 2% lithium perchlorate in acetone and storage at -20° C. for 20 min. After centrifugation at 14,000 rpm for 5 min, RNA pellets were washed twice with acetone and dried at 55° C. for 10 min.

Excess LissRhod was removed from RNA by butanol treatment: RNA pellets were suspended in 300 µl DEPC-treated H<sub>2</sub>O, and samples were concentrated to 60 µl by removal of water with butanol. Treatment was repeated until butanol was free of color. RNA was precipitated in 2% LiClO<sub>4</sub> in acetone at -20° C. for 20 min. After centrifugation at 14,000 rpm for 5 min, RNA pellets were washed twice with acetone, dried at 55° C. for 10 min, and suspended in 10 to 20 µl DEPC treated H<sub>2</sub>O.

## Hybridization with Microchips

The 35 µl of hybridization solution containing 0.1 to 1 µg fragmented and labeled RNA, 1M guanidine thiocyanate (GuSCN), 5 mM EDTA, and 40 mM HEPES (pH 7.5) was

passed through a 0.22µ filter to remove particulates, then heated at 95° C. for 3 min and placed on ice. Thirty µl of the hybridization solution was added to a hybridization chamber (Grace Biolabs, Bend, Oreg.), and the hybridization chamber was affixed to a microchip. The microchip was allowed to hybridize overnight at room temperature in the dark. After hybridization, the chamber and hybridization solution were removed from the microchip, and the microchip was washed twice for 10 sec each with 100 µl washing buffer. Washing buffer consisted of 0.9 M NaCl, 50 mM sodium phosphate (pH 7.0), 6 mM EDTA, and 1% Tween 20.

Hybridization Data Analysis

After hybridization the microchips were analyzed with a custom made wide-field-high-aperture fluorescence microscope (Vavilov State Optical Institute, St. Petersburg, Russia) equipped with a cooled CCD camera (Princeton Instruments, Acton, Mass.), a thermal table, and XY positioners, and operated with a computer with specially designed software. Parameters of the microscope are as follows: field of view 4 mm by 4 mm, aperture 0.4, working distance 12 mm. Up to 144 individual gel elements with the size of 100- by 100- by 20 µm spaced by 100 µm may be analyzed in parallel in one field of view. Images were captured with WinView Software (Princeton Instruments). The hybridization data was quantified from the WinView image using software (Lab View, version 4.0.1 and MicroChip Imager, Oleg Alferov).

TABLE 1

Primers used for PCR and for sequencing of 16S and 23S rRNA genes of <i>B. cereus</i> groups bacteria <sup>(a)</sup> , (SEQ ID NOS 96-125 respectively in order of appearance)		
Name	Sequence	Location
P1	5' - GTT TGA TCC TGG CTC AG	11-27 (16S rRNA)
P10	5' - CCA GTC TTA TGG GCA GGT TAC	136-116 (16S rRNA)
P11	5' - TCC ATA AGT GAC AGC CGA AGC	226-206 (16S rRNA)
P5	5' - CTA CGG GAG GCA GCA GTG GG	340-360 (16S rRNA)
P3	5' - GWA TTA CCG CGG CKG CTG	535-517 (16S rRNA)
P2	5' - GGA TTA GAT ACC CTG GTA GT	784-803 (16S rRNA)
P6	5' - CCG TCA ATT CCT TTR AGT TT	926-907 (16S rRNA)
P8	5' - TTC GGG AGC AGA GTG ACA GGT	1029-1049 (16S rRNA)
P9	5' - TAC ACA CCG CCC GTC ACA CCA	1392-1412 (16S rRNA)
P4	5' - RGT GAG CTR TTA CGC	1513-1492 (16S rRNA)
Pr1	5' - CCG AAT GGG GVA ACC C	114-129 (23S rRNA)

TABLE 1-continued

Primers used for PCR and for sequencing of 16S and 23S rRNA genes of <i>B. cereus</i> groups bacteria <sup>(a)</sup> , (SEQ ID NOS 96-125 respectively in order of appearance)		
Name	Sequence	Location
Pr13	5' - CCG TTT CGC TCG CCG CTA CTC	262-242 (23S rRNA)
PB1	5' - TAG TGA TCG ATA GTG AAC CAG	485-505 (23S rRNA)
Pr2	5' - CAT TMT ACA AAA GGY ACG C	621-603 (23S rRNA)
Pr3	5' - GCG TRC CTT TTG TAK AAT G	603-621 (23S rRNA)
PB2	5' - TAG TGA TCG ATA GTG AAC CAG	755-736 (23S rRNA)
PB3	5' - TAG TGA TCG ATA GTG AAC CAG	969-990 (23S rRNA)
Pr4	5' - RGT GAG CTR TTA CGC	1151-1137 (23S rRNA)
Pr5	5' - WGC GTA AYA GCT CAC	1136-1150 (23S rRNA)
PB4	5' - CAT ACC GGC ATT CTC ACT TC	1308-1289 (23S rRNA)
PB5	5' - ACA GGC GTA GGC GAT GGA C	1408-1426 (23S rRNA)
PB8	5' - AAC CTT TGG GCG CCT CC	1679-1661 (23S rRNA)
Pr6	5' - CYA CCT GTG WCG GTT T	1673-1659 (23S rRNA)
Pr7	5' - AAA CCG WCA CAG GTR G	1659-1673 (23S rRNA)
Pr8	5' - CAY GGG GTC TTT RCG TC	2092-2076 (23S rRNA)
Pr9	5' - GAC GYA AAG ACC CCR TG	2076-2092 (23S rRNA)
Pr10	5' - GAG YCG ACA TCG AGG	2535-2521 (23S rRNA)
Pr11	5' - CCT CGA TGT CGR CTC	2521-2535 (23S rRNA)
Pr12	5' - GYT TAG ATG CYT TC	2783-2770 (23S rRNA)
R1	5' - GGC GGC GTC CTA CTC TCA C	112-95 (5S rRNA)

TABLE 2

Classification of bacteria in the <i>Bacillus cereus</i> group according to 16S rRNA sequences					
Subgroup name	Subgroup-specific signatures (position)*	Start and end of sequence	Organism	GenBank AC	Positions of strain-specific variations
<i>Anthraxis</i>	Consensus	11-1556	<i>B.anthraxis str. Ames ANR</i> <sup>1*</sup>	AF155950,	—
		11-1556	<i>B. anthracis</i> str. DeltaAmes-1 <sup>a</sup>	TIGR <sup>2</sup>	—
		11-1556	<i>B. anthracis</i> str. Sterne <sup>a</sup>	AF155951	—
		1-1453	<i>B. anthracis</i> str. Sterne	AF176321 <sup>a</sup>	—
				X55059	del C(942) <sup>b</sup>

TABLE 2-continued

Classification of bacteria in the <i>Bacillus cereus</i> group according to 16S rRNA sequences						
Subgroup name	Subgroup-specific signatures (position)*	Start and end of sequence	Organism	GenBank AC	Positions of strain-specific variations	
<i>Cereus</i> A	Consensus	61-528, 815-1503	<i>B. anthracis</i> str. 1	***	—	
		61-528, 815-1503	<i>B. anthracis</i> str. 2	***	—	
		11-1556	<b><i>B. thuringiensis</i> str. B8<sup>a,e</sup></b>	AF155955	—	
		1-1453	<i>B. cereus</i> str. NCTC11143	X55063	?	
		—	<i>B. cereus</i> str. HER1414 <sup>f</sup>	—	—	
		31-1464	<i>B. sp.</i> str. JJ#1 <sup>h</sup>	Y15466	—	
		28-1536	<i>B. sp.</i> str. BSID723 <sup>h</sup>	AF027659	1232	
		49-1524	<i>B. cereus</i> str. WSBC10037 <sup>h</sup>	Z84576	178	
		49-1524	<i>B. cereus</i> str. WSBC10030 <sup>h</sup>	Z84575	353, 600, 864, 1146	
		28-1515	<i>B. cereus</i> str. 1396 <sup>h</sup>	AF206326	181, 467, 480, 482, 590, 995, 1146, 1244, 1345	
<i>Cereus</i> B	<b><i>CA(1015)</i></b>	11-1556	<b><i>B. cereus</i> str. NCTC9620<sup>a,e</sup></b>	AF155952	—	
		11-1556	<b><i>B. cereus</i> str. T<sup>a,e</sup></b>	AF176322	—	
		28-1515	<i>B. cereus</i> str. IAM12605 <sup>i</sup>	D16266	—	
		1-1453	<i>B. cereus</i> str. NCDO1771 <sup>i</sup>	X55060	—	
		49-1524	<i>B. cereus</i> str. ATCC27877	Z84581	828	
		26-1183	<i>B. cereus</i>	AF076031	498, 520, 523, 829, 1167	
		49-1524	<i>B. thuringiensis</i> str. WS2614	Z84584	127	
		49-1524	<i>B. thuringiensis</i> str. WS2617	Z84585	1153	
		49-1524	<i>B. thuringiensis</i> str. WS2618	Z84586	725	
		49-1524	<i>B. thuringiensis</i> str. WS2626	Z84588	—	
<i>Thuringiensis</i> A	<b><i>CA(1015)</i></b>	49-1524	<i>B. thuringiensis</i> str. WS2623	Y18473	109, 679, 1228, 1505	
		49-1524	<i>B. thuringiensis</i> str. WS2625	Z84587	565, 1183	
<i>Thuringiensis</i> B	<b><i>CA(1015)</i></b>	11-1556	<b><i>B. thuringiensis</i> str. 4Q281<sup>a,e</sup></b>	AF155954	—	
		11-1556	<b><i>B. medusa</i> str. ATCC25621<sup>a,e,e</sup></b>	AF155958	1038, 1383	
		11-1556	<i>B. medusa</i> str. NCIMB10437 <sup>c</sup>	X60628	—	
		28-1515	<i>B. thuringiensis</i> str. IAM12077 <sup>i</sup>	D16281	—	
		A/G(77), T/C(90), T/A(92)	1-1453	<i>B. thuringiensis</i> str. NCIMB9134 <sup>j</sup>	X55062	—
7-1552	<i>B. sp.</i> str. Termite isol. 'bac'	X81132	182, 186, 187, 769, 822, 823, 1281, 1282, 1283, 1301, 1429, 1430, 1463, 1464, 1475, 1476, 1478, 1479			
<i>Mycoides</i> A	<b><i>CA(1015)</i></b>	1-1453	<i>B. mycoides</i> str. DSM2048 <sup>d</sup>	X55061	—	
		49-1556	<i>B. mycoides</i> str. MWS5303-1-4	Z84591	1456	
		49-1526	<i>B. mycoides</i> str. DRCI	AF144645	63, 1279, 1319-1321, 1398, 1439, 1443, 1473, 1479, 1484	
		49-1524	<i>B. mycoides</i> str. MWS5303-2-51	Z84583	180	
		G/A(133), C/T(182), G/A(197), A/G(286)	32-1546	<i>B. mycoides</i> str. ATCC6462 <sup>d</sup>	AB021192	—
		14-1546	<i>B. weihenstephanensis</i> DSM11821	AB021199	—	
		C/T(1019), G/A(1030), T/A(1462)	49-1524	<i>B. cereus</i> str. WSBC10201	Z84577	203, no A/G(286), 1515
		49-1524	<i>B. cereus</i> str. WSBC10204	Z84578	128	
		49-1524	<i>B. cereus</i> str. WSBC10206	Z84579	225, 1519, 1520	
		49-1524	<i>B. cereus</i> str. WSBC10210	Z84580	60, 375, 1298	
<i>Mycoides</i> B	A/C(189), T/G(200), G/C(208), T/C(1036), A/G(1045)	11-1556	<b><i>B. mycoides</i> str. ATCC6462m<sup>a,e</sup></b>	AF155956	—	
		11-1556	<b><i>B. mycoides</i> str. ATCC10206<sup>a,e</sup></b>	AF155957	—	
		34-1374	<i>B. cereus</i> str. Ki21	AJ288157	95, no T/G(200), 202, 329, 752, 778, 793, no T/C(1036), 1350, 1360, 1374	
		7-1538	<i>B. pseudomycoides</i> sp. nov.	AF013121	55, 341, 495, 516, 566, 929, 1017, 1104, 1110, 1121, 1128, 1138	

\*for more details see FIG. 1.

<sup>a</sup>sequenced in this work.<sup>b</sup>need to be reexamined, see also Results.<sup>c</sup>according to Bergey's Manual, these two strains of *B. medusa* should be identical. This was not confirmed with 16S rRNA sequencing.<sup>d</sup>according to Bergey's Manual, these two strains of *B. mycoides* should be identical.<sup>e</sup>strains selected in this study as reference organisms to demonstrate subgroup identifications.<sup>f</sup>not sequenced, identified in this study by 16S/23S rRNA oligonucleotide microchip analysis.<sup>g</sup>partial (about 90%) sequences of whole *B. anthracis* str. Ames genome, data of TIGR (<http://www.tigr.org>).<sup>h</sup>final discrimination from *Anthraxis* subgroup will be done after testing 23S rRNA gene sequence.

\*\*\*J. Jackman, unpublished.

<sup>i</sup>synonym of *B. cereus* str. DSM31 (see also Table 3).<sup>j</sup>synonym of *B. thuringiensis* str. DSM 2046 (see also Table 3).

Subgroup-specific mutations, which are highlighted in bold, are identical for two or more subgroups and were placed on separate lines to demonstrate connections between different subgroups.

TABLE 3

Classification of bacteria in the <i>Bacillus cereus</i> group according to 23S rRNA sequences					
Subgroup name	Subgroup-specific signatures (position)*	Start and end of sequence	Organism	GenBank AC	Positions of strain-specific variations
<i>Anthraxis</i>	Consensus	1-2922	<b><i>B.anthraxis str. Ames ANR</i></b> <sup>a,d</sup>	AF267734 <sup>a</sup> , TIGR <sup>b</sup>	—
		1-2922	<i>B. anthracis</i> str. DeltaAmes-1 <sup>a</sup>	AF267876	—
		1-2922	<i>B. anthracis</i> str. Sterne <sup>a</sup>	AF267877 <sup>a</sup>	—
		15-2943	<i>B. anthracis</i> str. Sterne	S43426	T/C(491) <sup>e</sup> , del CG(1413, 1414) <sup>e</sup> , T/C(2651) <sup>e</sup>
<i>Cereus</i> A	<b><i>Y/C(594)</i></b>	1-2923	<b><i>B.thuringiensis str. B8</i></b> <sup>a,d</sup>	AF267880	—
		1-2923	<i>B. cereus</i> str. NCTC1143	X64646	—
		1-527	<i>B. cereus</i> str. WSBC10030 <sup>f</sup>	Z84589	—
<i>Cereus</i> B	Insertion G(1218-1219) <b><i>Y/C(594)</i></b>	—	<i>B. cereus</i> str. HER1414 <sup>e</sup>	—	?
		1-2922	<b><i>B.cereus str. NCTC9620</i></b> <sup>a,d</sup>	AF267878	—
		1-2922	<b><i>B.cereus str. T</i></b> <sup>a,d</sup>	AF267879	—
<i>Thuringiensis</i> B	G/R(1559) T/A(2153) Y/T(594) T/C(157)	1-2787	<i>B. cereus</i> str. DSM31 <sup>g</sup>	X94448	T/C(1275), G/A(1559)
		1-527	<i>B. thuringiensis</i> str. WS2617 <sup>f</sup>	Z84594	—
		1-527	<i>B. thuringiensis</i> str. WS2614 <sup>f</sup>	Z84593	—
		1-2922	<b><i>B.thuringiensis str. 4Q281</i></b> <sup>a,d</sup>	AF267881	G/R(1559)
		1-2922	<b><i>B.medusa str. ATCC25621</i></b> <sup>a,d</sup>	AF267885	—
<i>Mycoides</i> A	G/A(921), A/G(1020), C/T(1037), G/A(1209), A/G(1251), T/C(1283) C/T(132), A/T(174) T/A(2153) G/T(1250) T/C(157)	1-2784	<i>B. thuringiensis</i> str. DSM2046 <sup>h</sup>	X89895	C/T(57), T/G(413), ins(AATA)(479-480), del(GG)(541-542), G/A(646), C/G(670), G/A(1953), G/A(2055), ins(AGT)(2556-2557), del(G)(2573)
		1-527	<i>B. mycoides</i> str. 2048T	Z84592Z84591	—
		1-527	<i>B. mycoides</i> str. MWS5303-1-4	Z84590	—
		—	<i>B. cereus</i> str. WSBC10206	—	—
<i>Mycoides</i> B	C/T(132), A/T(174) C/T(375) Y/T(594) T/C(157) G/A(921), A/G(1020), C/T(1037), G/A(1209), A/G(1251), T/C(1283) CA/TC(265, 266), GT/AC(364, 365) GA/AG(346, 347), TC/CT(358, 359), C/A(482), C/T(672), A/T(1219), G/T(1268), C/G(1816), G/C(1849), A/G(2159)	1-2922	<b><i>B.mycoides str. ATCC6462m</i></b> <sup>a,d</sup>	AF267884	—
		1-2922	<b><i>B.mycoides str. ATCC10206</i></b> <sup>a,d</sup>	AF267883	—
		—	—	—	—

\*for more details see FIG. 2.

<sup>a</sup>23S rDNA sequenced in this work.

<sup>b</sup>partial (about 90%) sequences of whole *B. anthracis* str. Ames genome, data of TIGR (<http://www.tigr.org>).

<sup>c</sup>not sequenced, identified in this study by 16S/23S rRNA oligonucleotide microchip analysis.

<sup>d</sup>strains selected in this study as reference organisms to demonstrate subgroup identifications.

<sup>e</sup>need to be reexamined.

<sup>f</sup>final subgroup discrimination will be done after completion of 23S rRNA sequencing.

<sup>g</sup>synonym of *B. cereus* str. IAM 12605 and *B. cereus* str. NCDO1771 (see Table 2).

<sup>h</sup>synonym of *B. thuringiensis* str. IAM12077 and *B. thuringiensis* str. NCIMB 9134 (see Table 2). R = G, or A. Y = T, or C.

Subgroup-specific mutations, which are highlighted in bold, italics or underline denote mutations that are identical for two or more subgroups, and were grouped to demonstrate connections between different subgroups

TABLE 4

Degree of matching between oligonucleotide probes contained on microchip and the 16S and 23S rRNA sequences of eight reference microorganisms from the <i>B. cereus</i> group <sup>(*)</sup>													
Probes	Probe's target	<i>B. thur</i> + <i>B. med</i>			<i>B. thur</i>		<i>B. mycoides</i>				<i>B. anthr</i> + <i>B. myc</i>		all other <i>B. thur.</i> B8
		all other	all other	all other	all other	all other	all other	all other	all other	all other			
Probe's name		ps1	ps3	ps5	ps7	ps9	ps11	ps13	ps15	ps19	ps17	ps21	
		ps2	ps4	ps6	ps8	ps10	ps12	ps14	ps16	ps20	ps18	ps22	
Reference organisms	<i>B. anthracis</i> AMES	+/-	+/-	+/-	+/-	+/-	+/-	+/-	+/-	+/-	+/-	+/-	
	<i>B. thuringiensis</i> B8 ( <i>B. anthracis</i> mimic)	+/-	+/-	+/-	+/-	+/-	+/-	+/-	+/-	+/-	+/-	+/-	
	<i>B. thuringiensis</i> 4Q281	-/+	-/+	-/+	-/+	+/-2	+/-2	+/-	+/-	+/-	-/+	p	

TABLE 4-continued

Degree of matching between oligonucleotide probes contained on microchip and the 16S and 23S rRNA sequences of eight reference microorganisms from the <i>B. cereus</i> group(*)		<i>B. thur</i> + <i>B. med</i>			<i>B. thur</i>		<i>B. mycooides</i>				<i>B. anthr</i> + <i>B. myc</i>		all other
Probe's target	Probe's name	ps1	ps3	ps5	ps7	ps9	ps11	ps13	ps15	ps19	ps17	ps21	<i>B. thur.</i> B8
		ps2	ps4	ps6	ps8	ps10	ps12	ps14	ps16	ps20	ps18	ps22	
	<i>B. cereus</i> T	+/-	+/-	+/-	+/-	+/-	+/-	+/-	+/-	+/-	-/+		p
	<i>B. cereus</i> NCTC9620	+/-	+/-	+/-	+/-	+/-	+/-	+/-	+/-	+/-	-/+		p
	<i>B. medusa</i> ATCC25621	-/+	-/+	-/+	+/-	+/-	+/-	+/-	+/-	+/-	-/+		p
	<i>B. mycooides</i> ATCC10206	+/-	+/-	+/-	+/-3	-/+	-/+	-/+	-/+	-/+	-/+		+/-
	<i>B. mycooides</i> ATCC6462m	+/-	+/-	+/-	+/-3	-/+	-/+	-/+	-/+	-/+	-/+		+/-

(\*)data obtained from sequences of RNA genes for corresponding bacteria and represents the set of predicted signals after hybridization with labeled RNA from reference microorganisms.

+ denotes perfect matching

- denotes one mismatch

-2 denotes two mismatches

-3 denotes three mismatches

p denotes polymorphism

*B. thur.*: *B. thuringiensis* 4Q281

*B. med.*: *B. medusa* ATCC25621

*B. myc.*: *B. mycooides* ATCC10206 and *B. mycooides* ATCC6462m

*B. anthr.*: *B. anthracis* AMES

*B. thur.* B8: *B. thuringiensis* B8

(SEQ ID NOS 126-141, 84, 85, 82, 83, 142-145, 87, 86, 146-161, 92, 93, 162-163, 90, 91, 164, 77, 72-75, 70, 71, 165, 166, 156, 157, 167-173, 94, 174, 95, 79, 80, 81, 88, 89 and 175, respectively in order of appearance)

TABLE 5

Title	5'-3' Sequence	Target
23F1	TTT GGG CTA TGT TCC GTT TC	not <i>Mycoides</i> A, B
23F2	TTT GGG CTA gaT TCC GTT TC	<i>Mycoides</i> A, B
23F5	TAC GGG GTT GTT ACC CTC TA	not <i>Mycoides</i> A
23F6	TAC GGG GTT aTT ACC CTC TA	<i>Mycoides</i> A
23F7	CTA CGG GGT TGT TAC CCT CT	not <i>Mycoides</i> A
23F8	CTA CGG GGT TaT TAC CCT CT	<i>Mycoides</i> A
16A1	TCT TAT GGG CAG GTT ACC CA	not <i>Mycoides</i> A
16A2	TCT TAT GGG tAG GTT ACC CA	<i>Mycoides</i> A
16A3	ACG CAT CGT TGC CTT GGT GA	not <i>Mycoides</i> A
16A4	ACG CAT CGT cGC CTT GGT GA	<i>Mycoides</i> A
16A5	CAT CGT TGC CTT GGT GAG CC	not <i>Mycoides</i> A
16A6	CAT CGT cGC CTT GGT GAG CC	<i>Mycoides</i> A
16A7	GCG GCT GGC TCC AAA AAG GT	not <i>Mycoides</i> A
16A8	GCG GCT GGC TCC Ata AAG GT	<i>Mycoides</i> A
16A9	GGC TGG CTC CAA AAA GGT TA	not <i>Mycoides</i> A
16A10	GGC TGG CTC CAI AAA GGT TA	<i>Mycoides</i> A
#54 (ps15)	CGA AGC CGC CTT TCA ATT TC	not <i>Mycoides</i> B
SB25 (ps16)	CGA AGC CGC CTT TgA ATT TC	<i>Mycoides</i> B
SB10 (ps13)	GCC TTT CAA TTT CGA ACC AT	not <i>Mycoides</i> B
SB11 (ps14)	GCC TTT gAA TTT CGe ACC AT	<i>Mycoides</i> B
A7	CCC TCT ACG ACG GAC CTT TC	not <i>Mycoides</i> B
A8	CCC TCT gtG ACG agC CTT TC	<i>Mycoides</i> B
23F3	TTT CCA GGT CGC TTC GTC TA	not <i>Mycoides</i> B
23F4	TTT CCA GGe tGC TTC GTC TA	<i>Mycoides</i> B
SB22 (ps18)	TCT AGG GTT tTC AGA GGA TG	not <i>Anthraxis, Cereus</i> A, <i>Mycoides</i> B
SB23 (ps17)	TCT AGG GTT GTC AGA GGA TG	<i>Anthraxis, Cereus</i> A, <i>Mycoides</i> B
D1	CCG GTT TCA AAG GCT CCC GC	<i>Anthraxis, Cereus</i> A, <i>Mycoides</i> B
D2A	CCG GeT TCA AtG GCT CCC GC	not <i>Anthraxis, Cereus</i> A, <i>Mycoides</i> B
B1	GAC CCC TAG TCC AAT CAG TG	<i>Anthraxis, Cereus</i> A, B
B2	GAC CCC TAG TIC AAT CAG TG	<i>Thuringiensis</i> B, <i>Mycoides</i> B
B7	GGT ATC AAT CCG CAG CTT CG	<i>Anthraxis, Cereus</i> A, B
B8	GGT ATC AAT tCG CAG CTT CG	<i>Thuringiensis</i> B, <i>Mycoides</i> B
C5	ACT TCT AAG CAC TCC ACC AG	<i>Anthraxis, Cereus</i> A, B
C6	ACT TCT AAG CgC TCC ACC AG	<i>Thuringiensis</i> B, <i>Mycoides</i> B
C7	TCA CTT CTA AGC ACT CCA CC	<i>Anthraxis, Cereus</i> A, B
C8	TCA CTT CTA AGC gCT CCA CC	<i>Thuringiensis</i> B, <i>Mycoides</i> B
A3	ATG TAT TCA GAT AAG GAT AC	<i>Anthraxis, Cereus</i> A, B
A4	ATG TAT TCA GgT AAG GAT AC	<i>Thuringiensis</i> B, <i>Mycoides</i> B
23F13	ATA CCA TT- GGT ATC AAT CCG	<i>Anthraxis</i>
23F14	TA CCA TTe GGT ATC AAT CCG	<i>Cereus</i> A
23F15	TAC CAT T-G GTA TCA ATC CGC	<i>Anthraxis</i>

TABLE 5-continued

Title	5'-3' Sequence	Target
23F16	AC CAT TeG GTA TCA ATC CGC	<i>Cereus A</i>
B11 (ps23)	CAC TGA TAC CAT T-G GTA TCA	<i>Anthraxis</i>
B12 (ps24)	CAC TGA TAC CAT TeG GTA TCA	<i>Cereus A</i>
C9	GCT CAG CCT TCA CGA TAA GC	<i>Anthraxis</i>
C10	GCT CAG CCT TtA CGA TAA GC	<i>Cereus A</i>
C11 (ps21)	CAG CTC AGC CTT CAC GAT AA	<i>Anthraxis</i>
C12 (ps22)	CAG CTC AGC CTT TAC GAT AA	<i>Cereus A</i>
SB12 (ps7, ps9)	GAA CCA TGC GGT TCA AAA TG	not <i>Thuringiensis A, B</i>
#44 (ps8)	GAA CCA TGC aGT TCA AAA TG	<i>Thuringiensis A, B</i>
SB15 (ps3)	TAA CTT CAT AAG AGC AAG CT	not <i>Thuringiensis B</i>
SB16 (ps4)	TAA CTT Ctt gAG AGC AAG CT	<i>Thuringiensis B</i>
SB4 (ps5)	CCG CTA ACT TCA TAA GAG CA	not <i>Thuringiensis B</i>
SB4-1 (ps6)	CCG CTA ACT Tct TgA GAG CA	<i>Thuringiensis B</i>
SB1 (ps1)	AGC TCT TAA TCC ATT CGC TC	not <i>Thuringiensis B</i>
#41 (ps2)	AGC TCT eAA TCC ATT CGC TC	<i>Thuringiensis B</i>
A1	CAT TAC GTA TGG TGG GTT TC	not <i>Thuringiensis B, Mycooides A</i>
A2	CAT TAC GTA TaG TGG GTT TC	<i>Thuringiensis B, Mycooides A</i>
A3	ATG TAT TCA GAT AAG GAT AC	not <i>Thuringiensis B, Mycooides A, B</i>
A4	ATG TAT TCA GgT AAG GAT AC	<i>Thuringiensis B, Mycooides A, B</i>
A5	TCT GTC TTC CTT ACC CTA TG	not <i>Thuringiensis B, Mycooides A</i>
A6	TCT GTC TTC CaT ACC CTA TG	<i>Thuringiensis B, Mycooides A</i>
A9*	GCC ATC ACC CgT TAA CGG GC	not <i>Thuringiensis B, Mycooides B</i>
A10*	GCC ATC ACC CaT TAA CGG GC	<i>Thuringiensis B, Mycooides B</i>
A11*	ACG CCA TCA CCC gTT AAC GG	not <i>Thuringiensis B, Mycooides B</i>
A12*	ACG CCA TCA CCC aTT AAC GG	<i>Thuringiensis B, Mycooides B</i>
#55	CAA CTA GCA CTT GTT CTT CC	<i>Bacillus cereus</i> group
#57 (ps25)	CGG TCT TGC AGC TCT TTG TA	<i>Bacillus cereus</i> group
#66	ACA GAT TTG TGG GAT TGG CT	<i>Bacillus subtilis</i> group
#67 (ps26)	ATT CCA GCT TCA CGC AGT C	<i>Bacillus subtilis</i> group
SB17 (ps10)	GeA CCA TGC GGT gCA AAA TG	<i>Mycooides B</i>
SB9 (ps11)	CAA TTT CGA ACC ATG CGG TT	not <i>Mycooides B</i>
SB8 (ps12)	gAA TTT CGc ACC ATG CGG Tg	<i>Mycooides B</i>
SB26 (ps19)	TCT GCT CCC GAA GGA GAA GC	not <i>Mycooides B</i>
SB27 (ps20)	TCT GCc CCC GAA GGg GAA GC	<i>Mycooides B</i>
Hybr.Marker	GAT GAT GAT GAT GAT GAT GA	Internal standard for hybridization

\*bacteria from subgroup *Anthraxis* produce unpredictable results for these

35

TABLE 6

Preparation of Buffers for Preparation of Micro-Matrices				
Buffer	Chemical/ Solvent/ Elementary buffer	Amount	Final Concen- tration	Comments
Wash Buffer	20xSSPE buffer	15 ml	3xSSPE	Filter by using Millex GN 0.20
	Tween 20	500 µl	1% (v/v)	Filter and
	MQ H2O	34.5 ml	—	Luer Lok Syringe, B-D, 60 cc/2 oz
				Note: Discard first 5 ml of Wash Buffer when you start filtration
				Keep at room temperature
3x Hybridization Buffer	6M GuSCN 1M HEPES, pH 7.5	50 ml 15 ml	3M 0.15M	Store at room temperature
	0.2M EDTA, pH 8.0	7.5 ml	15 mM	
	MQ H2O	27.5 ml		

TABLE 6-continued

Preparation of Buffers for Preparation of Micro-Matrices				
Buffer	Chemical/ Solvent/ Elementary buffer	Amount	Final Concen- tration	Comments
45 Stripping buffer	Guanidinium thiocyanate	300 g	4.9M	Store solution at room temperature in a bottle with dark glass. Use for 20 stripping procedures (see below) then prepare a new portion.
	1 M HEPES, pH 7.5	13.2 ml	25 mM	
	10% (w/v) Triton X-100	5.2 ml	0.1%	
50	Distilled water	250 ml		

NOTE: KEEP ALL BUFFERS IN BOTTLES WITH PLASTIC CAPS

TABLE 7

Materials and Equipment for Preparation of Micro-Matrices			
60 Chemicals/Equipment	Manu- facturer	Catalog #	Lot #
Acetone	Fisher	A18-4	11685
Acrylamide/Bis (19/1) solution 40%	BioRad	161-0144	66767
3-(Trimethoxysilyl) propyl methacrylate	Aldrich	Z-6030	03915TI
65 Pyridine-borane complex Glycerol	Aldrich Sigma	17,975-2 G-7893	13905MU 118H0280

TABLE 7-continued

Materials and Equipment for Preparation of Micro-Matrices			
Chemicals/Equipment	Manufacturer	Catalog #	Lot #
Methylene blue	Merck	73881	51076
Ethyl Alcohol (absolute, 200 proof)	Aapec Alcohol and Chemical Co	N/A	099I15UA
Chloroform	Aldrich	31,998-8	CO 09980AO
Repel Silane	Amersham-Pharmacia-Biotech	39422	17-322-01
Sodium borohydride	Aldrich	21,346-2	DU 00220MS
Sodium Hydroxide Solid	Sigma	S-5881	11K0116
Sodium Periodate (meta)	Aldrich	S-1878	11K3644
Sodium Phosphate, dibasic, anhydrous	Sigma	S-9763	119H0196
Sodium Phosphate, monobasic monohydrate	Fisher	S-369	792237
Sulfuric Acid	Fisher	A300-500	994173
Sodium Dodecyl Sulfate SSPE, 20X	Sigma	L3771	83H08411
(N-(5,6-di-O-isopropylidene)hexyl acrylamide)	Sigma	T-7024	67H0136
TEMED	Aldrich	T6,220-0	8K3483
Trifluoro-acetic Acid Filter (0.45 µm filter unit): Milllex-HV 0.4	Millipore	SLHV 025 LS	
Glass slides, 3 <sup>2</sup> × 1 <sup>2</sup> Plain; Mask	Corning	2947	
Audio tape film	Nanofilm, California Radioshak XR 60; Type I		
Clamp, Medium Binger clips	Masterbrand	BTM00252	
Oriel Light Source	Oriel Instruments	92532-1000	S/N 139

## DOCUMENTS

The following documents are incorporated by reference to the extent they enable the present invention:

- Amann, R. I., W. Ludwig, and K.-H. Schleifer. 1995. Phylogenetic identification and in situ detection of individual microbial cells without cultivation. *Microbiol. Rev.* 59:143-169.
- Andersen, G. L., J. M. Simchock, and K. H. Wilson. 1996. Identification of a region of genetic variability among *Bacillus anthracis* strains and related species. *J. Bacteriol.* 178:377-384.
- Aronson, A. I. 1993. Insecticidal toxins, p. 953-963. In A. B. Sonenshein, J. A. Hoch, and R. Losick (ed), *Bacillus subtilis* and other gram-positive bacteria: biochemistry, physiology, and molecular genetics. American Society for Microbiology, Washington, D.C.
- Aronson, A. I., W. Beckman, and P. Dunn. 1986. *Bacillus thuringiensis* and related insect pathogens. *Microbiol. Rev.* 50:1-24.
- Ash, C., and M. D. Collins. 1992. Comparative analysis of 23S ribosomal RNA gene sequences of *Bacillus anthracis* and emetic *Bacillus cereus* determined by PCR-direct sequencing. *FEMS Microbiol. Lett.* 94:75-80.
- Ash, C., J. A. E. Farrow, M. Dorsch, E. Stackebrandt, and M. D. Collins. 1991. Comparative analysis of *Bacillus*

*anthracis*, *Bacillus cereus*, and related species on the basis of reverse transcriptase sequencing of 16S rRNA. *Int. J. Syst. Bacteriol.* 41:343-346.

- Ash, C., J. A. E. Farrow, W. Wallbanks, and M. D. Collins. 1991. Phylogenetic heterogeneity of the genus *Bacillus* revealed by comparative analysis of small-subunit-ribosomal RNA sequences. *Let. Appl. Microbiol.* 13:202-206.
- Barsky, I., A. Grammatin, A. Ivanov, E. Kreindlin, E. Kotova, V. Barsky, and A. D. Mirzabekov. 1998. Luminescent image analyzers of biological microchips. *J. Opt. Technol. (Russian)*. 65:83-87.
- Bavykin, S. G., J. P. Akowski, V. M. Zakhariev, V. E. Barsky, A. N. Perov and A. D. Mirzabekov. 2001. Portable system for microbial sample preparation and oligonucleotide microarray analysis. *Appl. Environ. Microbiol.*, 67: 922-928.
- Beyer, W., P. Glöckner, J. Otto, and R. Böhm. 1996. A nested PCR and DNA-amplification-fingerprinting method for detection and identification of *Bacillus anthracis* in soil samples from former tanneries. *Salisbury Medical Bulletin, Special Supplement No.* 87:47-49.
- Beyer, W., S. Pocivalsek, and R. Böhm. 1999. Polymerase chain reaction—ELISA to detect *Bacillus anthracis* from soil samples—limitations of present published primers. *J. Appl. Microbiol.* 87:229-236.
- Boom, R., C. J. Sol, M. M. Salimans, C. L. Jansen, P. M. Wertheim-van Dillen, and J. van der Noordaa. 1990. Rapid and simple method for purification of nucleic acids. *J. Clin. Microbiol.* 28:495-503.
- Chee, M., R. Yang, E. Hubbrll, A. Berno, X. C. Huang, D. Stern, J. Winkler, D. J. Lockhart, M. S. Morris, and S. P. A. Fodor. 1996. Accessing genetic information with high-density DNA arrays. *Science* 274: 610-614.
- Daffonchio, D., A. Cherif, and S. Borin. 2000. Homoduplex and heteroduplex polymorphisms of the amplified ribosomal 16S-23S internal transcribed spacers describe genetic relationships in the "*Bacillus cereus* Group." *Appl. Environ. Microbiol.* 66:5460-5468.
- Delaporte, de M. 1969. Description de *Bacillus medusa* n.sp. *C. R. Acad. Sc. Paris* 269 (Serie D): 1129-1131.
- Drobniewski, F. A. 1993. *Bacillus cereus* and related species, p. 324-338. In *Clinical microbiology reviews*, Vol. 6. American Society for Microbiology, Washington, D.C.
- Ezzell, J. W. Jr., T. G. Abshire, S. F. Little, B. C. Lidgerding, and C. Brown. 1990. Identification of *Bacillus anthracis* by using monoclonal antibody to cell wall galactose-Nacetylglucosamine polysaccharide. *J. Clin. Microbiol.* 28:223-231.
- Fox, A., G. E. Black, K. Fox, and S. Rostovtseva. 1993. Determination of carbohydrate profiles of *Bacillus anthracis* and *Bacillus cereus* including identification of O-methyl methylpentoses by using gas chromatography-mass spectrometry. *J. Clin. Microbiol.* 31:887-894.
- Giffel, M. C., R. R. Beumer, N. Klijn, A. Wagendorp, and F. M. Rombouts. 1997. Discrimination between *Bacillus cereus* and *Bacillus thuringiensis* using specific DNA probes based in variable regions of 16S rRNA. *FEMS Microbiol. Lett.* 146:47-51.
- Gonzalez Jr., J. M., B. J. Brown, and B. C. Carlton. 1982. Transfer of *Bacillus thuringiensis* plasmids coding for β-endotoxin among strains of *B. thuringiensis* and *B. cereus*. *Proc. Natl. Acad. Sci. USA* 79:6951-6955.
- Guschin, D., G. Yershov, A. Zaslavsky, A. Gemmill, V. Shick, D. Proudnikov, P. Arenkov, and A. Mirzabekov. 1997. Manual manufacturing of oligonucleotide, DNA, and protein microchips. *Anal. Biochem.* 250:203-211.

- Guschin, D. Y., B. K. Mobarry, D. Proudnikov, D. A. Stahl, B. E. Rittmann, and A. D. Mirzabekov. 1997. Oligonucleotide microchips as genosensors for determinative and environmental studies in microbiology. *Appl. Environ. Microbiol.* 63: 2397-2402.
- Harrell, L. J., G. L. Andersen, and K. H. Wilson. 1995. Genetic variability of *Bacillus anthracis* and related species. *J. Clin. Microbiol.* 33:1847-1850.
- Helgason, E., O. A. Økstad, D. A. Caugant, H. A. Johansen, A. Fouet, M. Mock, I. Hegna, and A.-B. Kolsto. 2000. *Bacillus anthracis*, *Bacillus cereus*, and *Bacillus thuringiensis*—one species on the basis of genetic evidence. *Appl. Environ. Microbiol.* 66:2627-2630.
- Henderson, I. 1996. Fingerprinting *Bacillus anthracis* strains. *Salisbury Medical Bulletin, Special Supplement No.* 87:55-58.
- Henderson, I., C. J. Duggleby, and P. C. B. Turnbull. 1994. Differentiation of *Bacillus anthracis* from other *Bacillus cereus* group bacteria with the PCR. *Int. J. Syst. Bacteriol.* 44:99-105.
- Henderson, I., Y. Dongzheng, and P. C. B. Turnbull. 1995. Differentiation of *Bacillus anthracis* and other *Bacillus cereus* group' bacteria using IS231-derived sequences. *FEMS Microbiol. Lett.* 128:113-118.
- Hutson, R. A., C. J. Duggleby, J. R. Lowe, R. J. Manchee, and P. C. B. Turnbull. 1993. The development and assessment of DNA and oligonucleotide probes for the specific detection of *Bacillus anthracis*. *J. Appl. Bacteriol.* 75:463-472.
- Jackson, P. J., K. K. Hill, M. T. Laker, L. O. Ticknor, and P. Keim. 1999. Genetic comparison of *Bacillus anthracis* and its close relatives using amplified fragment length polymorphism and polymerase chain reaction analysis. *J. Appl. Microbiol.* 87:263-269.
- Kiem, P., A. Kalif, J. Schupp, K. Hill, S. E. Travis, K. Richmond, D. M. Adair, M. Hugh-Jones, C. R. Kuske, and P. Jackson. 1997. Molecular evolution and diversity in *Bacillus anthracis* as detected by amplified fragment length polymorphism markers. *J. Bacteriol.* 179:818-824.
- Lander, E. S. 1999. Array of hope. *Nature Genet.* 21(suppl.): 3-4.
- Lane, D. J. 1991. 16S/23S rRNA sequencing. p. 115-176. In E. Stackenbrandt and M. Goodfellow (ed.), *Nucleic acid techniques in bacterial systematics*, John Wiley & Sons, City, State.
- Lechner, S., R. Mayr, K. P. Francis, B. M. Prub, T. Kaplan, E. Wiebner-Gunkel, G. S. Stewart, and A. B. Scherer. 1998. *Bacillus weihenstephanensis* sp. nov. is a new psychrotolerant species of the *Bacillus cereus* group. *Int. J. Syst. Bacteriol.* 48:1373-1382.
- Lee, M. A., G. Brightwell, D. Leslie, H. Bird, and A. Hamilton. 1999. Fluorescent detection techniques for real-time multiplex strand specific detection of *Bacillus anthracis* using rapid PCR. *J. Appl. Microbiol.* 87:218-223.
- Liang, X., and D. Yu. 1999. Identification of *Bacillus anthracis* strains in China. *J. Appl. Microbiol.* 87:200-203.
- Longchamp, P., and T. Leighton. 1999. Molecular recognition specificity of *Bacillus anthracis* spore antibodies. *J. Appl. Microbiol.* 87:246-249.
- Nakamura, L. K., and M. A. Jackson. 1995. Clarification of the taxonomy of *Bacillus mycoides*. *Int. J. Syst. Bacteriol.* 45:46-49.
- Nakamura, L. K. 1998. *Bacillus pseudomycoides* sp. nov. *Int. J. Syst. Bacteriol.* 48:1031-1034.

- Patra, G., P. Sylvestre, V. Ramisse, J. Therasse, and J. L. Guesdon. 1996. DNA fingerprinting of *Bacillus anthracis* strains. *Salisbury Medical Bulletin, Special Supplement No.* 87:59.
- 5 Patra, G., P. Sylvestre, V. Ramisse, J. Therasse, and J.-L. Guedson. 1996. Isolation of a specific chromosomal DNA sequence of *Bacillus anthracis* and its possible use in diagnosis. *FEMS Immunol. Med. Microbiol.* 15:223-231.
- Priest, F. G., D. A. Kaji, Y. B. Rosato, and V. P. Canhos. 10 1994. Characterization of *Bacillus thuringiensis* and related bacteria by ribosomal RNA gene restriction fragment length polymorphisms. *Microbiology* 140:1015-1022.
- Proudnikov, D., E. Timofeev, and A. Mirzabekov. 1998. Immobilization of DNA in polyacrylamide gel for the manufacture of DNA and DNA-oligonucleotide microchips. *Anal. Biochem.* 259:34-41.
- 15 Prub, B. M., K. P. Francis, F. von Stetten, and S. Scherer. 1999. Correlation of 16S ribosomal DNA signature sequences with temperature-dependent growth rates of Mesophilic and Psychrotolerant strains of the *Bacillus cereus* group. *J. Bacteriol.* 181:2624-2630.
- Ramisse, V., G. Patra, H. Garrigue, J.-L. Guesdon, and M. Mock. 1996. Identification and characterization of *Bacillus anthracis* by multiplex PCR analysis of sequences on plasmids pXO1 and pXO2 and chromosomal DNA. *FEMS Microbiol. Lett.* 145:9-16.
- 25 Ryzhov, V., Y. Hathout, and C. Fenselau. 2000. Rapid characterization of spores of *Bacillus cereus* group bacteria by matrix-assisted laser desorption-ionization time-of-flight mass spectrometry. *Appl Environ. Microbiol.* 66:3828-3834.
- Shangkuan, Y.-H., J.-F. Yang, H.-C. Lin, and M.-F. Shaio. 2000. Comparison of PCR-RFLP, ribotyping and ERIC-PCR for typing *Bacillus anthracis* and *Bacillus cereus* strains. *J. Appl. Microbiol.* 89:452-462.
- 35 Sj'stedt, A., U. Eriksson, V. Ramisse, and H. Garrigue. 1996. Detection of the vegetative form of *Bacillus anthracis* in soil by PCR. *Salisbury Medical Bulletin, Special Supplement No.* 87, 50.
- 40 Sneath, P. H. A. 1986. Endospore-forming Gram-positive rods and cocci, p. 1104-1139. In J. G. Holt (ed.), *Bergey's Manual of Systematic Bacteriology* The Williams & Wilkins Co., Baltimore, Md.
- 45 Stahl, D. A. and R. Amann. 1991. Development and application of nucleic acid probes in bacterial systematics, p. 205-248. In E. Stackenbrandt and M. Goodfellow (ed.), *Sequencing and hybridization techniques in bacterial systematics*. John Wiley and Sons, Chichester, England.
- 50 Strizhkov, B. N., A. L. Drobyshev, V. M. Mikhailovich, and A. D. Mirzabekov. 2000. PCR amplification on a microarray of gel-immobilized oligonucleotides: detection of bacterial toxin- and drug-resistant genes and their mutations. *BioTechniques* 29:844-857.
- 55 Timofeev, E. N., S. V. Kochetkova, A. D. Mirzabekov and V. L. Florentiev. 1996. Regioselective immobilization of short oligonucleotides to acrylic copolymer gels. *Nucl. Acids Res.* 24: 3142-3148.
- Thorne, C. B. 1985. Genetics of *Bacillus anthracis*, p. 56-62. In L. Leive (ed.), *Microbiology-1985*. American Society for Microbiology, Washington, D.C.
- Turnbull, P. C. B. 1999. Definitive identification of *Bacillus anthracis*—a review. *J. Appl. Microbiol.* 87:237-240.
- 60 Turnbull, P. C. B., R. A. Hutson, M. J. Ward, M. N. Jones, C. P. Quinn, N.J. Finnie, C. J. Duggleby, J. M. Kramer, and J. Melling. 1992. *Bacillus anthracis* but not always anthrax. *J. Appl. Bacteriol.* 72: 21-28.

- Woese, C. R. 1987. Bacterial evolution. *Microbiol. Rev.* 51:221-271.
- Wunschel, D., K. F. Fox, G. E. Black, and A. Fox. 1994. Discrimination among the *Bacillus cereus* group, in comparison to *B. subtilis*, by structural carbohydrate profiles and ribosomal RNA spacer region PCR. *Syst. Appl. Microbiol.* 17:625-635.
- Yamakama, I., D. Nakajama, and O. Ohara. 1996. Identification of sequence motifs causing band compressions on human cDNA sequencing. *DNA Research* 3:81-86.

- Yershov, G., V. Barsky, A. Belgovskiy, Eu. Kirillov, E. Kreindlin, I. Ivanov, S. Parinov, D. Guschin, A. Drobyshv, S. Dubiley, and A. Mirzabekov. 1996. DNA analysis and diagnostics on oligonucleotide microchips. *Proc. Natl. Acad. Sci. USA.* 93:4913-4918.
- Zlatanova, J., and A. D. Mirzabekov. 2001. Gel immobilized microarrays of nucleic acids and proteins. In J. B. Rampil (ed.), *Methods in Molecular Biology: DNA Arrays, Methods, and Protocols*, in press, Human Press, Inc., Totowa, N.J.

## SEQUENCE LISTING

<160> NUMBER OF SEQ ID NOS: 175

<210> SEQ ID NO 1

<211> LENGTH: 18

<212> TYPE: DNA

<213> ORGANISM: *Bacillus anthracis*

<400> SEQUENCE: 1

taagagcttg ctcttatg

18

<210> SEQ ID NO 2

<211> LENGTH: 18

<212> TYPE: DNA

<213> ORGANISM: *Bacillus cereus*

<400> SEQUENCE: 2

taagagcttg ctcttatg

18

<210> SEQ ID NO 3

<211> LENGTH: 18

<212> TYPE: DNA

<213> ORGANISM: *Bacillus cereus*

<400> SEQUENCE: 3

taagagcttg ctcttatg

18

<210> SEQ ID NO 4

<211> LENGTH: 18

<212> TYPE: DNA

<213> ORGANISM: *Bacillus thuringiensis*

<400> SEQUENCE: 4

taagagcttg ctcttatg

18

<210> SEQ ID NO 5

<211> LENGTH: 18

<212> TYPE: DNA

<213> ORGANISM: *Bacillus thuringiensis*

<400> SEQUENCE: 5

tgagagcttg ctctcaag

18

<210> SEQ ID NO 6

<211> LENGTH: 18

<212> TYPE: DNA

<213> ORGANISM: *Bacillus mycoides*

<400> SEQUENCE: 6

taagagcttg ctcttatg

18

-continued

---

<210> SEQ ID NO 7  
<211> LENGTH: 18  
<212> TYPE: DNA  
<213> ORGANISM: *Bacillus mycoides*

<400> SEQUENCE: 7

taagagcttg ctcttatg 18

<210> SEQ ID NO 8  
<211> LENGTH: 30  
<212> TYPE: DNA  
<213> ORGANISM: *Bacillus anthracis*

<400> SEQUENCE: 8

aacattttga accgcatggt tcgaaattga 30

<210> SEQ ID NO 9  
<211> LENGTH: 30  
<212> TYPE: DNA  
<213> ORGANISM: *Bacillus cereus*

<400> SEQUENCE: 9

aacattttga accgcatggt tcgaaattga 30

<210> SEQ ID NO 10  
<211> LENGTH: 30  
<212> TYPE: DNA  
<213> ORGANISM: *Bacillus cereus*

<400> SEQUENCE: 10

aacattttga accgcatggt tcgaaattga 30

<210> SEQ ID NO 11  
<211> LENGTH: 30  
<212> TYPE: DNA  
<213> ORGANISM: *Bacillus thuringiensis*

<400> SEQUENCE: 11

aacattttga actgcatggt tcgaaattga 30

<210> SEQ ID NO 12  
<211> LENGTH: 30  
<212> TYPE: DNA  
<213> ORGANISM: *Bacillus thuringiensis*

<400> SEQUENCE: 12

aacattttga actgcatggt tcgaaattga 30

<210> SEQ ID NO 13  
<211> LENGTH: 30  
<212> TYPE: DNA  
<213> ORGANISM: *Bacillus mycoides*

<400> SEQUENCE: 13

aatattttga actgcatagt tcgaaattga 30

<210> SEQ ID NO 14  
<211> LENGTH: 30  
<212> TYPE: DNA  
<213> ORGANISM: *Bacillus mycoides*

<400> SEQUENCE: 14

aacattttgc accgcatggt gcgaaattca 30

-continued

---

<210> SEQ ID NO 15  
 <211> LENGTH: 33  
 <212> TYPE: DNA  
 <213> ORGANISM: *Bacillus anthracis*  
 <400> SEQUENCE: 15  
 acaaccctag agatagggct tctccttcgg gag 33

<210> SEQ ID NO 16  
 <211> LENGTH: 33  
 <212> TYPE: DNA  
 <213> ORGANISM: *Bacillus cereus*  
 <400> SEQUENCE: 16  
 acaaccctag agatagggct tctccttcgg gag 33

<210> SEQ ID NO 17  
 <211> LENGTH: 33  
 <212> TYPE: DNA  
 <213> ORGANISM: *Bacillus cereus*  
 <400> SEQUENCE: 17  
 aaaaccctag agatagggct tctccttcgg gag 33

<210> SEQ ID NO 18  
 <211> LENGTH: 33  
 <212> TYPE: DNA  
 <213> ORGANISM: *Bacillus thuringiensis*  
 <400> SEQUENCE: 18  
 aaaaccctag agatagggct tctccttcgg gag 33

<210> SEQ ID NO 19  
 <211> LENGTH: 33  
 <212> TYPE: DNA  
 <213> ORGANISM: *Bacillus thuringiensis*  
 <400> SEQUENCE: 19  
 aaaaccctag agatagggct tctccttcgg gag 33

<210> SEQ ID NO 20  
 <211> LENGTH: 33  
 <212> TYPE: DNA  
 <213> ORGANISM: *Bacillus mycoides*  
 <400> SEQUENCE: 20  
 aaaactctag agatagagct tctccttcgg gag 33

<210> SEQ ID NO 21  
 <211> LENGTH: 33  
 <212> TYPE: DNA  
 <213> ORGANISM: *Bacillus mycoides*  
 <400> SEQUENCE: 21  
 acaaccctag agatagggct tccccttcgg ggg 33

<210> SEQ ID NO 22  
 <211> LENGTH: 18  
 <212> TYPE: DNA  
 <213> ORGANISM: *Bacillus anthracis*  
 <400> SEQUENCE: 22  
 taagagcttg ctcttatg 18

---

-continued

---

<210> SEQ ID NO 23  
<211> LENGTH: 18  
<212> TYPE: DNA  
<213> ORGANISM: *Bacillus thuringiensis*  
  
<400> SEQUENCE: 23  
taagagcttg ctcttatg 18

<210> SEQ ID NO 24  
<211> LENGTH: 18  
<212> TYPE: DNA  
<213> ORGANISM: *Bacillus cereus*  
  
<400> SEQUENCE: 24  
taagagcttg ctcttatg 18

<210> SEQ ID NO 25  
<211> LENGTH: 18  
<212> TYPE: DNA  
<213> ORGANISM: *Bacillus cereus*  
  
<400> SEQUENCE: 25  
taagagcttg ctcttatg 18

<210> SEQ ID NO 26  
<211> LENGTH: 18  
<212> TYPE: DNA  
<213> ORGANISM: *Bacillus thuringiensis*  
  
<400> SEQUENCE: 26  
tgagagcttg ctctcaag 18

<210> SEQ ID NO 27  
<211> LENGTH: 18  
<212> TYPE: DNA  
<213> ORGANISM: *Bacillus medusa*  
  
<400> SEQUENCE: 27  
tgagagcttg ctctcaag 18

<210> SEQ ID NO 28  
<211> LENGTH: 18  
<212> TYPE: DNA  
<213> ORGANISM: *Bacillus mycoides*  
  
<400> SEQUENCE: 28  
taagagcttg ctcttatg 18

<210> SEQ ID NO 29  
<211> LENGTH: 18  
<212> TYPE: DNA  
<213> ORGANISM: *Bacillus mycoides*  
  
<400> SEQUENCE: 29  
taagagcttg ctcttatg 18

<210> SEQ ID NO 30  
<211> LENGTH: 30  
<212> TYPE: DNA  
<213> ORGANISM: *Bacillus anthracis*  
  
<400> SEQUENCE: 30

-continued

---

aacattttga accgcatggt tcgaaattga	30
<210> SEQ ID NO 31 <211> LENGTH: 30 <212> TYPE: DNA <213> ORGANISM: Bacillus thuringiensis <400> SEQUENCE: 31	
aacattttga accgcatggt tcgaaattga	30
<210> SEQ ID NO 32 <211> LENGTH: 30 <212> TYPE: DNA <213> ORGANISM: Bacillus cereus <400> SEQUENCE: 32	
aacattttga accgcatggt tcgaaattga	30
<210> SEQ ID NO 33 <211> LENGTH: 30 <212> TYPE: DNA <213> ORGANISM: Bacillus cereus <400> SEQUENCE: 33	
aacattttga accgcatggt tcgaaattga	30
<210> SEQ ID NO 34 <211> LENGTH: 30 <212> TYPE: DNA <213> ORGANISM: Bacillus thuringiensis <400> SEQUENCE: 34	
aacattttga actgcatggt tcgaaattga	30
<210> SEQ ID NO 35 <211> LENGTH: 30 <212> TYPE: DNA <213> ORGANISM: Bacillus medusa <400> SEQUENCE: 35	
aacattttga accgcatggt tcgaaattga	30
<210> SEQ ID NO 36 <211> LENGTH: 30 <212> TYPE: DNA <213> ORGANISM: Bacillus mycoides <400> SEQUENCE: 36	
aacattttgc accgcatggt gcgaaattca	30
<210> SEQ ID NO 37 <211> LENGTH: 30 <212> TYPE: DNA <213> ORGANISM: Bacillus mycoides <400> SEQUENCE: 37	
aacattttgc accgcatggt gcgaaattca	30
<210> SEQ ID NO 38 <211> LENGTH: 33 <212> TYPE: DNA <213> ORGANISM: Bacillus anthracis <400> SEQUENCE: 38	

-continued

---

acaaccctag agatagggt tctccttcgg gag	33
<210> SEQ ID NO 39	
<211> LENGTH: 33	
<212> TYPE: DNA	
<213> ORGANISM: Bacillus thuringiensis	
<400> SEQUENCE: 39	
acaaccctag agatagggt tctccttcgg gag	33
<210> SEQ ID NO 40	
<211> LENGTH: 33	
<212> TYPE: DNA	
<213> ORGANISM: Bacillus cereus	
<400> SEQUENCE: 40	
aaaaccctag agatagggt tctccttcgg gag	33
<210> SEQ ID NO 41	
<211> LENGTH: 33	
<212> TYPE: DNA	
<213> ORGANISM: Bacillus cereus	
<400> SEQUENCE: 41	
aaaaccctag agatagggt tctccttcgg gag	33
<210> SEQ ID NO 42	
<211> LENGTH: 33	
<212> TYPE: DNA	
<213> ORGANISM: Bacillus thuringiensis	
<400> SEQUENCE: 42	
aaaaccctag agatagggt tctccttcgg gag	33
<210> SEQ ID NO 43	
<211> LENGTH: 33	
<212> TYPE: DNA	
<213> ORGANISM: Bacillus medusa	
<400> SEQUENCE: 43	
aaaaccctag agatagggt tctccttcgg gag	33
<210> SEQ ID NO 44	
<211> LENGTH: 33	
<212> TYPE: DNA	
<213> ORGANISM: Bacillus mycoides	
<400> SEQUENCE: 44	
acaaccctag agatagggt tccccttcgg ggg	33
<210> SEQ ID NO 45	
<211> LENGTH: 33	
<212> TYPE: DNA	
<213> ORGANISM: Bacillus mycoides	
<400> SEQUENCE: 45	
acaaccctag agatagggt tccccttcgg ggg	33
<210> SEQ ID NO 46	
<211> LENGTH: 20	
<212> TYPE: DNA	
<213> ORGANISM: Artificial Sequence	
<220> FEATURE:	

-continued

---

<223> OTHER INFORMATION: Description of Artificial Sequence: Synthetic oligonucleotide

<400> SEQUENCE: 46

gagcgaatgg attaagagct 20

<210> SEQ ID NO 47  
 <211> LENGTH: 20  
 <212> TYPE: DNA  
 <213> ORGANISM: Artificial Sequence  
 <220> FEATURE:  
 <223> OTHER INFORMATION: Description of Artificial Sequence: Synthetic oligonucleotide

<400> SEQUENCE: 47

gagcgaatgg attgagagct 20

<210> SEQ ID NO 48  
 <211> LENGTH: 20  
 <212> TYPE: DNA  
 <213> ORGANISM: Artificial Sequence  
 <220> FEATURE:  
 <223> OTHER INFORMATION: Description of Artificial Sequence: Synthetic oligonucleotide

<400> SEQUENCE: 48

agcttgctct tatgaagtta 20

<210> SEQ ID NO 49  
 <211> LENGTH: 20  
 <212> TYPE: DNA  
 <213> ORGANISM: Artificial Sequence  
 <220> FEATURE:  
 <223> OTHER INFORMATION: Description of Artificial Sequence: Synthetic oligonucleotide

<400> SEQUENCE: 49

agcttgctct caagaagtta 20

<210> SEQ ID NO 50  
 <211> LENGTH: 20  
 <212> TYPE: DNA  
 <213> ORGANISM: Artificial Sequence  
 <220> FEATURE:  
 <223> OTHER INFORMATION: Description of Artificial Sequence: Synthetic oligonucleotide

<400> SEQUENCE: 50

tgctcttatg aagttagcgg 20

<210> SEQ ID NO 51  
 <211> LENGTH: 20  
 <212> TYPE: DNA  
 <213> ORGANISM: Artificial Sequence  
 <220> FEATURE:  
 <223> OTHER INFORMATION: Description of Artificial Sequence: Synthetic oligonucleotide

<400> SEQUENCE: 51

tgctctcaag aagttagcgg 20

<210> SEQ ID NO 52  
 <211> LENGTH: 20  
 <212> TYPE: DNA  
 <213> ORGANISM: Artificial Sequence  
 <220> FEATURE:  
 <223> OTHER INFORMATION: Description of Artificial Sequence: Synthetic

-continued

---

oligonucleotide

<400> SEQUENCE: 52

cattttgaac cgcatggttc 20

<210> SEQ ID NO 53  
 <211> LENGTH: 20  
 <212> TYPE: DNA  
 <213> ORGANISM: Artificial Sequence  
 <220> FEATURE:  
 <223> OTHER INFORMATION: Description of Artificial Sequence: Synthetic  
 oligonucleotide

<400> SEQUENCE: 53

cattttgaac tgcattggttc 20

<210> SEQ ID NO 54  
 <211> LENGTH: 20  
 <212> TYPE: DNA  
 <213> ORGANISM: Artificial Sequence  
 <220> FEATURE:  
 <223> OTHER INFORMATION: Description of Artificial Sequence: Synthetic  
 oligonucleotide

<400> SEQUENCE: 54

cattttgaac cgcatggttc 20

<210> SEQ ID NO 55  
 <211> LENGTH: 20  
 <212> TYPE: DNA  
 <213> ORGANISM: Artificial Sequence  
 <220> FEATURE:  
 <223> OTHER INFORMATION: Description of Artificial Sequence: Synthetic  
 oligonucleotide

<400> SEQUENCE: 55

cattttgcac cgcatgggtgc 20

<210> SEQ ID NO 56  
 <211> LENGTH: 20  
 <212> TYPE: DNA  
 <213> ORGANISM: Artificial Sequence  
 <220> FEATURE:  
 <223> OTHER INFORMATION: Description of Artificial Sequence: Synthetic  
 oligonucleotide

<400> SEQUENCE: 56

aaccgcatgg ttcgaaattg 20

<210> SEQ ID NO 57  
 <211> LENGTH: 20  
 <212> TYPE: DNA  
 <213> ORGANISM: Artificial Sequence  
 <220> FEATURE:  
 <223> OTHER INFORMATION: Description of Artificial Sequence: Synthetic  
 oligonucleotide

<400> SEQUENCE: 57

caccgcatgg tgcgaaattc 20

<210> SEQ ID NO 58  
 <211> LENGTH: 20  
 <212> TYPE: DNA  
 <213> ORGANISM: Artificial Sequence  
 <220> FEATURE:  
 <223> OTHER INFORMATION: Description of Artificial Sequence: Synthetic  
 oligonucleotide

-continued

---

<400> SEQUENCE: 58  
atggttcgaa attgaaaggc 20

<210> SEQ ID NO 59  
<211> LENGTH: 20  
<212> TYPE: DNA  
<213> ORGANISM: Artificial Sequence  
<220> FEATURE:  
<223> OTHER INFORMATION: Description of Artificial Sequence: Synthetic  
oligonucleotide

<400> SEQUENCE: 59  
atggtgcgaa attcaaaggc 20

<210> SEQ ID NO 60  
<211> LENGTH: 20  
<212> TYPE: DNA  
<213> ORGANISM: Artificial Sequence  
<220> FEATURE:  
<223> OTHER INFORMATION: Description of Artificial Sequence: Synthetic  
oligonucleotide

<400> SEQUENCE: 60  
gaaattgaaa ggcggcttcg 20

<210> SEQ ID NO 61  
<211> LENGTH: 20  
<212> TYPE: DNA  
<213> ORGANISM: Artificial Sequence  
<220> FEATURE:  
<223> OTHER INFORMATION: Description of Artificial Sequence: Synthetic  
oligonucleotide

<400> SEQUENCE: 61  
gaaattcaaa ggcggcttcg 20

<210> SEQ ID NO 62  
<211> LENGTH: 20  
<212> TYPE: DNA  
<213> ORGANISM: Artificial Sequence  
<220> FEATURE:  
<223> OTHER INFORMATION: Description of Artificial Sequence: Synthetic  
oligonucleotide

<400> SEQUENCE: 62  
catcctctga caaccctaga 20

<210> SEQ ID NO 63  
<211> LENGTH: 20  
<212> TYPE: DNA  
<213> ORGANISM: Artificial Sequence  
<220> FEATURE:  
<223> OTHER INFORMATION: Description of Artificial Sequence: Synthetic  
oligonucleotide

<400> SEQUENCE: 63  
catcctctga aaaccctaga 20

<210> SEQ ID NO 64  
<211> LENGTH: 20  
<212> TYPE: DNA  
<213> ORGANISM: Artificial Sequence  
<220> FEATURE:  
<223> OTHER INFORMATION: Description of Artificial Sequence: Synthetic  
oligonucleotide

-continued

---

<400> SEQUENCE: 64  
gcttctcctt cgggagcaga 20

<210> SEQ ID NO 65  
<211> LENGTH: 20  
<212> TYPE: DNA  
<213> ORGANISM: Artificial Sequence  
<220> FEATURE:  
<223> OTHER INFORMATION: Description of Artificial Sequence: Synthetic  
oligonucleotide

<400> SEQUENCE: 65  
gcttcccctt cgggggcaga 20

<210> SEQ ID NO 66  
<211> LENGTH: 20  
<212> TYPE: DNA  
<213> ORGANISM: Artificial Sequence  
<220> FEATURE:  
<223> OTHER INFORMATION: Description of Artificial Sequence: Synthetic  
oligonucleotide

<400> SEQUENCE: 66  
ttatcgtgaa ggctgagctg 20

<210> SEQ ID NO 67  
<211> LENGTH: 20  
<212> TYPE: DNA  
<213> ORGANISM: Artificial Sequence  
<220> FEATURE:  
<223> OTHER INFORMATION: Description of Artificial Sequence: Synthetic  
oligonucleotide

<400> SEQUENCE: 67  
ttatcgtaaa ggctgagctg 20

<210> SEQ ID NO 68  
<211> LENGTH: 20  
<212> TYPE: DNA  
<213> ORGANISM: Artificial Sequence  
<220> FEATURE:  
<223> OTHER INFORMATION: Description of Artificial Sequence: Synthetic  
oligonucleotide

<400> SEQUENCE: 68  
tgataccaat ggtatcagtg 20

<210> SEQ ID NO 69  
<211> LENGTH: 21  
<212> TYPE: DNA  
<213> ORGANISM: Artificial Sequence  
<220> FEATURE:  
<223> OTHER INFORMATION: Description of Artificial Sequence: Synthetic  
oligonucleotide

<400> SEQUENCE: 69  
tgataccgaa tggatcagtg g 21

<210> SEQ ID NO 70  
<211> LENGTH: 20  
<212> TYPE: DNA  
<213> ORGANISM: Artificial Sequence  
<220> FEATURE:  
<223> OTHER INFORMATION: Description of Artificial Sequence: Synthetic  
oligonucleotide

<400> SEQUENCE: 70

-continued

---

agctcttaat ccattcgctc 20

<210> SEQ ID NO 71  
 <211> LENGTH: 20  
 <212> TYPE: DNA  
 <213> ORGANISM: Artificial Sequence  
 <220> FEATURE:  
 <223> OTHER INFORMATION: Description of Artificial Sequence: Synthetic  
 oligonucleotide

<400> SEQUENCE: 71

agctctcaat ccattcgctc 20

<210> SEQ ID NO 72  
 <211> LENGTH: 20  
 <212> TYPE: DNA  
 <213> ORGANISM: Artificial Sequence  
 <220> FEATURE:  
 <223> OTHER INFORMATION: Description of Artificial Sequence: Synthetic  
 oligonucleotide

<400> SEQUENCE: 72

taacttcata agagcaagct 20

<210> SEQ ID NO 73  
 <211> LENGTH: 20  
 <212> TYPE: DNA  
 <213> ORGANISM: Artificial Sequence  
 <220> FEATURE:  
 <223> OTHER INFORMATION: Description of Artificial Sequence: Synthetic  
 oligonucleotide

<400> SEQUENCE: 73

taacttcttg agagcaagct 20

<210> SEQ ID NO 74  
 <211> LENGTH: 20  
 <212> TYPE: DNA  
 <213> ORGANISM: Artificial Sequence  
 <220> FEATURE:  
 <223> OTHER INFORMATION: Description of Artificial Sequence: Synthetic  
 oligonucleotide

<400> SEQUENCE: 74

ccgctaactt cataagagca 20

<210> SEQ ID NO 75  
 <211> LENGTH: 20  
 <212> TYPE: DNA  
 <213> ORGANISM: Artificial Sequence  
 <220> FEATURE:  
 <223> OTHER INFORMATION: Description of Artificial Sequence: Synthetic  
 oligonucleotide

<400> SEQUENCE: 75

ccgctaactt cttgagagca 20

<210> SEQ ID NO 76  
 <211> LENGTH: 20  
 <212> TYPE: DNA  
 <213> ORGANISM: Artificial Sequence  
 <220> FEATURE:  
 <223> OTHER INFORMATION: Description of Artificial Sequence: Synthetic  
 oligonucleotide

<400> SEQUENCE: 76

-continued

---

gaaccatgcg gttcaaaatg 20

<210> SEQ ID NO 77  
 <211> LENGTH: 20  
 <212> TYPE: DNA  
 <213> ORGANISM: Artificial Sequence  
 <220> FEATURE:  
 <223> OTHER INFORMATION: Description of Artificial Sequence: Synthetic  
 oligonucleotide

<400> SEQUENCE: 77

gaaccatgca gttcaaaatg 20

<210> SEQ ID NO 78  
 <211> LENGTH: 20  
 <212> TYPE: DNA  
 <213> ORGANISM: Artificial Sequence  
 <220> FEATURE:  
 <223> OTHER INFORMATION: Description of Artificial Sequence: Synthetic  
 oligonucleotide

<400> SEQUENCE: 78

gaaccatgcg gttcaaaatg 20

<210> SEQ ID NO 79  
 <211> LENGTH: 20  
 <212> TYPE: DNA  
 <213> ORGANISM: Artificial Sequence  
 <220> FEATURE:  
 <223> OTHER INFORMATION: Description of Artificial Sequence: Synthetic  
 oligonucleotide

<400> SEQUENCE: 79

gcaccatgcg gtgcaaaatg 20

<210> SEQ ID NO 80  
 <211> LENGTH: 20  
 <212> TYPE: DNA  
 <213> ORGANISM: Artificial Sequence  
 <220> FEATURE:  
 <223> OTHER INFORMATION: Description of Artificial Sequence: Synthetic  
 oligonucleotide

<400> SEQUENCE: 80

caatttcgaa ccatgcggtt 20

<210> SEQ ID NO 81  
 <211> LENGTH: 20  
 <212> TYPE: DNA  
 <213> ORGANISM: Artificial Sequence  
 <220> FEATURE:  
 <223> OTHER INFORMATION: Description of Artificial Sequence: Synthetic  
 oligonucleotide

<400> SEQUENCE: 81

gaatttcgca ccatgcggtg 20

<210> SEQ ID NO 82  
 <211> LENGTH: 20  
 <212> TYPE: DNA  
 <213> ORGANISM: Artificial Sequence  
 <220> FEATURE:  
 <223> OTHER INFORMATION: Description of Artificial Sequence: Synthetic  
 oligonucleotide

<400> SEQUENCE: 82

gcctttcaat ttcgaacct 20

-continued

---

<210> SEQ ID NO 83  
<211> LENGTH: 20  
<212> TYPE: DNA  
<213> ORGANISM: Artificial Sequence  
<220> FEATURE:  
<223> OTHER INFORMATION: Description of Artificial Sequence: Synthetic  
oligonucleotide

<400> SEQUENCE: 83

gcctttgaat ttcgcacat 20

<210> SEQ ID NO 84  
<211> LENGTH: 20  
<212> TYPE: DNA  
<213> ORGANISM: Artificial Sequence  
<220> FEATURE:  
<223> OTHER INFORMATION: Description of Artificial Sequence: Synthetic  
oligonucleotide

<400> SEQUENCE: 84

cgaagccgcc tttcaatttc 20

<210> SEQ ID NO 85  
<211> LENGTH: 20  
<212> TYPE: DNA  
<213> ORGANISM: Artificial Sequence  
<220> FEATURE:  
<223> OTHER INFORMATION: Description of Artificial Sequence: Synthetic  
oligonucleotide

<400> SEQUENCE: 85

cgaagccgcc tttgaatttc 20

<210> SEQ ID NO 86  
<211> LENGTH: 20  
<212> TYPE: DNA  
<213> ORGANISM: Artificial Sequence  
<220> FEATURE:  
<223> OTHER INFORMATION: Description of Artificial Sequence: Synthetic  
oligonucleotide

<400> SEQUENCE: 86

tctagggttg tcagaggatg 20

<210> SEQ ID NO 87  
<211> LENGTH: 20  
<212> TYPE: DNA  
<213> ORGANISM: Artificial Sequence  
<220> FEATURE:  
<223> OTHER INFORMATION: Description of Artificial Sequence: Synthetic  
oligonucleotide

<400> SEQUENCE: 87

tctagggttt tcagaggatg 20

<210> SEQ ID NO 88  
<211> LENGTH: 20  
<212> TYPE: DNA  
<213> ORGANISM: Artificial Sequence  
<220> FEATURE:  
<223> OTHER INFORMATION: Description of Artificial Sequence: Synthetic  
oligonucleotide

<400> SEQUENCE: 88

tctgctcccg aaggagaagc 20

-continued

---

```

<210> SEQ ID NO 89
<211> LENGTH: 20
<212> TYPE: DNA
<213> ORGANISM: Artificial Sequence
<220> FEATURE:
<223> OTHER INFORMATION: Description of Artificial Sequence: Synthetic
      oligonucleotide

<400> SEQUENCE: 89

tctgcccccg aaggggaagc                20

<210> SEQ ID NO 90
<211> LENGTH: 20
<212> TYPE: DNA
<213> ORGANISM: Artificial Sequence
<220> FEATURE:
<223> OTHER INFORMATION: Description of Artificial Sequence: Synthetic
      oligonucleotide

<400> SEQUENCE: 90

cagctcagcc ttcacgataa                20

<210> SEQ ID NO 91
<211> LENGTH: 20
<212> TYPE: DNA
<213> ORGANISM: Artificial Sequence
<220> FEATURE:
<223> OTHER INFORMATION: Description of Artificial Sequence: Synthetic
      oligonucleotide

<400> SEQUENCE: 91

cagctcagcc tttacgataa                20

<210> SEQ ID NO 92
<211> LENGTH: 20
<212> TYPE: DNA
<213> ORGANISM: Artificial Sequence
<220> FEATURE:
<223> OTHER INFORMATION: Description of Artificial Sequence: Synthetic
      oligonucleotide

<400> SEQUENCE: 92

cactgatacc attggtatca                20

<210> SEQ ID NO 93
<211> LENGTH: 21
<212> TYPE: DNA
<213> ORGANISM: Artificial Sequence
<220> FEATURE:
<223> OTHER INFORMATION: Description of Artificial Sequence: Synthetic
      oligonucleotide

<400> SEQUENCE: 93

cactgatacc attcggtatc a                21

<210> SEQ ID NO 94
<211> LENGTH: 20
<212> TYPE: DNA
<213> ORGANISM: Artificial Sequence
<220> FEATURE:
<223> OTHER INFORMATION: Description of Artificial Sequence: Synthetic
      oligonucleotide

<400> SEQUENCE: 94

cggctcttgca gctctttgta                20

```



-continued

---

```

<211> LENGTH: 20
<212> TYPE: DNA
<213> ORGANISM: Artificial Sequence
<220> FEATURE:
<223> OTHER INFORMATION: Description of Artificial Sequence: Synthetic
      oligonucleotide

<400> SEQUENCE: 101
ggattagata ccctggtagt                20

<210> SEQ ID NO 102
<211> LENGTH: 20
<212> TYPE: DNA
<213> ORGANISM: Artificial Sequence
<220> FEATURE:
<223> OTHER INFORMATION: Description of Artificial Sequence: Synthetic
      oligonucleotide

<400> SEQUENCE: 102
ccgtcaattc cttraggttt                20

<210> SEQ ID NO 103
<211> LENGTH: 21
<212> TYPE: DNA
<213> ORGANISM: Artificial Sequence
<220> FEATURE:
<223> OTHER INFORMATION: Description of Artificial Sequence: Synthetic
      oligonucleotide

<400> SEQUENCE: 103
ttcgggagca gactgacagg t              21

<210> SEQ ID NO 104
<211> LENGTH: 21
<212> TYPE: DNA
<213> ORGANISM: Artificial Sequence
<220> FEATURE:
<223> OTHER INFORMATION: Description of Artificial Sequence: Synthetic
      oligonucleotide

<400> SEQUENCE: 104
tacacaccgc ccgtcacacc a              21

<210> SEQ ID NO 105
<211> LENGTH: 15
<212> TYPE: DNA
<213> ORGANISM: Artificial Sequence
<220> FEATURE:
<223> OTHER INFORMATION: Description of Artificial Sequence: Synthetic
      oligonucleotide

<400> SEQUENCE: 105
rgtgagcrtt tacgc                      15

<210> SEQ ID NO 106
<211> LENGTH: 16
<212> TYPE: DNA
<213> ORGANISM: Artificial Sequence
<220> FEATURE:
<223> OTHER INFORMATION: Description of Artificial Sequence: Synthetic
      oligonucleotide

<400> SEQUENCE: 106
ccgaatgggg vaacct                    16

<210> SEQ ID NO 107
<211> LENGTH: 21

```

-continued

---

```

<212> TYPE: DNA
<213> ORGANISM: Artificial Sequence
<220> FEATURE:
<223> OTHER INFORMATION: Description of Artificial Sequence: Synthetic
      oligonucleotide

<400> SEQUENCE: 107
ccgtttcgct cgccgctact c                               21

<210> SEQ ID NO 108
<211> LENGTH: 21
<212> TYPE: DNA
<213> ORGANISM: Artificial Sequence
<220> FEATURE:
<223> OTHER INFORMATION: Description of Artificial Sequence: Synthetic
      oligonucleotide

<400> SEQUENCE: 108
tagtgatcga tagtgaacca g                               21

<210> SEQ ID NO 109
<211> LENGTH: 19
<212> TYPE: DNA
<213> ORGANISM: Artificial Sequence
<220> FEATURE:
<223> OTHER INFORMATION: Description of Artificial Sequence: Synthetic
      oligonucleotide

<400> SEQUENCE: 109
cattmtacaa aaggyacgc                               19

<210> SEQ ID NO 110
<211> LENGTH: 19
<212> TYPE: DNA
<213> ORGANISM: Artificial Sequence
<220> FEATURE:
<223> OTHER INFORMATION: Description of Artificial Sequence: Synthetic
      oligonucleotide

<400> SEQUENCE: 110
gcgtrccttt tgtakaatg                               19

<210> SEQ ID NO 111
<211> LENGTH: 21
<212> TYPE: DNA
<213> ORGANISM: Artificial Sequence
<220> FEATURE:
<223> OTHER INFORMATION: Description of Artificial Sequence: Synthetic
      oligonucleotide

<400> SEQUENCE: 111
tagtgatcga tagtgaacca g                               21

<210> SEQ ID NO 112
<211> LENGTH: 21
<212> TYPE: DNA
<213> ORGANISM: Artificial Sequence
<220> FEATURE:
<223> OTHER INFORMATION: Description of Artificial Sequence: Synthetic
      oligonucleotide

<400> SEQUENCE: 112
tagtgatcga tagtgaacca g                               21

<210> SEQ ID NO 113
<211> LENGTH: 15
<212> TYPE: DNA

```

-continued

---

```

<213> ORGANISM: Artificial Sequence
<220> FEATURE:
<223> OTHER INFORMATION: Description of Artificial Sequence: Synthetic
      oligonucleotide

<400> SEQUENCE: 113

rgtgagctrt tacgc                                     15

<210> SEQ ID NO 114
<211> LENGTH: 15
<212> TYPE: DNA
<213> ORGANISM: Artificial Sequence
<220> FEATURE:
<223> OTHER INFORMATION: Description of Artificial Sequence: Synthetic
      oligonucleotide

<400> SEQUENCE: 114

wgcgtaayag ctcac                                     15

<210> SEQ ID NO 115
<211> LENGTH: 20
<212> TYPE: DNA
<213> ORGANISM: Artificial Sequence
<220> FEATURE:
<223> OTHER INFORMATION: Description of Artificial Sequence: Synthetic
      oligonucleotide

<400> SEQUENCE: 115

cataccggca ttctcacttc                               20

<210> SEQ ID NO 116
<211> LENGTH: 19
<212> TYPE: DNA
<213> ORGANISM: Artificial Sequence
<220> FEATURE:
<223> OTHER INFORMATION: Description of Artificial Sequence: Synthetic
      oligonucleotide

<400> SEQUENCE: 116

acagggctag gcgatggac                               19

<210> SEQ ID NO 117
<211> LENGTH: 17
<212> TYPE: DNA
<213> ORGANISM: Artificial Sequence
<220> FEATURE:
<223> OTHER INFORMATION: Description of Artificial Sequence: Synthetic
      oligonucleotide

<400> SEQUENCE: 117

aacctttggg cgctcc                                   17

<210> SEQ ID NO 118
<211> LENGTH: 16
<212> TYPE: DNA
<213> ORGANISM: Artificial Sequence
<220> FEATURE:
<223> OTHER INFORMATION: Description of Artificial Sequence: Synthetic
      oligonucleotide

<400> SEQUENCE: 118

cyacctgtgw cggttt                                   16

<210> SEQ ID NO 119
<211> LENGTH: 16
<212> TYPE: DNA
<213> ORGANISM: Artificial Sequence

```

-continued

---

```

<220> FEATURE:
<223> OTHER INFORMATION: Description of Artificial Sequence: Synthetic
      oligonucleotide

<400> SEQUENCE: 119
aaaccgwcac aggtrg                                     16

<210> SEQ ID NO 120
<211> LENGTH: 17
<212> TYPE: DNA
<213> ORGANISM: Artificial Sequence
<220> FEATURE:
<223> OTHER INFORMATION: Description of Artificial Sequence: Synthetic
      oligonucleotide

<400> SEQUENCE: 120
cayggggtct ttrcgtc                                     17

<210> SEQ ID NO 121
<211> LENGTH: 17
<212> TYPE: DNA
<213> ORGANISM: Artificial Sequence
<220> FEATURE:
<223> OTHER INFORMATION: Description of Artificial Sequence: Synthetic
      oligonucleotide

<400> SEQUENCE: 121
gacgyaaaga ccccrtg                                     17

<210> SEQ ID NO 122
<211> LENGTH: 15
<212> TYPE: DNA
<213> ORGANISM: Artificial Sequence
<220> FEATURE:
<223> OTHER INFORMATION: Description of Artificial Sequence: Synthetic
      oligonucleotide

<400> SEQUENCE: 122
gagycgacat cgagg                                       15

<210> SEQ ID NO 123
<211> LENGTH: 15
<212> TYPE: DNA
<213> ORGANISM: Artificial Sequence
<220> FEATURE:
<223> OTHER INFORMATION: Description of Artificial Sequence: Synthetic
      oligonucleotide

<400> SEQUENCE: 123
cctcgatgtc grctc                                       15

<210> SEQ ID NO 124
<211> LENGTH: 14
<212> TYPE: DNA
<213> ORGANISM: Artificial Sequence
<220> FEATURE:
<223> OTHER INFORMATION: Description of Artificial Sequence: Synthetic
      oligonucleotide

<400> SEQUENCE: 124
gyttagatgc yttc                                        14

<210> SEQ ID NO 125
<211> LENGTH: 19
<212> TYPE: DNA
<213> ORGANISM: Artificial Sequence
<220> FEATURE:

```

-continued

---

<223> OTHER INFORMATION: Description of Artificial Sequence: Synthetic oligonucleotide

<400> SEQUENCE: 125

ggcggcgtcc tactctcac 19

<210> SEQ ID NO 126  
 <211> LENGTH: 20  
 <212> TYPE: DNA  
 <213> ORGANISM: Artificial Sequence  
 <220> FEATURE:  
 <223> OTHER INFORMATION: Description of Artificial Sequence: Synthetic oligonucleotide

<400> SEQUENCE: 126

tttgggctat gttccgtttc 20

<210> SEQ ID NO 127  
 <211> LENGTH: 20  
 <212> TYPE: DNA  
 <213> ORGANISM: Artificial Sequence  
 <220> FEATURE:  
 <223> OTHER INFORMATION: Description of Artificial Sequence: Synthetic oligonucleotide

<400> SEQUENCE: 127

tttgggctag attccgtttc 20

<210> SEQ ID NO 128  
 <211> LENGTH: 20  
 <212> TYPE: DNA  
 <213> ORGANISM: Artificial Sequence  
 <220> FEATURE:  
 <223> OTHER INFORMATION: Description of Artificial Sequence: Synthetic oligonucleotide

<400> SEQUENCE: 128

tacggggttg ttaccctcta 20

<210> SEQ ID NO 129  
 <211> LENGTH: 20  
 <212> TYPE: DNA  
 <213> ORGANISM: Artificial Sequence  
 <220> FEATURE:  
 <223> OTHER INFORMATION: Description of Artificial Sequence: Synthetic oligonucleotide

<400> SEQUENCE: 129

tacggggtta ttaccctcta 20

<210> SEQ ID NO 130  
 <211> LENGTH: 20  
 <212> TYPE: DNA  
 <213> ORGANISM: Artificial Sequence  
 <220> FEATURE:  
 <223> OTHER INFORMATION: Description of Artificial Sequence: Synthetic oligonucleotide

<400> SEQUENCE: 130

ctacggggtt gttaccctct 20

<210> SEQ ID NO 131  
 <211> LENGTH: 20  
 <212> TYPE: DNA  
 <213> ORGANISM: Artificial Sequence  
 <220> FEATURE:  
 <223> OTHER INFORMATION: Description of Artificial Sequence: Synthetic

-continued

---

oligonucleotide

<400> SEQUENCE: 131

ctacggggtt attaccctct 20

<210> SEQ ID NO 132  
 <211> LENGTH: 20  
 <212> TYPE: DNA  
 <213> ORGANISM: Artificial Sequence  
 <220> FEATURE:  
 <223> OTHER INFORMATION: Description of Artificial Sequence: Synthetic  
 oligonucleotide

<400> SEQUENCE: 132

tcttatgggc aggttaccca 20

<210> SEQ ID NO 133  
 <211> LENGTH: 20  
 <212> TYPE: DNA  
 <213> ORGANISM: Artificial Sequence  
 <220> FEATURE:  
 <223> OTHER INFORMATION: Description of Artificial Sequence: Synthetic  
 oligonucleotide

<400> SEQUENCE: 133

tccttatgggt aggttaccca 20

<210> SEQ ID NO 134  
 <211> LENGTH: 20  
 <212> TYPE: DNA  
 <213> ORGANISM: Artificial Sequence  
 <220> FEATURE:  
 <223> OTHER INFORMATION: Description of Artificial Sequence: Synthetic  
 oligonucleotide

<400> SEQUENCE: 134

acgcatcggt gccttggtga 20

<210> SEQ ID NO 135  
 <211> LENGTH: 20  
 <212> TYPE: DNA  
 <213> ORGANISM: Artificial Sequence  
 <220> FEATURE:  
 <223> OTHER INFORMATION: Description of Artificial Sequence: Synthetic  
 oligonucleotide

<400> SEQUENCE: 135

acgcatcgtc gccttggtga 20

<210> SEQ ID NO 136  
 <211> LENGTH: 20  
 <212> TYPE: DNA  
 <213> ORGANISM: Artificial Sequence  
 <220> FEATURE:  
 <223> OTHER INFORMATION: Description of Artificial Sequence: Synthetic  
 oligonucleotide

<400> SEQUENCE: 136

catcggtgcc ttggtgagcc 20

<210> SEQ ID NO 137  
 <211> LENGTH: 20  
 <212> TYPE: DNA  
 <213> ORGANISM: Artificial Sequence  
 <220> FEATURE:  
 <223> OTHER INFORMATION: Description of Artificial Sequence: Synthetic  
 oligonucleotide

---

-continued

---

<400> SEQUENCE: 137  
catcgtcgcc ttggtgagcc 20

<210> SEQ ID NO 138  
<211> LENGTH: 20  
<212> TYPE: DNA  
<213> ORGANISM: Artificial Sequence  
<220> FEATURE:  
<223> OTHER INFORMATION: Description of Artificial Sequence: Synthetic  
oligonucleotide

<400> SEQUENCE: 138  
gcggtggct ccaaaaaggt 20

<210> SEQ ID NO 139  
<211> LENGTH: 20  
<212> TYPE: DNA  
<213> ORGANISM: Artificial Sequence  
<220> FEATURE:  
<223> OTHER INFORMATION: Description of Artificial Sequence: Synthetic  
oligonucleotide

<400> SEQUENCE: 139  
gctggctgc ccataaaggt 20

<210> SEQ ID NO 140  
<211> LENGTH: 20  
<212> TYPE: DNA  
<213> ORGANISM: Artificial Sequence  
<220> FEATURE:  
<223> OTHER INFORMATION: Description of Artificial Sequence: Synthetic  
oligonucleotide

<400> SEQUENCE: 140  
ggctggctcc aaaaagggtta 20

<210> SEQ ID NO 141  
<211> LENGTH: 20  
<212> TYPE: DNA  
<213> ORGANISM: Artificial Sequence  
<220> FEATURE:  
<223> OTHER INFORMATION: Description of Artificial Sequence: Synthetic  
oligonucleotide

<400> SEQUENCE: 141  
ggctggctcc ataaagggtta 20

<210> SEQ ID NO 142  
<211> LENGTH: 20  
<212> TYPE: DNA  
<213> ORGANISM: Artificial Sequence  
<220> FEATURE:  
<223> OTHER INFORMATION: Description of Artificial Sequence: Synthetic  
oligonucleotide

<400> SEQUENCE: 142  
ccctctacga cggaccttc 20

<210> SEQ ID NO 143  
<211> LENGTH: 20  
<212> TYPE: DNA  
<213> ORGANISM: Artificial Sequence  
<220> FEATURE:  
<223> OTHER INFORMATION: Description of Artificial Sequence: Synthetic  
oligonucleotide

-continued

---

<400> SEQUENCE: 143  
ccctctgtga cgagcctttc 20

<210> SEQ ID NO 144  
<211> LENGTH: 20  
<212> TYPE: DNA  
<213> ORGANISM: Artificial Sequence  
<220> FEATURE:  
<223> OTHER INFORMATION: Description of Artificial Sequence: Synthetic  
oligonucleotide

<400> SEQUENCE: 144  
tttccaggtc gcttcgtcta 20

<210> SEQ ID NO 145  
<211> LENGTH: 20  
<212> TYPE: DNA  
<213> ORGANISM: Artificial Sequence  
<220> FEATURE:  
<223> OTHER INFORMATION: Description of Artificial Sequence: Synthetic  
oligonucleotide

<400> SEQUENCE: 145  
tttccaggct gcttcgtcta 20

<210> SEQ ID NO 146  
<211> LENGTH: 20  
<212> TYPE: DNA  
<213> ORGANISM: Artificial Sequence  
<220> FEATURE:  
<223> OTHER INFORMATION: Description of Artificial Sequence: Synthetic  
oligonucleotide

<400> SEQUENCE: 146  
ccggtttcaa aggctcccgc 20

<210> SEQ ID NO 147  
<211> LENGTH: 20  
<212> TYPE: DNA  
<213> ORGANISM: Artificial Sequence  
<220> FEATURE:  
<223> OTHER INFORMATION: Description of Artificial Sequence: Synthetic  
oligonucleotide

<400> SEQUENCE: 147  
ccggcttcaa tggctcccgc 20

<210> SEQ ID NO 148  
<211> LENGTH: 20  
<212> TYPE: DNA  
<213> ORGANISM: Artificial Sequence  
<220> FEATURE:  
<223> OTHER INFORMATION: Description of Artificial Sequence: Synthetic  
oligonucleotide

<400> SEQUENCE: 148  
gaccctagt ccaatcagt 20

<210> SEQ ID NO 149  
<211> LENGTH: 20  
<212> TYPE: DNA  
<213> ORGANISM: Artificial Sequence  
<220> FEATURE:  
<223> OTHER INFORMATION: Description of Artificial Sequence: Synthetic  
oligonucleotide

<400> SEQUENCE: 149

-continued

---

gaccacctagt tcaatcagtg 20

<210> SEQ ID NO 150  
 <211> LENGTH: 20  
 <212> TYPE: DNA  
 <213> ORGANISM: Artificial Sequence  
 <220> FEATURE:  
 <223> OTHER INFORMATION: Description of Artificial Sequence: Synthetic  
 oligonucleotide

<400> SEQUENCE: 150

ggtatcaatc cgcagcttcg 20

<210> SEQ ID NO 151  
 <211> LENGTH: 20  
 <212> TYPE: DNA  
 <213> ORGANISM: Artificial Sequence  
 <220> FEATURE:  
 <223> OTHER INFORMATION: Description of Artificial Sequence: Synthetic  
 oligonucleotide

<400> SEQUENCE: 151

ggtatcaatt cgcagcttcg 20

<210> SEQ ID NO 152  
 <211> LENGTH: 20  
 <212> TYPE: DNA  
 <213> ORGANISM: Artificial Sequence  
 <220> FEATURE:  
 <223> OTHER INFORMATION: Description of Artificial Sequence: Synthetic  
 oligonucleotide

<400> SEQUENCE: 152

acttctaagc actccaccag 20

<210> SEQ ID NO 153  
 <211> LENGTH: 20  
 <212> TYPE: DNA  
 <213> ORGANISM: Artificial Sequence  
 <220> FEATURE:  
 <223> OTHER INFORMATION: Description of Artificial Sequence: Synthetic  
 oligonucleotide

<400> SEQUENCE: 153

acttctaagc gctccaccag 20

<210> SEQ ID NO 154  
 <211> LENGTH: 20  
 <212> TYPE: DNA  
 <213> ORGANISM: Artificial Sequence  
 <220> FEATURE:  
 <223> OTHER INFORMATION: Description of Artificial Sequence: Synthetic  
 oligonucleotide

<400> SEQUENCE: 154

tcacttctaa gcactccacc 20

<210> SEQ ID NO 155  
 <211> LENGTH: 20  
 <212> TYPE: DNA  
 <213> ORGANISM: Artificial Sequence  
 <220> FEATURE:  
 <223> OTHER INFORMATION: Description of Artificial Sequence: Synthetic  
 oligonucleotide

<400> SEQUENCE: 155

-continued

---

tcacttctaa gcgctccacc	20
<210> SEQ ID NO 156 <211> LENGTH: 20 <212> TYPE: DNA <213> ORGANISM: Artificial Sequence <220> FEATURE: <223> OTHER INFORMATION: Description of Artificial Sequence: Synthetic oligonucleotide <400> SEQUENCE: 156	
atgtattcag ataaggatac	20
<210> SEQ ID NO 157 <211> LENGTH: 20 <212> TYPE: DNA <213> ORGANISM: Artificial Sequence <220> FEATURE: <223> OTHER INFORMATION: Description of Artificial Sequence: Synthetic oligonucleotide <400> SEQUENCE: 157	
atgtattcag gtaaggatac	20
<210> SEQ ID NO 158 <211> LENGTH: 20 <212> TYPE: DNA <213> ORGANISM: Artificial Sequence <220> FEATURE: <223> OTHER INFORMATION: Description of Artificial Sequence: Synthetic oligonucleotide <400> SEQUENCE: 158	
ataccattgg tatcaatccg	20
<210> SEQ ID NO 159 <211> LENGTH: 20 <212> TYPE: DNA <213> ORGANISM: Artificial Sequence <220> FEATURE: <223> OTHER INFORMATION: Description of Artificial Sequence: Synthetic oligonucleotide <400> SEQUENCE: 159	
taccattcgg tatcaatccg	20
<210> SEQ ID NO 160 <211> LENGTH: 20 <212> TYPE: DNA <213> ORGANISM: Artificial Sequence <220> FEATURE: <223> OTHER INFORMATION: Description of Artificial Sequence: Synthetic oligonucleotide <400> SEQUENCE: 160	
taccattggt atcaatccgc	20
<210> SEQ ID NO 161 <211> LENGTH: 20 <212> TYPE: DNA <213> ORGANISM: Artificial Sequence <220> FEATURE: <223> OTHER INFORMATION: Description of Artificial Sequence: Synthetic oligonucleotide <400> SEQUENCE: 161	
accattcgggt atcaatccgc	20

-continued

---

<210> SEQ ID NO 162  
<211> LENGTH: 20  
<212> TYPE: DNA  
<213> ORGANISM: Artificial Sequence  
<220> FEATURE:  
<223> OTHER INFORMATION: Description of Artificial Sequence: Synthetic  
oligonucleotide

<400> SEQUENCE: 162

gctcagcctt cacgataagc 20

<210> SEQ ID NO 163  
<211> LENGTH: 20  
<212> TYPE: DNA  
<213> ORGANISM: Artificial Sequence  
<220> FEATURE:  
<223> OTHER INFORMATION: Description of Artificial Sequence: Synthetic  
oligonucleotide

<400> SEQUENCE: 163

gctcagcctt tacgataagc 20

<210> SEQ ID NO 164  
<211> LENGTH: 20  
<212> TYPE: DNA  
<213> ORGANISM: Artificial Sequence  
<220> FEATURE:  
<223> OTHER INFORMATION: Description of Artificial Sequence: Synthetic  
oligonucleotide

<400> SEQUENCE: 164

gaaccatgcg gttcaaaatg 20

<210> SEQ ID NO 165  
<211> LENGTH: 20  
<212> TYPE: DNA  
<213> ORGANISM: Artificial Sequence  
<220> FEATURE:  
<223> OTHER INFORMATION: Description of Artificial Sequence: Synthetic  
oligonucleotide

<400> SEQUENCE: 165

cattacgtat ggtgggtttc 20

<210> SEQ ID NO 166  
<211> LENGTH: 20  
<212> TYPE: DNA  
<213> ORGANISM: Artificial Sequence  
<220> FEATURE:  
<223> OTHER INFORMATION: Description of Artificial Sequence: Synthetic  
oligonucleotide

<400> SEQUENCE: 166

cattacgtat agtgggtttc 20

<210> SEQ ID NO 167  
<211> LENGTH: 20  
<212> TYPE: DNA  
<213> ORGANISM: Artificial Sequence  
<220> FEATURE:  
<223> OTHER INFORMATION: Description of Artificial Sequence: Synthetic  
oligonucleotide

<400> SEQUENCE: 167

tctgtcttcc ttaccctatg 20

-continued

---

<210> SEQ ID NO 168  
<211> LENGTH: 20  
<212> TYPE: DNA  
<213> ORGANISM: Artificial Sequence  
<220> FEATURE:  
<223> OTHER INFORMATION: Description of Artificial Sequence: Synthetic  
oligonucleotide

<400> SEQUENCE: 168

tctgtcttcc ataccctatg 20

<210> SEQ ID NO 169  
<211> LENGTH: 20  
<212> TYPE: DNA  
<213> ORGANISM: Artificial Sequence  
<220> FEATURE:  
<223> OTHER INFORMATION: Description of Artificial Sequence: Synthetic  
oligonucleotide

<400> SEQUENCE: 169

gccatcaccc gttaacgggc 20

<210> SEQ ID NO 170  
<211> LENGTH: 20  
<212> TYPE: DNA  
<213> ORGANISM: Artificial Sequence  
<220> FEATURE:  
<223> OTHER INFORMATION: Description of Artificial Sequence: Synthetic  
oligonucleotide

<400> SEQUENCE: 170

gccatcaccc attaacgggc 20

<210> SEQ ID NO 171  
<211> LENGTH: 20  
<212> TYPE: DNA  
<213> ORGANISM: Artificial Sequence  
<220> FEATURE:  
<223> OTHER INFORMATION: Description of Artificial Sequence: Synthetic  
oligonucleotide

<400> SEQUENCE: 171

acgccatcac ccgtaacgg 20

<210> SEQ ID NO 172  
<211> LENGTH: 20  
<212> TYPE: DNA  
<213> ORGANISM: Artificial Sequence  
<220> FEATURE:  
<223> OTHER INFORMATION: Description of Artificial Sequence: Synthetic  
oligonucleotide

<400> SEQUENCE: 172

acgccatcac ccattaacgg 20

<210> SEQ ID NO 173  
<211> LENGTH: 20  
<212> TYPE: DNA  
<213> ORGANISM: Artificial Sequence  
<220> FEATURE:  
<223> OTHER INFORMATION: Description of Artificial Sequence: Synthetic  
oligonucleotide

<400> SEQUENCE: 173

caactagcac ttgttcttcc 20

-continued

```

<210> SEQ ID NO 174
<211> LENGTH: 20
<212> TYPE: DNA
<213> ORGANISM: Artificial Sequence
<220> FEATURE:
<223> OTHER INFORMATION: Description of Artificial Sequence: Synthetic
      oligonucleotide

<400> SEQUENCE: 174

acagatttgt gggattggct                                20

<210> SEQ ID NO 175
<211> LENGTH: 20
<212> TYPE: DNA
<213> ORGANISM: Artificial Sequence
<220> FEATURE:
<223> OTHER INFORMATION: Description of Artificial Sequence: Synthetic
      oligonucleotide

<400> SEQUENCE: 175

gatgatgatg atgatgatga                                20
    
```

We claim:

1. A microarray comprising an oligonucleotide probe comprising the sequence set forth in SEQ ID NO:143, wherein the microarray further comprises one or more oligonucleotide probes selected from the group consisting of SEQ ID NOS: 70-95 and 126-175.
2. The microarray of claim 1, wherein the oligonucleotides are arranged in a specific pattern wherein I, II, III and IV are columns and A, B, C, D, E, and F are rows in the microarray:

	I	II	III	IV
A	(SEQ ID NO: 88)	(SEQ ID NO: 89)	(SEQ ID NO: 76)	(SEQ ID NO: 77)
B	(SEQ ID NO: 84)	(SEQ ID NO: 85)	(SEQ ID NO: 72)	(SEQ ID NO: 73)
C	(SEQ ID NO: 78)	(SEQ ID NO: 79)	(SEQ ID NO: 74)	(SEQ ID NO: 75)
D	(SEQ ID NO: 82)	(SEQ ID NO: 83)	(SEQ ID NO: 70)	(SEQ ID NO: 71)
E	(SEQ ID NO: 80)	(SEQ ID NO: 81)		
F	(SEQ ID NO: 142)	(SEQ ID NO: 143)	(SEQ ID NO: 86)	(SEQ ID NO: 87)

3. A microarray as in claim 1, wherein the oligonucleotides are arranged in pairs: ps19 (SEQ ID NO: 88) and ps20 (SEQ ID NO: 89); ps5 (SEQ ID NO: 74) and ps6 (SEQ ID NO: 75); ps17 (SEQ ID NO: 86) and ps18 (SEQ ID NO: 87).
4. A diagnostic kit to detect *B. anthracis* target rRNA in a sample, the diagnostic kit comprising the microarray of claim 1.
5. A method for detecting an isolate of a *B. cereus* group, in a sample, the method comprising:
  - (a) placing on a microarray of claim 1, oligonucleotide probes targeted to rRNA sequences wherein at least one mismatch is sufficient to discriminate among the *B. cereus* subgroups;
  - (b) providing conditions for hybridization of the probes with rRNA from the sample; and
  - (c) analyzing hybridization signals in the microarray from which the particular isolate is detected.

6. The method of claim 5, wherein the oligonucleotide probes are directed to 16S rRNA and 23S rRNA.
7. The method of claim 5, wherein the probes are labeled.
8. The method of claim 7, wherein the labels are selected from the group consisting of fluorescent dyes, radio isotopes, immunological labels, immuno-chemical labels and gold particles.
9. The method of claim 5, wherein the oligonucleotide probes discriminate one or more subgroups *Anthraxis*,

10. The method of claim 5, wherein pairs of oligonucleotide probes that discriminate subgroups *Anthraxis* from *Cereus A* are ps21 (SEQ ID NO: 90)/ps22 (SEQ ID NO: 91).
11. The method of claim 5, wherein a ratio of hybridization signals of oligonucleotide probes ps17 (SEQ ID NO: 86) and ps18 (SEQ ID NO: 87) discriminates between *B. anthracis* Ames and *B. cereus* 9620.
12. The method of claim 5, wherein the oligonucleotide probes ps21 (SEQ ID NO: 90) and ps22 (SEQ ID NO: 91) discriminate *B. anthracis* Sterne from *B. cereus* HER 1414 and *B. thuringensis* B8.
13. The method of claim 5, wherein the oligonucleotide probes are ps7, ps8, and ps9 to discriminate *B. thuringensis* 4Q281 from other *B. cereus* subgroup isolates.
14. An isolated oligonucleotide probe comprising the sequence of SEQ ID NO: 143.

93

15. A method for taxonomically classifying *B. cereus* groups, said method comprising:

- (a) developing strain- and subgroup-specific signature profiles of 16S and 23S rRNA sequences for *B. cereus* group isolates including subgroup *Mycoides* B, wherein the *Mycoides* B subgroup is differentiated by SEQ ID NO: 143 from other subgroups; and

94

- (b) using the signature profiles to construct phylogenetic trees in order to classify the various *B. cereus* group isolates.

\* \* \* \* \*