



US 20160152694A1

(19) **United States**

(12) **Patent Application Publication**
AMBROSINO et al.

(10) **Pub. No.: US 2016/0152694 A1**
(43) **Pub. Date: Jun. 2, 2016**

(54) **ANTIBODIES AGAINST CLOSTRIDIUM DIFFICILE TOXINS AND USES THEREOF**

(71) Applicants: **UNIVERSITY OF MASSACHUSETTS**, Boston, MA (US); **E. R. Squibb & Sons, L.L.C.**, Princeton, NJ (US)

(72) Inventors: **Donna M. AMBROSINO**, Jamaica Plain, MA (US); **Gregory J. BABCOCK**, Marlborough, MA (US); **Teresa BROERING**, Brookline, MA (US); **Robert GRAZIANO**, Frenchtown, NJ (US); **Hector Javier HERNANDEZ**, Canton, MA (US); **Israel LOWY**, Dobbs Ferry, NY (US); **Robert MANDELL**, Collins, IA (US); **Deborah MOLRINE**, Newton, MA (US); **William D. THOMAS, JR.**, Dedham, MA (US); **Hui-Fen ZHANG**, Bridgewater, NJ (US)

(21) Appl. No.: **14/926,706**

(22) Filed: **Oct. 29, 2015**

Related U.S. Application Data

(60) Continuation of application No. 14/080,598, filed on Nov. 14, 2013, now Pat. No. 9,217,029, which is a

division of application No. 13/490,757, filed on Jun. 7, 2012, now Pat. No. 8,609,111, which is a continuation of application No. 12/533,501, filed on Jul. 31, 2009, now Pat. No. 8,236,311, which is a division of application No. 11/051,453, filed on Feb. 4, 2005, now Pat. No. 7,625,559.

(60) Provisional application No. 60/613,854, filed on Sep. 28, 2004, provisional application No. 60/542,357, filed on Feb. 6, 2004.

Publication Classification

(51) **Int. Cl.**
C07K 16/12 (2006.01)
(52) **U.S. Cl.**
CPC **C07K 16/1282** (2013.01); **C07K 2317/565** (2013.01); **C07K 2317/56** (2013.01); **C07K 2317/92** (2013.01); **C07K 2317/76** (2013.01); **A61K 2039/505** (2013.01)

(57) **ABSTRACT**

Antibodies that specifically bind to toxins of *C. difficile*, antigen binding portions thereof, and methods of making and using the antibodies and antigen binding portions thereof are provided herein.

FIG. 1

Amino Acid Sequences of Monoclonal Anti-Toxin A Antibodies Variable Light Chain Regions (L) and Variable Heavy Chain Regions (H)

Clone	chain		Amino Acid Sequence	SEQ ID NO: (SEQ ID NO: without leader sequence)
3D8	L	I	<u>mdmrvpaqlgllllwfpgsr</u> cDIQMTQSPSSVSASVGDRVITTCRASQGISS <u>WLA</u> WYQHKGPKAPKLLIYAASSLQSGVPSRFSGSGSGTDFLTISS <u>LQPEDFATYYCOQANSFPWTFGQGTKVEIK</u>	SEQ ID NO:43 (SEQ ID NO:4)
		II	<u>mdmrvlaqlgllllcfpgarc</u> DIQMTQSPSSLSASVGDRVITTCRASQGISSW <u>A</u> WYQQKPEKAPKSLIYAASSLQSGVPSRFSGSGSGTDFLTISSLQ <u>EDFATYYCQOYNSYPWTFGQGTKVEIK</u>	SEQ ID NO:44 (SEQ ID NO:30)
		III	<u>mdmrvpaqlgllllwfpgsr</u> cVIWMTQSPSLLSASTGDRVITTCRMSOGISSY <u>LA</u> WYQQKPKGKAPPELLIYAASLQSGVPSRFSGSGSGTDFLTISSLQ <u>PEDFATYYCQOYNSYPWTFGQGTKVEIK</u>	SEQ ID NO:45 (SEQ ID NO:31)
		IV	<u>mdmrvpaqlgllllwfpgsr</u> cDIQMTQSPSSVSASVGDRVITTCRASQGISS <u>WLA</u> WYQHKGPKAPKLLIYAASSLQSGVPSRFSGSGSGTDFLTISS <u>LQPEDFATYYCQOYNSYPWTFGQGTKVEIK</u>	SEQ ID NO:46 (SEQ ID NO:32)
		V	<u>mdmrvpaqlgllllcfpgarc</u> DIQMTQSPSSVSASVGDRVITTCRASQGISSW <u>LA</u> WYQQKPEKAPKSLIYAASSLQSGVPSRFSGSGSGTDFLTISSLQ <u>PEDFATYYCQOYNSYPWTFGQGTKVEIK</u>	SEQ ID NO:47 (SEQ ID NO:33)
		VI	<u>mdmrvlaqlgllllcfpgarc</u> DIQMTQSLSSLSASVGDRVITTCRASQGISSW <u>A</u> WYQQKPEKAPKSLIYAASSLQSGVPSRFSGSGSGTDFLTISSLQ <u>EDFATYYCQOANSFPWTFGQGTKVEIK</u>	SEQ ID NO:48 (SEQ ID NO:34)
	H		<u>mefglswvflvllrgvqc</u> QVQLVESGGGVVQPGRSLRLSCEASGFSFNSYQ <u>MHWVRQAPGKGLEWVALIWDGSDNYTDSVKGRFTISRDNKSN</u> <u>TYLQMNLSRAEDTAVYYCARWGMVIRGVIVDFDIWGQGITVTVSS</u>	SEQ ID NO:49 (SEQ ID NO:1)
1B11	L		<u>mcapaqlhllllwlpdttg</u> EIVLTQSPATLSLSPGERATLSCRASQSVSSYLA <u>WYQQKPGQAPRLLIYDASNRATGIPARFSGSGSGTDFLTISSLEPE</u> <u>DFAVYYCQQRNSWSQFTFGPGTKVDIK</u>	SEQ ID NO:50 (SEQ ID NO:5)
		H	<u>mefglswvflvllrgvqc</u> QVQLVESGGGVVQPGRSLRLSCEASGFSFNSYQ <u>MHWVRQAPGKGLEWVSVIWDGSDNYTDSVKGRFTISRDNKSN</u> <u>TYLQMNLSRAEDTAVYYCARANFDYWGQGITLVTVSS</u>	SEQ ID NO:51 (SEQ ID NO:2)
33.3H2	L		<u>mdmrvlaqlgllllcfpgarc</u> DIQMTQSPSSLSASVGDRVITTCRASQGISSW <u>A</u> WYQQKPEKAPKSLIYAASSLQSGVPSRFSGSGSGTDFLTISSLQ <u>EDFATYYCQOYKSYPVTFGGGTKVEIK</u>	SEQ ID NO:52 (SEQ ID NO:6)
		H	<u>mefglswvflvllrgvqc</u> QVQLVESGGGVVQPGRSLRLSCEASGFTFNKY <u>GMIHWVRQAPGKGLEWVAIVYDGTNKKYYADSMKGRFTISRDN</u> <u>KNMLYLQMNLSRAEDTAVYYCARDPPTANYWGQGITLVTVSS</u>	SEQ ID NO:53 (SEQ ID NO:3)

FIG. 2A

Anti-Toxin A 3D8 VK Sequences

V-segment: 1,19
 J-segment: JK1

```

1   D I Q M T Q S P S S V S A S V G D R
    GAC ATC CAG ATG ACC CAG TCT CCA TCT TCC GTG TCT GCA TCT GTA GGA GAC AGA

                                CDR1
55  V T I T C R A S Q G I S S W L A W Y
    GTC ACC ATC ACT TGT CGG GCG AGT CAG GGT ATT AGC AGC TGG TTA GCC TGG TAT

                                CDR2
109 Q H K P G K A P K L L I Y A A S S L
    CAG CAT AAA CCA GGG AAA GCC CCT AAG CTC CTG ATC TAT GCT GCA TCC AGT TTG

    CDR2
163 Q S G V P S R F S G S G S G T D F T
    CAA AGT GGG GTC CCA TCA AGG TTC AGC GGC AGT GGA TCT GGG ACA GAT TTC ACT

                                CDR3
217 L T I S S L Q P E D F A T Y Y C Q Q
    CTC ACC ATC AGC AGC CTG CAG CCT GAA GAT TTT GCA ACT TAC TAT TGT CAA CAG

    CDR3
271 A N S F P W T F G Q G T K V E I K
    GCT AAT AGT TTC CCT TGG ACG TTC GGC CAA GGG ACC AAG GTG GAA ATC AAA

    ↙
    JK1
    
```

Amino acid sequence = SEQ ID NO:4

Nucleic acid sequence = SEQ ID NO:35

FIG. 2B

Anti-Toxin A 3D8 VH Sequences

V-segment: VH3-33

D-segment: D3-10

J-segment: JH3b

```

1      Q V Q L V E S G G G V V Q P G R S L
      CAC CTC CAG CTG GTG GAG TCT GGG CGA GCC CTG CTC CAG CCT GGC AGG TCC CTG

                                CDR1
                                -----
55     R L S C A A S G F S F S N Y G M H W
      AGA CTC TCC TGT GCG GCG TCT GGA TTC AGC TTC AGT AAC TAT GGC ATG CAC TGG

                                CDR2
                                -----
109    V R Q A P S K G L E W V A L I W Y D
      GTC CGC CAG GCT CCA GGC AAG GGG CTG GAG TGG GTC GCA CTT ATA TGG TAT GAT

                                CDR2
                                -----
163    G S N E D Y T D S V K G R F T I S R
      GGA AGT AAT GAG GAC TAT ACA GAC TCC GTG AAG GGC CGA TTC ACC ATC TCC AGA

217    D N S K N T L Y L Q M N S L R A E D
      GAC AAT TCC AAG AAC ACG CTG TAT CTG CAA ATG AAC AGC CTG AGA GCC GAG GAC

                                CDR3
                                -----
271    T A V Y Y C A R W G M V R G V I D V
      ACG GCT GTG TAT TAC TGT GCG AGA TGG GGG ATG GTT CCG GGA GTT ATG GAT GTT
      [D3-10/DXP'1] → JH3b

                                CDR3
                                -----
325    F E I W G Q G T V V T V S S
      TTT GAT ATC TGG GGC CAA GGG ACA GTG GTC ACC GTC TCT TCA
    
```

amino acid sequence=SEQ ID NO:1

nucleic acid sequence=SEQ ID NO:38

FIG. 3A

Anti-Toxin A 1B11 VK Sequences

V-segment: L6
 J-segment: JK3

```

      E I V L T Q S P A T L S L S P G E R
1   GAA ATT GTG TTG ACA CAG TCT CCA GCC ACC CTG TCT TTG TCT CCA GGG GAA AGA

                                CDR1
      A T L S C R A S Q S V S S Y L A W Y
55  GCC ACC CTC TCC TGC AGG GCC AGT CAG AGT GTT AGC AGC TAC TTA GCC TGG TAC

                                CDR2
      Q Q K P G Q A P R L L I Y D A S N R
109 CAA CAG AAA CCT GGC CAG GCT CCC AGG CTC CTC ATC TAT GAT GCA TCC AAC AGG

      CDR2
      A T G I P A R F S G S G S G T D F T
163 GCC ACT GGC ATC CCA GCC AGC TTC AGT GGC AGT GGC TCT GCG ACA GAC TTC ACT

                                CDR3
      L T I S S L E P E D F A V Y Y C Q Q
217 CTC ACC ATC AGC AGC CTA GAG CCT GAA GAT TTT GCA GTT TAT TAC TGT CAG CAG

      CDR3
      R S N W S Q F T F G P G T K V D I K
271 CGT AGC AAC TGG TCT CAA TTC ACT TTC GGC CCT GGG ACC AAA GTG GAT ATC AAA

      L--> JK3
    
```

Amino acid sequence = SEQ ID NO:5
 Nucleic acid sequence = SEQ ID NO:36

FIG. 3B

Anti-Toxin A 1B11 VH Sequences

V-segment: VH3-33
 D-segment: unknown
 J-segment: JH4b

```

1   Q M Q L V E S G G G V V Q P G R S L
    CAG ATG CAG CTG GTG CAG TCT GGG GGC GGC CTG GTC CAG CCT GGG AGG TCC CTG

                                CDR1
                                ~~~~~
55  R L S C E A S G F S F N S Y G M H W
    AGA CTC TCC TGT GAA GCG TCT GGA TTC TCC TTC AAT AGC TAT GGC ATG CAC TGG

                                CDR2
                                ~~~~~
109 V R O A P G K G L E W V S V I W A S
    GTC CGC CAG GCT CCA GGC AAG GGG CTG GAG TGG GTG TCA GTC ATA TGG GCC AGT

                                CDR2
                                ~~~~~
163 G N K K Y Y I E S V E G R F T I S R
    GGA AAT AAG AAA TAT TAT ATA GAA TCC GTG GAG GGC CGA TTC ACC ATC TCC AGA

217 D N S K N T L Y L Q M N S L R A E D
    GAC AAT TCC AAG AAC ACG CTG TAT CTG CAA ATG AAC AGC CTG AGA GCC GAG GAC

                                CDR3
                                ~~~~~
271 T A V Y Y C A R A N F D Y W G Q G T
    ACG GCT GTG TAT TAC TGT GCG AGA GCC AAT TTT CAC TAC TGG GGC CAG GGA ACC

                                JH4b
                                ~~~~~
325 L V T V S S
    CTG GTC ACC GTC TCC TCA
    
```

Amino acid sequence = SEQ ID NO:2

Nucleic acid sequence = SEQ ID NO:39

FIG. 4A

Anti-Toxin A 33.3H2 VK Sequences

V-segment: L15
J-segment: JK4

```
1   D I Q M T Q S P S S L S A S V G D R  
   GAC ATC CAG ATG ACC CAG TCT CCA TCC TCA CTG TCT GCA TCT GTA GGA GAC AGA  
  
                               CDR1  
   -----  
55  V T I T C R A S Q G I S S W L A W Y  
   GTC ACC ATC ACT TGT CCG GCG AGT CAG GGT ATT AGC AGC TGG TTA GCC TGG TAT  
  
                               CDR2  
   -----  
109 Q Q K P E K A P K S L I Y A A S S L  
   CAG CAG AAA CCA GAG AAA GCC CCT AAG TCC CTG ATC TAT GCT GCA TCC AGT TTG  
  
   CDR2  
   -----  
163 Q S G V P S R F S G S G S G T D F T  
   CAA AGT GGG GTC CCA TCA AGG TTC AGC GGC AGT GGA TCT GGG ACA GAT TTC ACT  
  
                               CDR3  
   -----  
217 L T I S S L Q P E D F A T Y Y C Q Q  
   CTC ACC ATC AGC AGC CTG CAG CCT GAA GAT TTT GCA ACT TAT TAC TGC CAA CAG  
  
   CDR3  
   -----  
271 Y K S Y P V T F G G G T K V E I K  
   TAT AAG AGT TAC CCG GTC ACT TTC GGC GGA GGG ACC AAC STG GAG ATC AAA  
  
                                |  
                                v  
                                JK4
```

Amino acid sequence = SEQ ID NO:6
Nucleic acid sequence = SEQ ID NO:37

FIG. 4B

Anti-Toxin A 33.3H2 VH Sequences

V-segment: VH3-33
 D-segment: Unknown
 J-segment: JH4b

```

1      Q V Q L V E S G G G V V Q P G R S L
      CAG GTG CAG CTG GTG GAG TCT GGG GGA GGC GTG GTC CAG CCT GGG AGG TCC CTG

                                CDR 1
                                ~~~~~
55     R L S C A A S G F T F N K Y G M H W
      AGA CTC TCC TGT GCA GCG TCT GGA TTC ACC TTC AAT AAA TAT GGC ATG CAC TGG

                                CDR 2
                                ~~~~~
109    V R Q A P G K G L E W V A V I W Y D
      GTC CGC CAG GCT CCA GGC AAG GGG CTG GAG TGG GTG GCA GTT ATA TGG TAT GAT

                                CDR 2
                                ~~~~~
163    G T N K Y Y A D S M K G R F T I S R
      GGA ACT AAT AAA TAC TAT GCA GAC TCC ATG AAG GGC CGA TTC ACC ATC TCC AGA

217    D N S K N M L Y L Q M N S L R A E D
      GAC AAT TCC AAG AAT ATG CTG TAT CTG CAA ATG AAC AGC CTA AGA GCC GAG GAC

                                CDR 3
                                ~~~~~
271    T A V Y Y C A R D P P T A N Y W G Q
      ACG GCT GTG TAT TAC TGT GCG AGA GAT CCC CCC ACT GCT AAC TAC TGG GGC CAG

                                ~~~~~
325    G T L V T V S S
      GGA ACC CTG GTC ACC GTC TCC TCR
    
```

└─ JH4b

Amino acid sequence = SEQ ID NO:3

Nucleic acid sequence = SEQ ID NO:40

FIG. 5

Comparison of *C. difficile* MAbs in the Toxin A Binding ELISA;
 Standard 8E6.1G12.2G2; 3D8.2A4.2A4; 33.3H2.2H8.2B8; 1B11.2A10.4A7

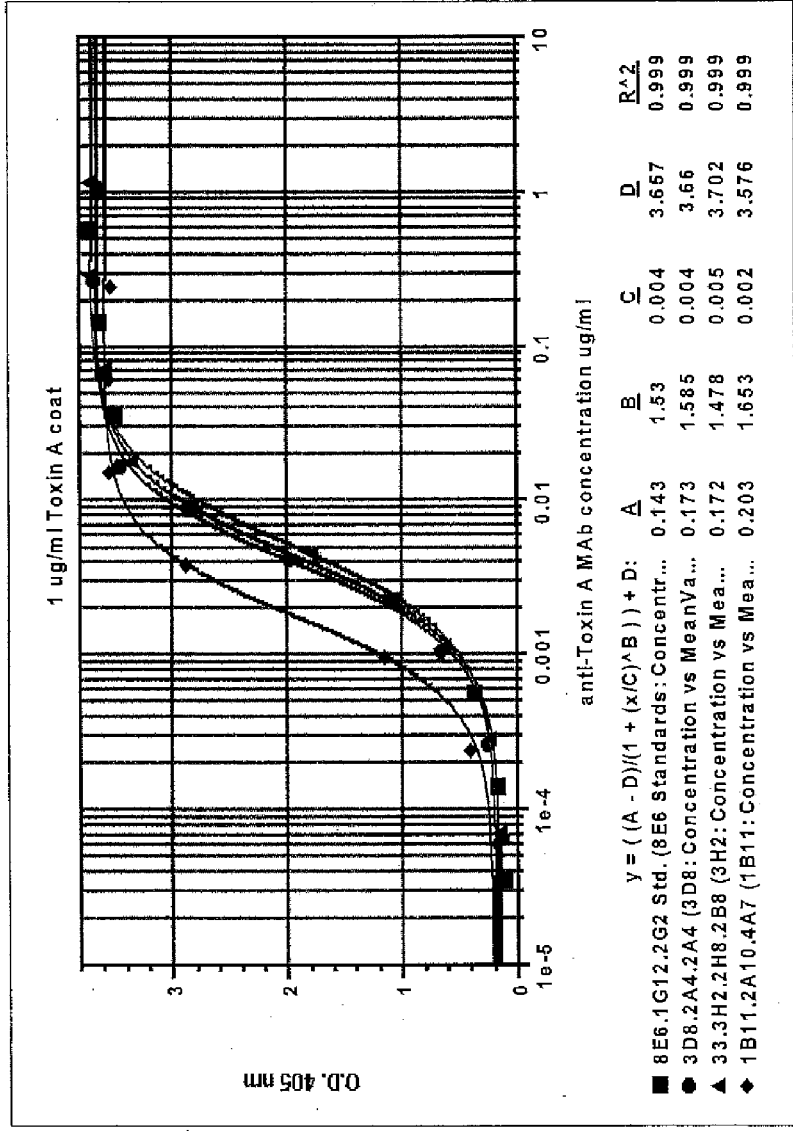


FIG. 6

FIG. 6A

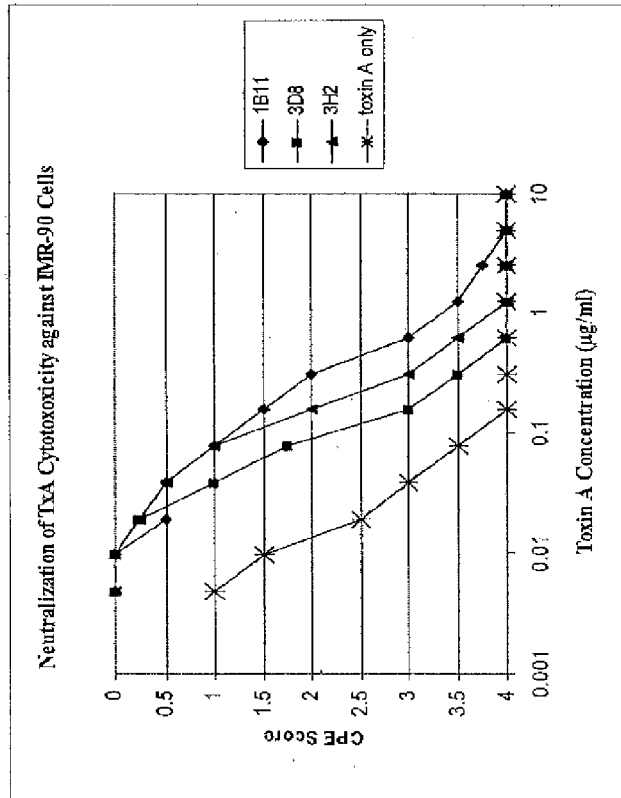


FIG. 6B

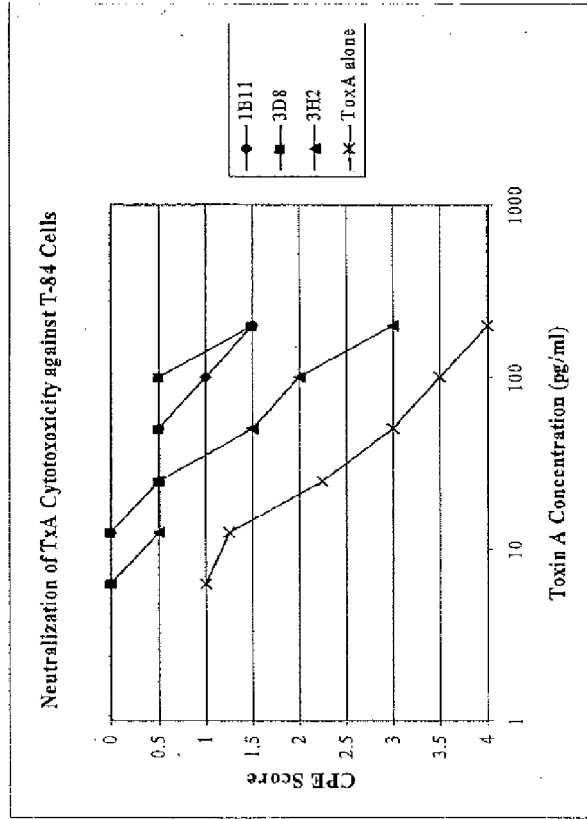


FIG. 7

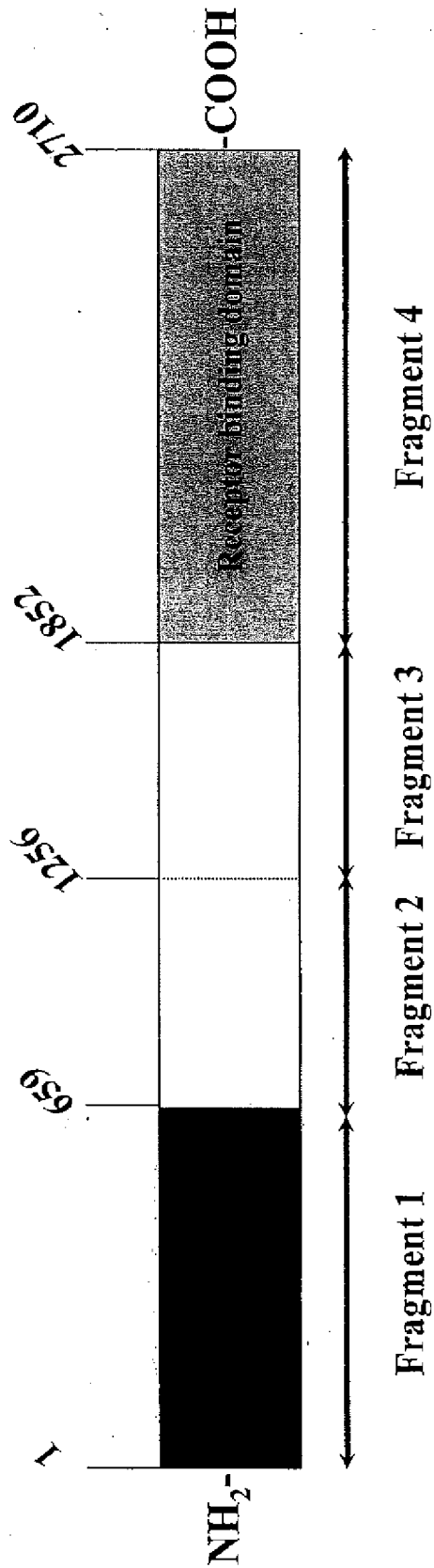


FIG. 8

FIG. 8A

Fragment 1 - Enzymatic

+	1-659
+	1-540
-	1-415
-	1-290
-	1-165 (from last expt.)

1B11 epitope = AA 415-540.

FIG. 8B

Fragment 2 - Unknown

+	660-1255
+	660-1146
+	660-1033
-	660-920
-	660-807

3H2 epitope = AA 920-1033

FIG. 9
Summary of mouse protection from Toxin A lethality by 1B11, 3D8, and 3H2.

TxA lot # (dose)	Control (Synagis)	% survival (dose*)		
		3D8	3H2	1B11
0100005 (100 ng)	10	80		50
0100005 (100 ng)	40	100		
0100005 (100 ng)	0		100	
0100005 (100 ng)	50		100	
0100005 (100 ng)	10	10-50 (250, 50, 10)	60 (50)	0-60 (250, 50, 10)
1002047 (500 ng)	30	10-80 (250, 25, 2.5)	20-40 (250, 25, 2.5)	0-30 (250, 25, 2.5)
1002047 (300 ng)	20	40, 30 (500, 50)	90, 30 (150, 15)	40, 20 (500, 50)
1002047 (100 ng)	30	80, 70 (250, 25)	90, 80 (250, 25)	
1002047 (100 ng)	30	30, 40 (250, 25)	100, 80 (250, 25)	
1002047 (100 ng)	25	50, 10, 10 (100, 10, 1)	90, 40, 10 (100, 10, 1)	10, 10, 30 (100, 10, 1)
1002047 (100 ng)	15	50, 50, 20 (100, 10, 1)	90, 60, 60 (100, 10, 1)	
1002047 (100 ng)	15	60, 60, 40*** (100, 10, 1)		

*HuMAb dose was 250 µg unless otherwise noted
 ** HuMAbs were injected 24 hours prior to challenge
 *** expressed from CHO cells

FIG. 10

Intestinal Loop Fluid Accumulation

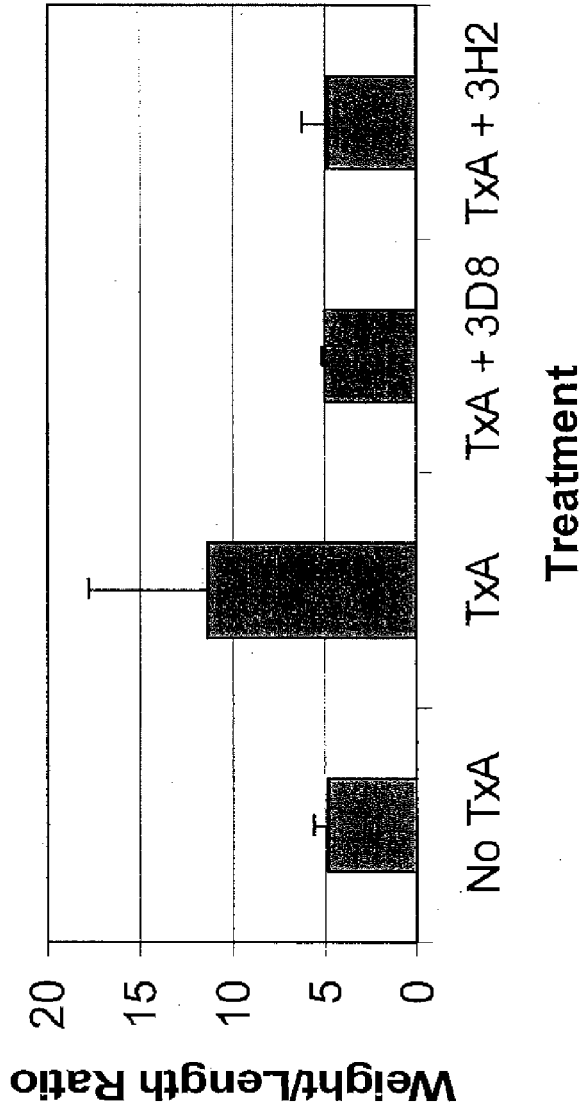


FIG. 11A

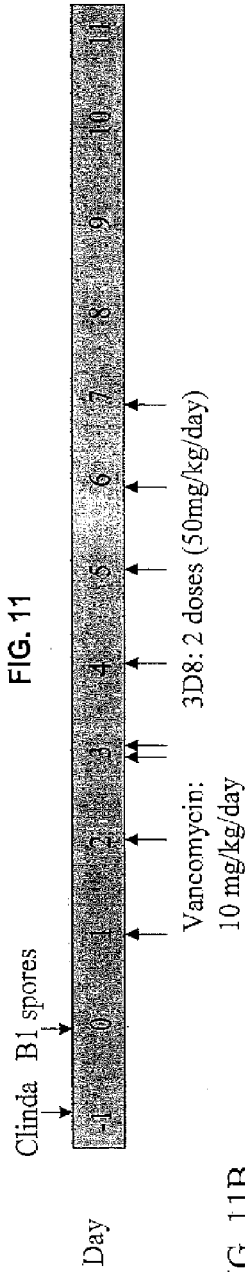


FIG. 11B

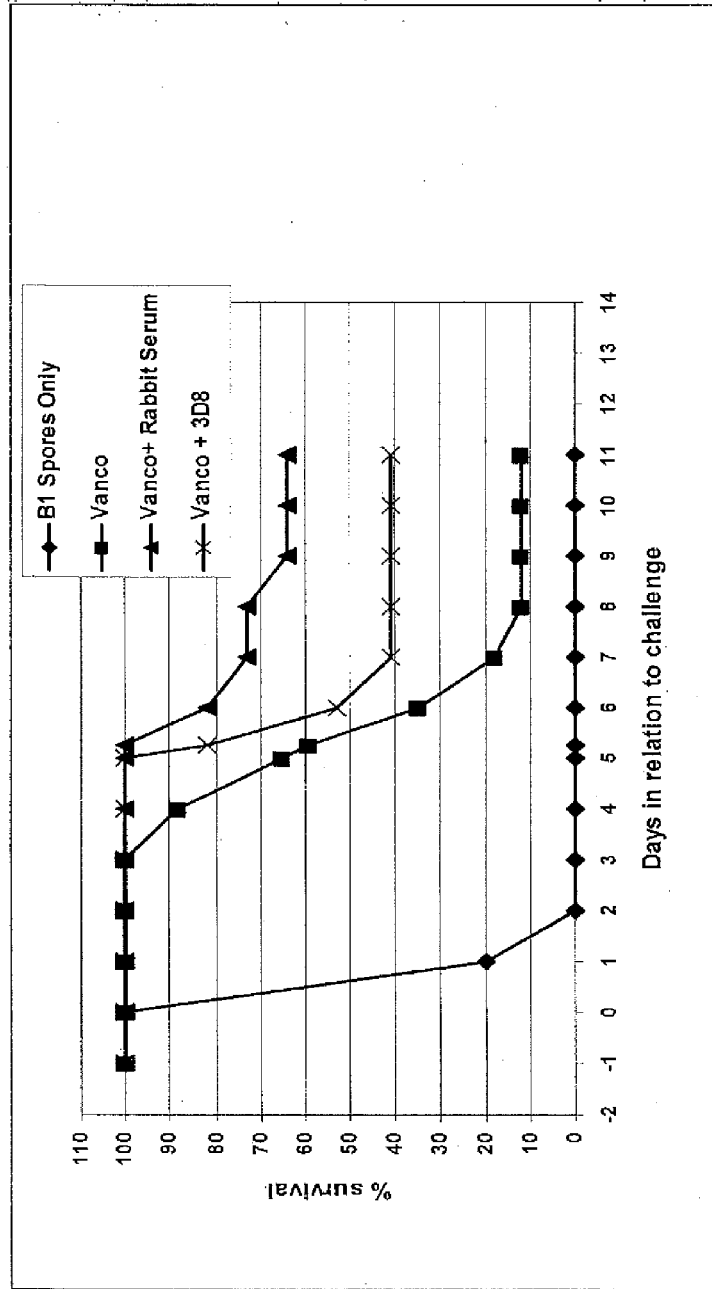


FIG. 12

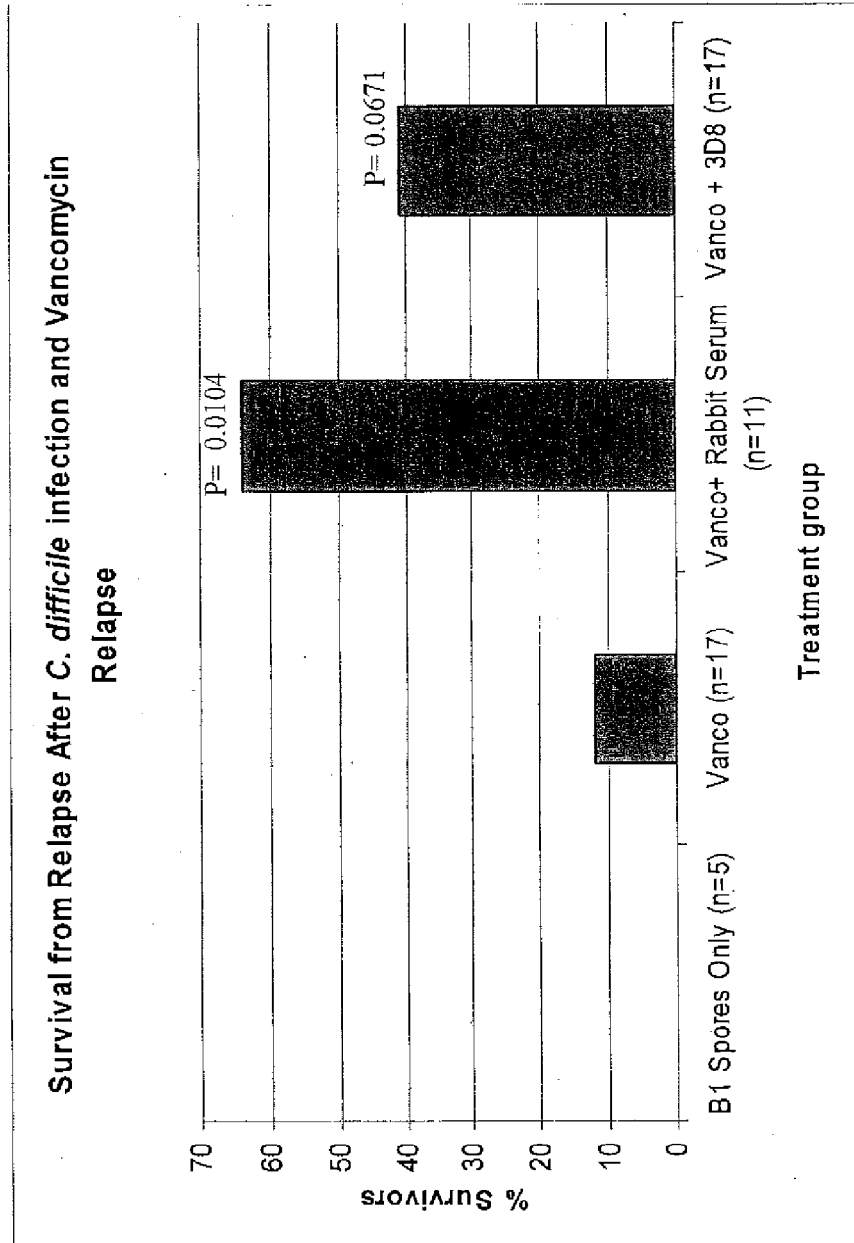


FIG. 14

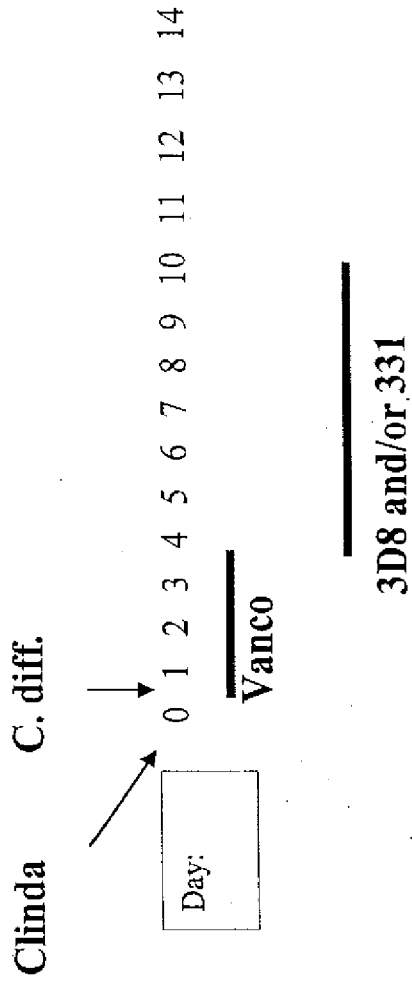


FIG. 15

Survival from *C. difficile* relapse in hamsters after treatment with 3D8, Goat anti-toxin B serum or both

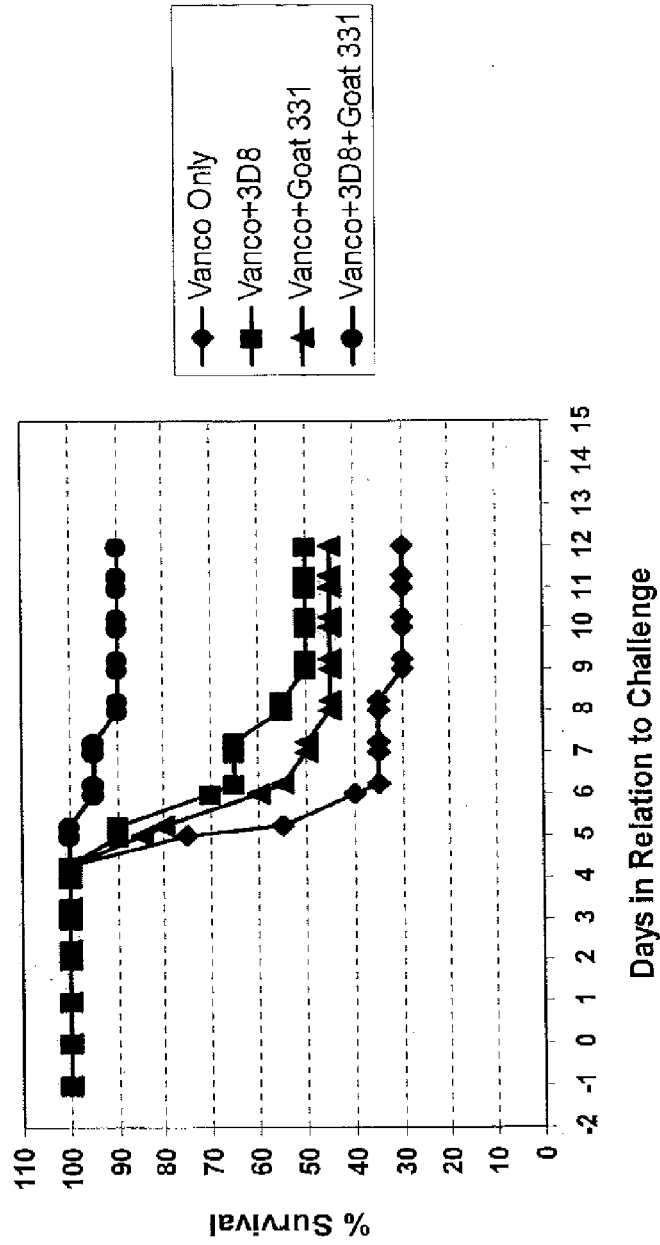


FIG. 16

Protection from *C. difficile* illness after relapse in hamsters treated with 3D8, Goat anti-toxin B serum or both

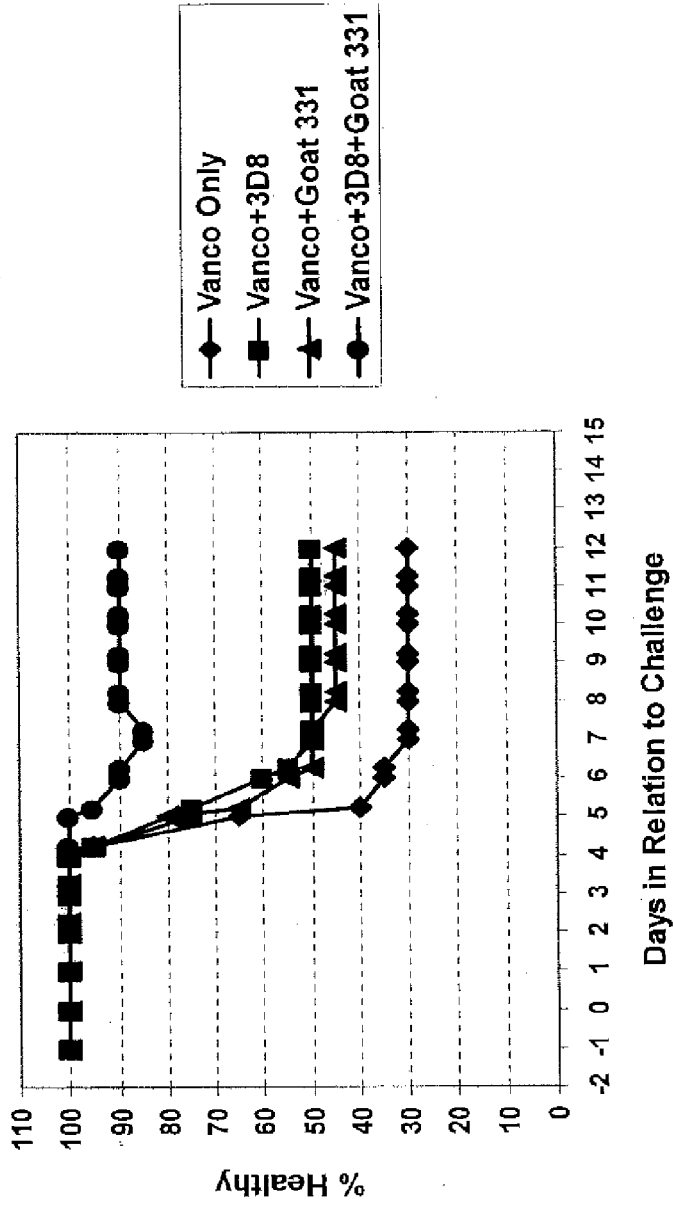


FIG. 17
Hamster Immunization with Toxin B fragment 4 / Relapse
Protection (Survival) Experiment

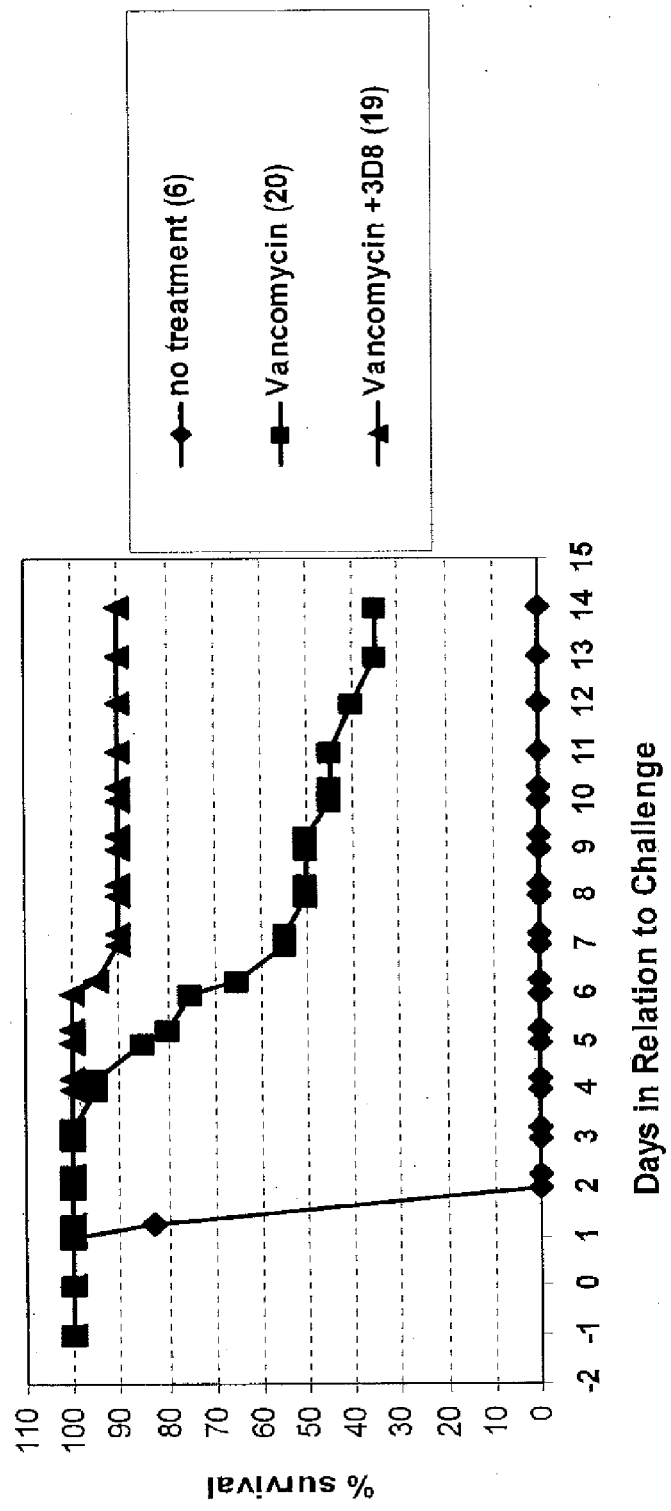


FIG. 18

Hamster Immunization with Toxin B fragment 4 / Relapse

Protection Experiment (illness)

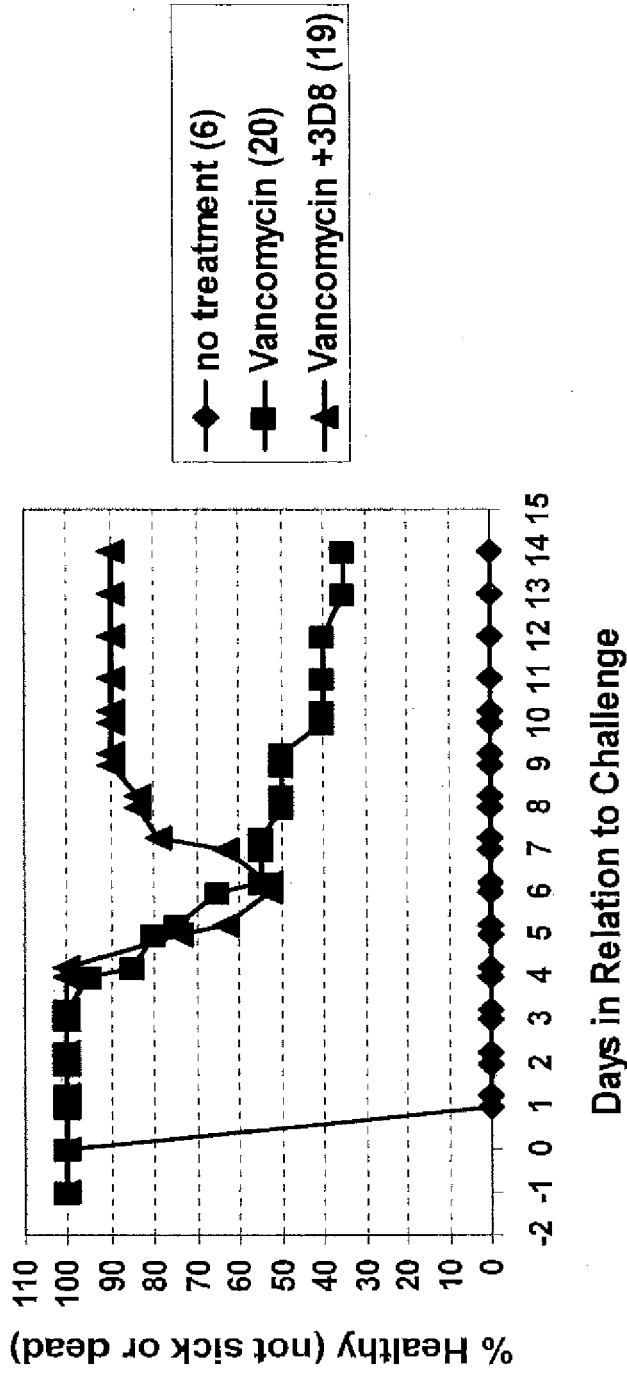
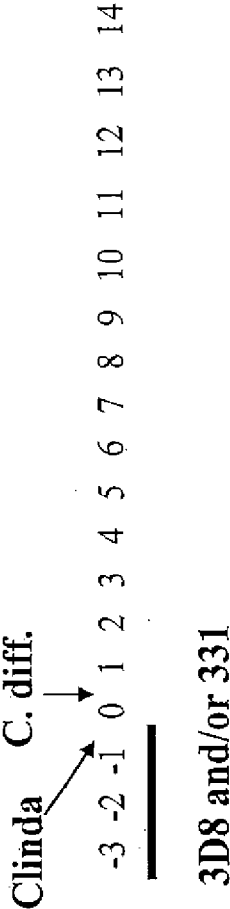


FIG. 19



Day:

FIG. 20

Passive Protection of Hamsters from Primary
C. difficile Challenge Using 3D8 with or without Goat Anti-Toxin B
Sera (Survival)

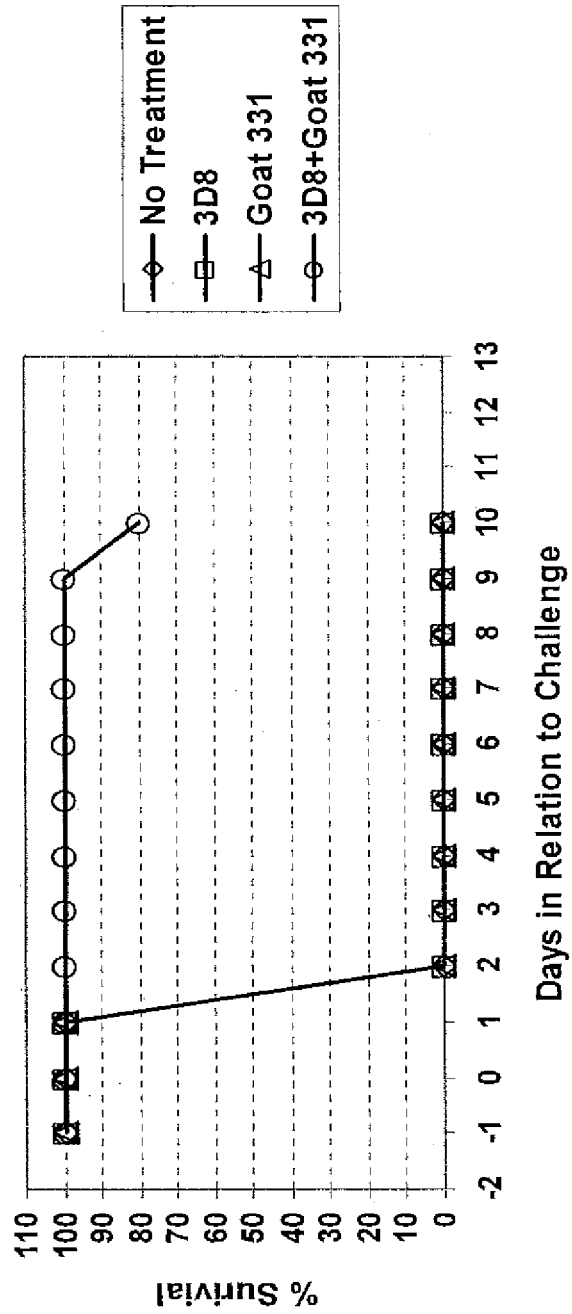


FIG. 21

Passive Protection of Hamsters from Primary *C. difficile* Challenge Using 3D8 with or without Goat Anti-Toxin B Sera (Illness)

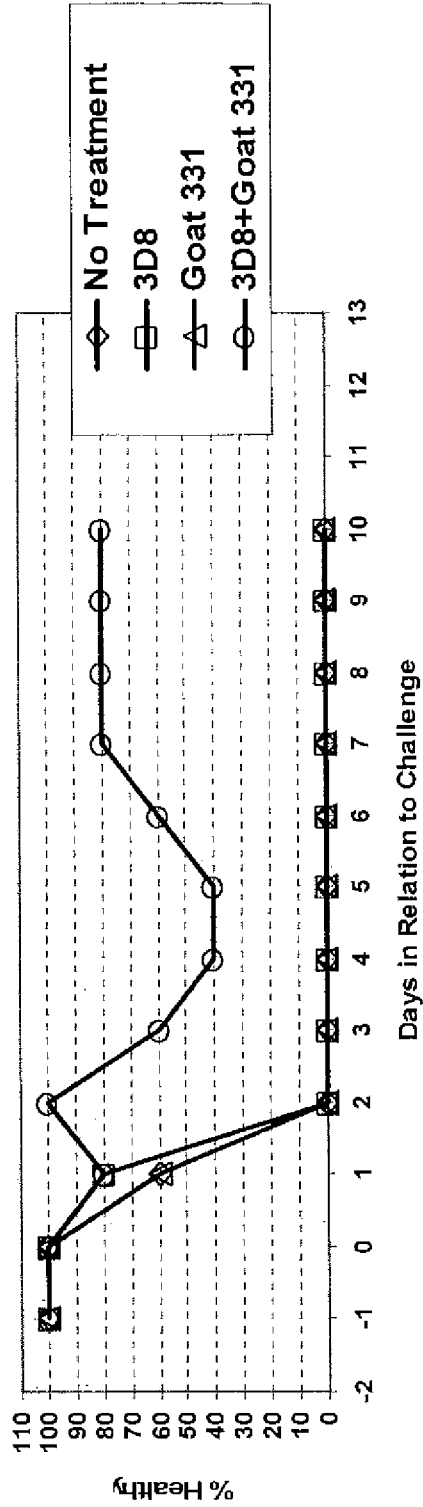


FIG. 22

C. difficile Toxin A Amino Acid Sequence

(See also GenBank® GI No:98593, Acc. No:A37052)

MSLISKEELIKLAYSIRPRENEYKTILTNLDEYNKLT'TNNNENKYLQI.KKI.NF.S.T.DVFMNKY
KTS.SRRNALSNT.KKDI.LKEV.I.I.KNSNTSPVFKNLHFVWIGGEVSDIALEYIKQWADINAAY
NIKLYWDSEAF.LVNTLKKALVESST'EALQLLEEIQNPQ'F'DNMKFYKKRMEFTYDRQKRFT
NYYKSQINKPTVPTIDDI.KSHLVSEYNRDET.VLESYRTNSLRKINSNHGIDIRANSLFTEQ
ELLNIYSQELLNRGNLAAASDI.VRLALAKNFEGGVYLDVDMPLGTHSDLFKTI.SRPSSIGLDR
WEMIKLEAIMKYYKYINNYTSENF'DKLDQQLKDNFKLIESKSEKSEIFSKLENLNVSDLEL
KIAPALGSVINQALISKQGSYLTNLVIEQVKNRYQFLNQHLNPAIESDNNF'DTTKIFHDSL
ENSATAENSMFLT.KIAPYLQVGFMPPEARSTISLSGPGAYASAYYDFINLOENTIEKTLKASD
LLEFK'F'PENNL.SOLTEQEINLSWSFDQASAKYQFEKYVRDYTGGSLSLEDNGVDFNKNTALDK
NYLLNKNIPSNVVEEAGSKNYVHYIIQLQGD.DISYEATCNLFSKNPKNSII.IQRNMNESAKS
YFLSDDGESILELNKYRIPERLKNKEKVKVTFIGHGKDEFNTSEFARLSVDSLSNEISSFLD
TIKLDISPKNVEVNLGCMNFSYDFNVEETYPGKLLLSIMDKITSTLPDVNKNSTITIGANQY
EVRINSEGRKELL.AHSGKWLNKEEAIMSDLSSKEYIFFDSIDNKLKAKSKNIPGLASISED
KTL.LLDASVSPDTKFILN.NLKNIESSIGDYIYYEKLEPVKNI.IHNSIDDLIDEFNLENVS
DELYELKKNLNLDEKYLISFEDISKNNSTYSVRFINKSNGESVYVETEKEIFSKYSEHITKE
ISTIKNSIITDVNGNLLDNIQLDHTSQVNTLNAAFFIQSLIDYSSNKDVLNLDLSTSVKQVLY
AQLFSTGLNTIYDSIQLVNLSNAVNDTINVLPITTEGIPVSTILDGINLGAAIKELLDLDEH
DPLLKKELEAKVGVLA.NMSLSIAATVASIVGIGA.EVTIFLLPIAGISAGIPSLVNNELILH
DKATSVVNYFNHLSSEKKGPLKTEDDKILVPIDDLVISEIDFNNSIKLGT.CN.LAMEGGS
GHTVTVGNIDHFFSSPSISSHIPSLSIYSAIGIETENLDFS.KKIMMLPNAPSRVFWWETGAVP
GLRSLENDGTR.LLDSIRDLYPGKPYWRFYAFFDYAITTLKPVYEDTNIKIKLDDKOTRNFIMP
TIT'TNEIRNKLSYSFDGAGGTYSLI.L.SSYPISTNINLSKDDLWIENIDNEVREISIENTIK
KGLIKDVLKIDINKNKLIIGNQTI.DFSGDIDNKRDIYIFLTCELDKISLIEINLVAKSY
SLLSGDKNYLISNLSNTIEKINTLGLD.SKNIAANYTDESNNKYFGAISKTSOKSIIHYKKD
SKNILEFYNDKTYLEFNSKDFIAEDINVMKDDINTITGKYVDNNTDKSIDFSISLVSKNQV
KVNGLYLNESVYSSYLD.FVKNSDGHHTSNFMNLF.DNISFWKLF.GFENIN.FVIDKYFTLVG
KTNLGYVEFICDNNKNIDIYFGWKTS.SSKSTIFSGNGRNVVVEPIYNPDTGEDISTSLDFS
YEPLYGIDRYINKVLIAPDLYTSLININTNYYSNEYYPEITVINPNTFHKKVNI.NI.DSSSFE
YKWFTEGSDFIT.VRYL.EESNKKTI.QKIRTKGITL.SNTQS.FNKMSJDFKDIKKLSLGYIMSNEK
SFENSENELDRDHLGF.KIIDNKTYYYDEDSKLVKGLININNSLFYFDPLEFNLV'GWQTINGK
KYYFDINTGAA.LTSYK.I.NGKH.FYFNNDGVMQLGVFKGPDGF.FYFAPANTQNNNIEGQAI.VY
QSKFLT.LNGKKYYFDNNSKAVTGWRIINNEKY.FNPNNAIAAVGLQVIDNNKY.FNPDTAII
SKGWQTVNGSRYYFD.TDTAIAFNGYKTI.DGKH.FYFDS.DCVVKIGVFST.SNG.FYFAPANTYN
NNIEGQAI.VYQSKFLT.LNGKKYYFDNNSKAVTGWQTI.DSKKY.FFNTNTA.EAATGWQTI.DGKK
YYFNTNTA.EAATGWQTI.DGKKYYFNTNTA.IASTGYTI.NGKH.FYFNTD.GIMQIGVF.KGPNGF
EYFAPANTDANNIEGQAI.LYQNEFLT.LNGKKYY.FGSDSKAVTGWRIINNKKY.FNPNNAIAA
IHLCTINNDKY.FSYD.GILQNGYI.TIERN.FYFDANNESKMVTGVFKGPNGF.FYFAPANTHN
NNIEGQAI.VYQNKFLT.LNGKKYYFDNNSKAVTGWQTI.DGKKYY.FNLT.AEAATGWQTI.DGKK
YYFNLNTA.EAATGWQTI.DGKKYYFNTNT.FIASTGYTSINGKH.FYFNTD.GIMQIGVF.KGPNGF
EYFAPANTDANNIEGQAI.LYQNKFLT.LNGKKYY.FGSDSKAVTGLRTI.DGKKYYFNTNTA.VAV
TGWQTINGKKYYFNTNTS.IASTGYTIISGKH.FYFNTD.GIMQIGVF.KGPDGF.FYFAPANTDAN
NIEGQAI.RYQNR.FLYLHDNIY.FGNNSKAATGWVTIDGN.RY.FEPNTAMGANGYKTI.DNKNF
YFRNGLPQIGVF.KGSDGF.FYFAPANTDANNIEGQAI.RYQNR.FL.H.I.GKI.YY.FGNNSKAVTGW
QTINGKYY.FMPDTAMA.AAGGLE.FRIDGVY.FFGVDGVKAPGIYG (SEQ ID NO: 41)

FIG. 23

C. difficile Toxin B Amino Acid Sequence

(See also GenBank® GI No: 7476000, Acc. No: S70172)

MSLVNRKQLEKMANVRFVQDEYVAILDALAEYHNMSSENTVVEKYLKLDINSITDTYIDT
YKSGRNKALKKFKKEYLVIEILELKNLNTPVEKNLHFHWIGGQINDTAINYINQWKDVNSD
YNVNVFYDSNAFLINTLKKTIIESASNDTLESFRENLDNDFEFNHATAFFRKRMQITTYDKQQNF
JNYKAKQKEENPDLIIDDIVKTYLSNEYSKDIDELNAYIEESLNKVTENSGNDVRFNFEFKT
GEVENLYEQESVERWNLGASDILRVAIILKNIGGVYLDVDMLPGIHPDLFKDINKPDSVKTA
VDWEEMQLEAIMKHKKEYIPEYTSKHFDLDEEVQSSFESVLASKSDKSEIFLPLGDIEVSPL
EVKIAFAKGSIIINQALISAKDSYCSDLJIKQIQNRYKILNDTLGPIISQGNDFNTTMNNEGE
SLGAIANEENISFIAKIGSYLRVGFYPEANTTITLSGPTIYAGAYKDLITFKEMSIDTISLS
SELRNFEFPKVNISQATEQEKNSLWQFNEERAKIQFEYKKNYFEGALGEDDNLDFSONFTV
DKEYLLEKISSSTKSSEGGYVHYIVQLQGDKISYEAAACNLFAKNPYDSILFQRNIEDSEVAY
YYNPTDSEIQEIDKYRIPDRIIDRPKIKLTFIGHGKAEFNTDIFAGLDVDSLSEIETAIGL
AKEDISPKSIEINLLGCNMFSYSVNVEETYPGKLLLRVKDKVSELMPSMSQDSIIVSANQYE
VRINSEGRRELLDHSGEWINKEESI IKDISSKEYISFNPKENKILVSKNLPELSTLLQEIR
NNSNSSDIELEEKVMLAECEINVISNIETQVVEERIEEAKSLTSDSINYIKNEFKLIESISE
ALCDLQKQNELEDSHFISFEDISETDEGFSIRFINKETGESIFVETEKTI FSEYANHITEEI
SKIKGTIFDTVNGKLVKKVNLDTTHEVNTI.NAAFFTQSTIEYNSSKESLNLVAMKVQVYA
QLFSTGLNITDAKVVELVSTALDEITDILLPTLSEGLPIIATIIDGVSLGAAIKELSETSD
PLLRQELRAKIGIMAVNLTATTATITSSLGIASGFSILLVPIAGTSAGIPSLVNNELVLRD
KATKVVDFYFKHVSIVETEGVFTLLDDKVMQDDLVI SEIDFNNSIIVLGKCEIWRMEGGSG
HTVTDIDHFFSAPSITYREPHLSIYDVLEVOKEELDLSKDLMLVLPNAPNRVFAWETGWTPG
LRSLENDGFKLLDRIRDNYEGEFYWRYPAFIADALITTLKPRYEDTNRINLDSNTRSFIVP
IITTEYIREKLSYSFYGSGGTALPLSQYMGINTRESESDVWIIDVDNVVRDVTIESDKIK
KGDLEIGILSTLSIEENKIILNSHEINFSEVNGSNGFVSLTFSILEGINAITEVDLLSKSY
KLLISGELKILMLNSNHIQKIDYIGFNSSELQKNIPYSFVDSEKENGFIINGSTKEGLFVSE
LPDVVLSKVYMDQSKPSFGYYSNNLKDVKVTKDNVNILTYGYYLKDDIKISLSLTLQDEK
IKLNSVHLDESGVAEILKFMNRKGSNTSDSLMSFLESMNIKSI FVNFLQSNIKFILDANFI
ISGTTISIQQFEFICDENNNIQPYFKFNTLETNYTLYVGNRQNMIVEPNYDLDDSGDISSTV
INFQKYLGYIDSCVNKVVISPNITYTDEINIPVYETNNTYPEVIVLDANYINEKINVNIND
LSIRYVWSNDGNDFILMSTSEENKVSQVKIRFVNVEFKDKTLANKLSFNFSKQDVPVSEIIL
SFTPSYYEDGLIGYDLGLVSLYNEKFIYNNFGMMVSGLIYINDSLYFKPPVNNLITGFVTV
GDDKYYFNPINGGAASIGETIIDDKNYFNSQSVIQTGVFSTEDGFKYFAPANTLDENLEGE
AIDFTGKLIIDENIYFEDNYRGAVEWKELDGEMHYFSPETGKAFKGLNQIGDDKYYFNSDG
VMQKGFVSINDNKHYFDDSGVMKVGYTEIDGKHFFAENGEMQIGVFNTEDGFKYFAHNED
LGNEEGEEISYSGILNFNNKIYYFDDSFYAVVGWKDLEDGSKYFFDEDTAEAYIGLSLINDG
QYYFNDDGIMQVGFVTINDKVYFSDSGIIESGVQNI DDNYFYIDDNGIVQIGVFDTSDGYK
YFAPANTVNDNIYQAVEYSGLVRVGEDVYFGETYTIETGWIYDMENESDKYFVFPETKKA
CKGINLIDDIKYYFDEKGI MRTGLISFENNYYFNENGEIQFGYINIEDKMFYFGEDGVMQI
GVFNTPDGPKYFAHQNTLDENFEGESINYTGWLGLDEKRYFFTDEYIAATGSVIDGEEYFF
DPDTAQLVISE

Fig. 24

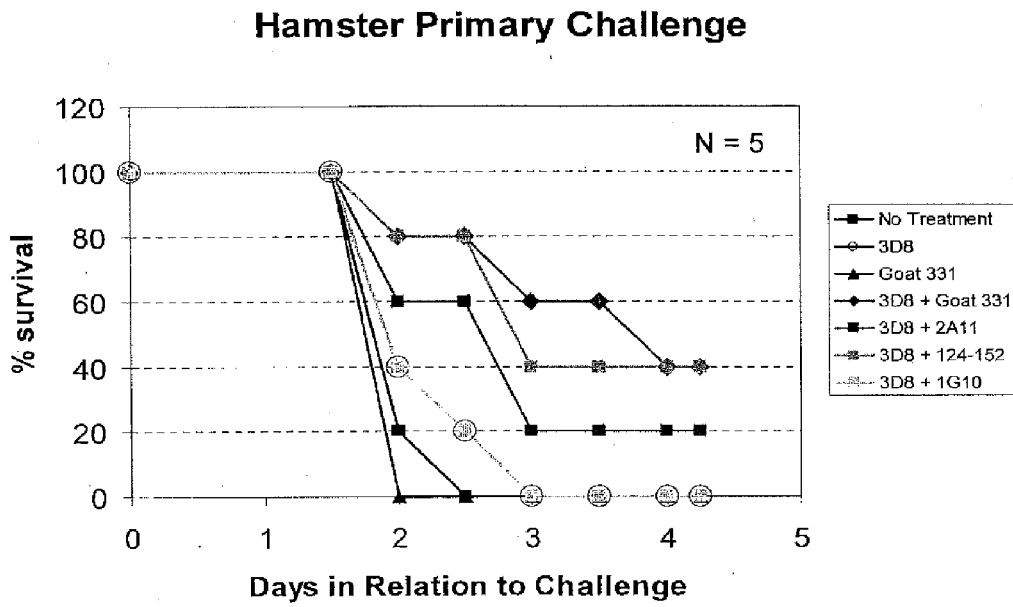


Fig. 25

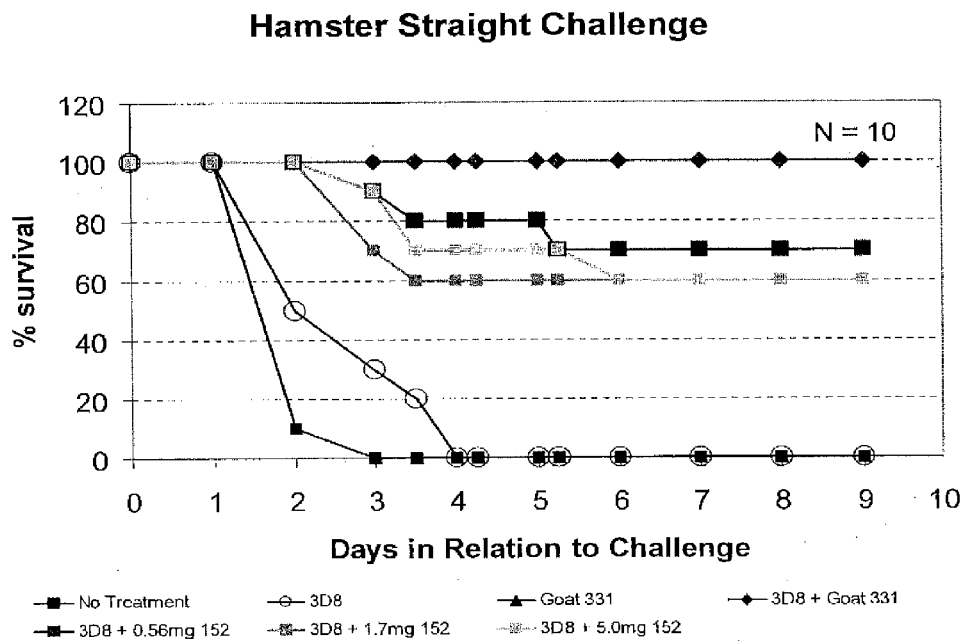


Fig. 26

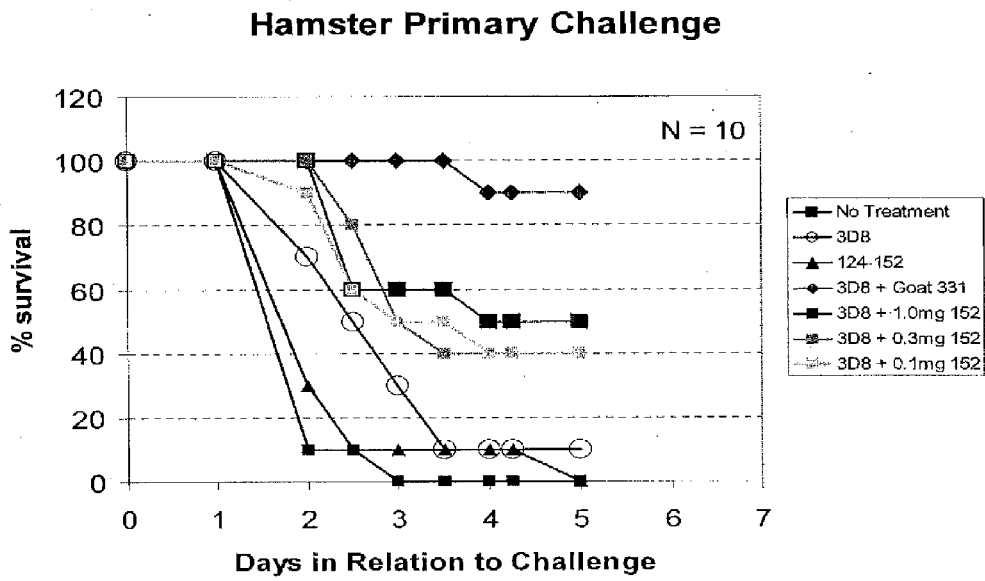
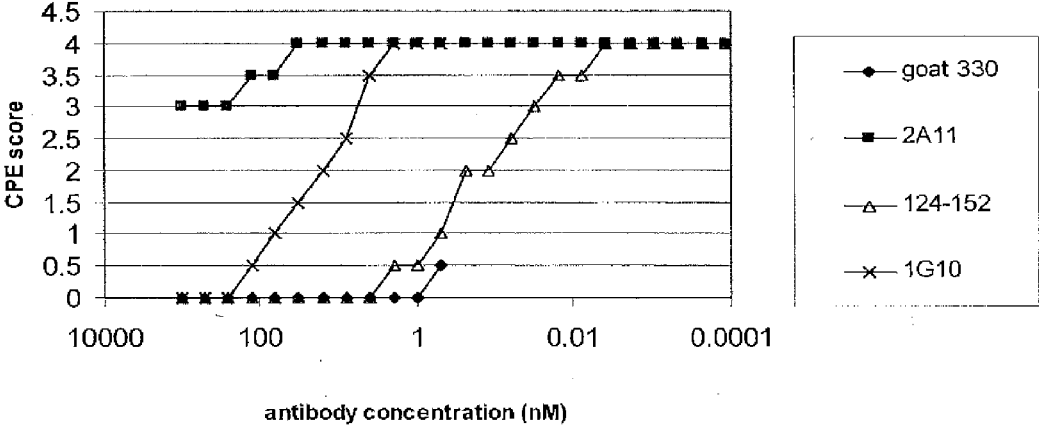


Fig. 27

Neutralization of Toxin B Cytotoxicity against IMR-90 Cells Using 2A11, 124-152 or 1G10



Anti-CDTox B 124-152 VH

Fig. 28

V segment: 5-51
 D segment: 7-27
 J segment: JH3b

```

      E V Q L V Q S G A E V K K S G E S L
1 GAG GTG CAG CTG GTG CAG TCT GGA GCA GAG GTG AAA AAG TCC CCG CAG TCT CTG

                                         CDR1 SEQ ID NO:62 (aa) 63 (nt)
      K I S C K G S G Y S F T S Y W I C W
55 AAG ATC TCC TGT AAG GGT TCT GGA TAC AGC TTT ACC AGC TAC TGG ATC GGC TGG

                                         CDR2
      V R Q M P G K G L E W M G I F Y P G
109 GTG CCG CAG ATG CCC GGG AAG GGC CTG GAG TGG ATG GGG ATC TTC TAT CCT GG

      CDR2 SEQ ID NO:64 (aa) 65 (nt)
      D S S T R Y S P S F Q G Q V T I S A
163 GAC TCT AGT ACC AGA TAC AGC CCG TCC TTC CAA GGC CAG GTC ACC ATC TCA GCC

      D K S V N T A Y L Q W S S L K A S D
217 GAC AAG TCC GTC AAC ACC GCC TAC CTG CAG TGG AGC AGC CTG AAG GCC TCG GAC

                                         CDR3 SEQ ID NO:66 (aa) 67 (nt)
      T A M Y Y C A R R R N W G N A F D I
271 ACC GCC ATG TAT TAC TGT GCG AGA CGT CGA AAC TGG GGA AAT GCT TTT GAT ATC

      W G Q G T M V T V S S SEQ ID NO:54
325 TGG GGC CAA GGG ACA ATG GTC ACC GTC TCT TCA SEQ ID NO:55
    
```

>CDTox B, 124-152, VH-NT with leader SEQ ID NO:57
 ATGGGGTCAACCGCCATCCTCGCCCTCCTCCTGGCTGTTCTCCAAGGAGTCTGTGCCGAGGTGCA
 GCTGGTGCAGTCTGGAGCAGAGGTGAAAAAGTCCGGGGAGTCTCTGAAGATCTCCTGTAAGGGTT
 CTGGATACAGCTTTACCAGCTACTGGATCGGCTGGGTGCCCCAGATGCCCGGGAAGGGCCTGGAG
 TGGATGGGGATCTTCTATCCTGGTGACTCTAGTACCAGATACAGCCCGTCTTCCAAGGCCAGGT
 CACCATCTCAGCCGACAAGTCCGTCAACACCGCCTACCTGCAGTGGAGCAGCCTGAAGGCCCTCGG
 ACACCGCCATGTATTACTGTGGCAGACGTCGAAACTGGGGAAATGCTTTTGATAICTGGGGCCAA
 GGGACAATGGTCAACCGTCTCTTCA

>CDTox B, 124-152, VH-AA with leader SEQ ID NO:56
 MGSTAILALLLAVLQGVCAEVQLVQSGAEVKKSGESLKI SCKGSGYSFTSYWIGWVRQMPGKGLE
 WMGIFYPGDSSSTRYSPSPGQVVISADKSVNTAYLQWSSLLKASDTAMYYCARRRNWGNAFDIWQQ
 GTMVTVSS

Fig. 29

Anti-CDTox B 124-152 VK

V segment: A27
 J segment: JK1

SEQ ID NO:58

E I V L T Q S P G T L S L S P G E R
 1 GAA ATT GTG TTC ACC CAG TCT CCA GCC ACC CTG TCT TTG TCT CCA GGG GAA AGA

SEQ ID NO:59

CDR1 SEQ ID NO:68 (aa) 69 (nt)

A T L S C R A S Q S V S S S Y T A W
 55 GCC ACC CTC TCC TGC AGG GCC AGT CAG AGT GTT AGC AGC AGC TAC TTA GCC TCC

CDR2

Y Q Q K P G Q A P R L L I Y G A S S
 109 TAC CAG CAG AAA CCT GGC CAG GCT CCC AGG CTC CTC ATC TAT GGT GCA TCC AGC

CDR2 SEQ ID NO:70 (aa) 71 (nt)

R A T G L P D R F S G S G S G T D F
 163 AGG GCC ACT GGC ATC CCA GAC AGG TTC AGT GGC AGT GGG TCT GGG ACA GAU TTC

CDR3

T L T I S R L E P E D F A V Y Y C C
 217 ACT CTC ACC ATC AGC AGA CTG GAG CCT GAA GAT TTT GCA GTG TAT TAC TGT CAG

CDR3 SEQ ID NO:72 (aa) 73 (nt)

Q Y G S S T W T F G Q G T K V E I K
 271 CAG TAT GGT AGC TCA ACG TGG ACG TTC GGC CAA GGG ACC AAG CTG GAA ATC AAA

>CDTox B, 124-152, VK-NT with leader SEQ ID NO:61
 ATGGAAACCCAGCGCAGCTTCTCTTCCTCCTGCTACTCTGGCTCCCAGATACCACCGGAGAAAT
 TGTGTTCAACGAGTCTCCAGGCACCCTGTCTTTGTCTCCAGGGGAAAGAGCCACCCTCTCCTGCA
 GGGCCAGTCAGAGTGTTAGCAGCAGCTACTTAGCCTGGTACCAGCAGAAACCTGGCCAGGCTCCC
 AGGCTCCTCATCTATGGTGCATCCACCAGGCCACTGGCATCCCAGACAGGTTTCAGTGGCACTGC
 GTC'GGGACAGACTT'CACTCT'CAACAT'CAGCAGACTGGAGCCTGAAGATTTTGCAGTGTAT'ACI
 GTCAGCASTATGGTAGCTCAACGTGGACGTTTCGGCCAAGGGACCAAGGTGGAAATCAAA

>CDTox B, 124-152, VK-AA with leader SEQ ID NO:60
 METPAQLLELLLLLWLPDITTRIVLITQSPGTTLSLSPGFRATLSCRASQSVSSSYLAWYQQKFGQA
 PRLLIYGASSRATGIPDRFSGSGSGTDFLLTISRLEPEDFAVYYCQQYGSSTWTFGQGTKVEIK

Fig. 30

Anti-CDTox B 124-152 VH region

SEQ ID NO:75

5-51 germline EVQLVQSGCAEVKKPKGESLKISCKGSGYSFTSYWIGW
124-152 VH -----S-----
CDR1

SEQ ID NO:76

5-51 germline VRQMPGKGLLEWMGIIPGDSDTRYSPSFQGGVITSA
124-152 VH -----F-----S-----
CDR2

SEQ ID NO:77

5-51 germline DKSIPTAYLQWSSLKASDTAMYYSAR
JH3b germline -----AFDI
124-152 VH -----V-----N-----R-----R-----N-----W-----G-----N-----
CDR3

SEQ ID NO:74

JH3b germline WGQGTMTVTVSS
124-152 VH -----(JH3b)

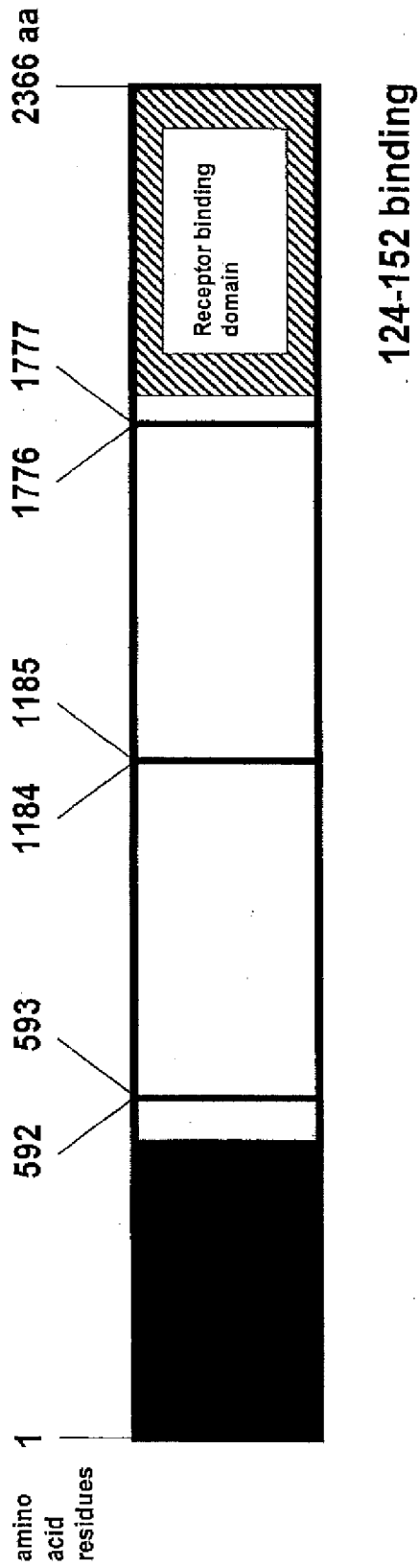
Fig. 31

Anti-CDT_{ox} B 124-152 VK region

		CDR1	SEQ ID NO:78
A27 germline	E I V L T Q S P G T L S L S P G E R A T L S C R A S Q S V S S S Y L A W		
124-152 VK	- - - - -		
		CDR2	
A27 germline	Y Q Q K P G Q A P R L L I Y G A S S R A T G I P D R F S G S G S G T D F		
124-152 VK	- - - - -		
		CDR3	SEQ ID NO:79
A27 germline	T L T I S R L E P E D F A V Y Y C	D Q Y G S S P	
JK1 germline		W T	
124-152 VK	- - - - -		
(JK1)			

FIG. 32

Mab 124-152 binds to the C-terminus of *C. difficile* Toxin B (TcdB)



ANTIBODIES AGAINST CLOSTRIDIUM DIFFICILE TOXINS AND USES THEREOF

RELATED INFORMATION

[0001] The application is a continuation of U.S. patent application Ser. No. 14/080,598, filed on Nov. 14, 2013, which is a divisional application of U.S. patent application Ser. No. 13/490,757, filed on Jun. 7, 2012, now U.S. Pat. No. 8,609,111, which is a continuation of U.S. patent application Ser. No. 12/533,501, filed on Jul. 31, 2009, now U.S. Pat. No. 8,236,311, which is a divisional application of U.S. patent application Ser. No. 11/051,453, filed on Feb. 4, 2005, now U.S. Pat. No. 7,625,559, which claims priority to U.S. provisional patent application No. 60/542,357, filed on Feb. 6, 2004, and U.S. provisional patent application No. 60/613,854, filed on Sep. 28, 2004, the entire contents both of which are hereby incorporated by reference.

[0002] The contents of any patents, patent applications, and references cited throughout this specification are hereby incorporated by reference in their entireties.

BACKGROUND OF THE INVENTION

[0003] *Clostridium difficile* (*C. difficile*) is a gram-positive bacterium that causes gastrointestinal disease in humans. *C. difficile* is the most common cause of infectious diarrhea in hospital patients, and is one of the most common nosocomial infections overall (Kelly et al., *New Eng. J. Med.*, 330:257-62, 1994). In fact, disease associated with this pathogen may afflict as many as three million hospitalized patients per year in the United States (McFarland et al., *New Eng. J. Med.*, 320:204-10, 1989; Johnson et al., *Lancet*, 336:97-100, 1990).

[0004] Treatment with antibiotics such as ampicillin, amoxicillin, cephalosporins, and clindamycin that disrupt normal intestinal flora can allow colonization of the gut with *C. difficile* and lead to *C. difficile* disease (Kelly and Lamont, *Annu. Rev. Med.*, 49:375-90, 1998). The onset of *C. difficile* disease typically occurs four to nine days after antibiotic treatment begins, but can also occur after discontinuation of antibiotic therapy. *C. difficile* can produce symptoms ranging from mild to severe diarrhea and colitis, including pseudomembranous colitis (PMC), a severe form of colitis characterized by abdominal pain, watery diarrhea, and systemic illness (e.g., fever, nausea). Relapsing disease can occur in up to 20% of patients treated for a first episode of disease, and those who relapse are at a greater risk for additional relapses (Kelly and Lamont, *Annu. Rev. Med.*, 49:375-90, 1998).

[0005] *C. difficile* disease is believed to be caused by the actions of two exotoxins, toxin A and toxin B, on gut epithelium. Both toxins are high molecular weight proteins (280-300 kDa) that catalyze covalent modification of Rho proteins, small GTP-binding proteins involved in actin polymerization, in host cells. Modification of Rho proteins by the toxins inactivates them, leading to depolymerization of actin filaments and cell death. Both toxins are lethal to mice when injected parenterally (Kelly and Lamont, *Annu. Rev. Med.*, 49:375-90, 1998).

[0006] *C. difficile* disease can be diagnosed by assays that detect the presence or activity of toxin A or toxin B in stool samples, e.g., enzyme immunoassays. Cytotoxin assays can be used to detect toxin activity. To perform a cytotoxin assay, stool is filtered to remove bacteria, and the cytopathic effects

of toxins on cultured cells are determined (Merz et al., *J. Clin. Microbiol.*, 32:1142-47, 1994).

[0007] *C. difficile* treatment is complicated by the fact that antibiotics trigger *C. difficile* associated disease. Nevertheless, antibiotics are the primary treatment option at present. Antibiotics least likely to cause *C. difficile* associated disease such as vancomycin and metronidazole are frequently used. Vancomycin resistance evolving in other microorganisms is a cause for concern in using this antibiotic for treatment, as it is the only effective treatment for infection with other microorganisms (Gerding, *Curr. Top. Microbiol. Immunol.*, 250:127-39, 2000). Probiotic approaches, in which a subject is administered non-pathogenic microorganisms that presumably compete for niches with the pathogenic bacteria, are also used. For example, treatment with a combination of vancomycin and *Saccharomyces boulardii* has been reported (McFarland et al., *JAMA.*, 271(24):1913-8, 1994. Erratum in: *JAMA*, 272(7):518, 1994).

[0008] Vaccines have been developed that protect animals from lethal challenge in infectious models of disease (Torres et al., *Infect. Immun.* 63(12):4619-27, 1995). In addition, polyclonal antibodies have been shown to protect hamsters from disease when administered by injection or feeding (Giannasca et al., *Infect. Immun.* 67(2):527-38, 1999; Kink and Williams, *Infect. Immun.*, 66(5):2018-25, 1998). Murine monoclonal antibodies have been isolated that bind to *C. difficile* toxins and neutralize their activities in vivo and in vitro (Corthier et al., *Infect. Immun.*, 59(3):1192-5, 1991). There are some reports that human polyclonal antibodies containing toxin neutralizing antibodies can prevent *C. difficile* relapse (Salcedo et al., *Gut.*, 41(3):366-70, 1997). Antibody response against toxin A has been correlated with disease outcome, indicating the efficacy of humoral responses in controlling infection. Individuals with robust toxin A ELISA responses had less severe disease compared to individuals with low toxin A antibody levels (Kyne et al., *Lancet*, 357(9251):189-93, 2001).

[0009] The individual role of toxin A and toxin B in disease pathogenesis, and the role of anti-toxin antibodies in protection from *C. difficile* disease are controversial and may depend on the host. In humans, the anti-toxin A antibody response has been correlated to disease outcome, suggesting a requirement for anti-toxin A response for protection. This observation is in contrast with reports of disease-causing *C. difficile* organisms that express only toxin B, implying that toxin B can contribute to disease in humans. These toxin A-negative strains can also cause disease in hamsters (Sambol et al., *J. Infect. Dis.*, 183(12):1760-6, 2001).

SUMMARY OF THE INVENTION

[0010] This invention is based, in part, on the discovery that administration of antibodies against *C. difficile* toxin A to a subject can protect the subject from relapse of *C. difficile*-mediated disease in vivo. Administration of antibodies to one or both of toxin A and toxin B can prevent primary *C. difficile*-mediated disease. High affinity antibodies against *C. difficile* toxins can be produced, e.g., in mice, such as transgenic mice expressing human immunoglobulin gene segments. These antibodies can neutralize toxin cytotoxicity in vitro, and neutralize toxin enterotoxicity in vivo. Antibodies that recognize toxin A and/or toxin B can inhibit and protect from disease in vivo.

[0011] In one aspect, the invention features isolated human monoclonal antibodies or antigen binding portions thereof

that specifically bind to an exotoxin of *Clostridium difficile* (*C. difficile*). In certain embodiments, the antibodies or antigen binding portions thereof specifically bind to *C. difficile* toxin A (toxin A). In other embodiments, the antibody or antigen binding portions thereof specifically bind to *C. difficile* toxin B (toxin B). In other embodiments, the antibodies or antigen binding portions thereof specifically bind to both toxin A and toxin B.

[0012] In certain embodiments, the antibodies or antigen binding portions thereof neutralize toxin A in vitro, inhibit binding of toxin A to mammalian cells, and/or inhibit *C. difficile*-mediated disease in vivo.

[0013] In various embodiments, the antibodies or antigen binding portions thereof have one or more of the following characteristics: when administered to a mouse, they protect the mouse against administration of a *C. difficile* toxin in an amount that would be fatal to a control mouse not administered the antibody; protect from or inhibit *C. difficile*-mediated colitis, antibiotic-associated colitis, or pseudomembranous colitis (PMC) in a subject; protect from or inhibit diarrhea in a subject; and/or inhibit relapse of *C. difficile*-mediated disease.

[0014] The antibodies or antigen binding portions thereof can specifically bind to an epitope within the N-terminal half of toxin A, e.g., an epitope between amino acids 1-1256 of toxin A. In other embodiments, the antibodies or antigen binding portions thereof specifically bind to an epitope within the C-terminal receptor binding domain of toxin A, e.g., an epitope between amino acids 1852-2710 of toxin A, or an epitope between amino acids 659-1852, e.g., an epitope within amino acid residues 900-1852, 900-1200, or 920-1033 of toxin A. In other embodiments, the antibodies or antigen binding portions thereof specifically bind an epitope within amino acids 1-600, 400-600, or 415-540 of toxin A. Other particular antibodies or antigen binding portions thereof, can specifically bind to an epitope within amino acid residues 1-100, 100-200, 200-300, 300-400, 400-500, 500-600, 600-700, 700-800, 900-1000, 1100-1200, 1200-1300, 1300-1400, 1400-1500, 1500-1600, 1600-1700, 1800-1900, 1900-200, 2100-2200 or 2200-2300, 2300-2400, 2400-2500, 2500-2600, 2600-2710 of toxin A, or any interval, portion or range thereof.

[0015] In certain embodiments, the antibodies or antigen binding portions thereof specifically bind to toxin A with a K_D of less than about 20×10^{-6} M. In a particular embodiment, the antibody, or antigen binding portion thereof, specifically binds to toxin A with a K_D of less than about 10×10^{-7} M, less than about 10×10^{-8} M, less than about 10×10^{-9} M, or less than about 10×10^{-10} M. In other particular embodiments, the antibody, or antigen binding portion thereof, specifically binds to toxin A with a K_D of M, less than about 50×10^{-10} m less than about 20×10^{-10} M, less than about 15×10^{-10} M, less than about 8×10^{-10} M, or less than about 5×10^{-10} M.

[0016] In various other embodiments, the antibodies or antigen binding portions thereof include a variable heavy chain region including an amino acid sequence at least 80%, 85%, 90%, 95%, 98%, 99%, or more identical to a variable heavy chain region amino acid sequence of the antibody produced by clone 3D8 (SEQ ID NO:1), 1B11 (SEQ ID NO:2), or 3H2 (SEQ ID NO:3).

[0017] In certain embodiments, the antibodies or antigen binding portions thereof include a variable light chain region comprising an amino acid sequence at least 80%, 85%, 90%, 95%, 98%, 99%, or more identical to a variable light chain

region amino acid sequence of the antibody produced by clone 3D8 (SEQ ID NO:4), 1B11 (SEQ ID NO:5), or 3H2 (SEQ ID NO:6).

[0018] In certain embodiments, the antibodies or antigen binding portions thereof each include both a variable heavy chain region including an amino acid sequence at least 80%, 85%, 90%, 95%, 98%, 99%, or more identical to a variable heavy chain region amino acid sequence of the antibody produced by clone 3D8 (SEQ ID NO:1), 1B11 (SEQ ID NO:2), or 3H2 (SEQ ID NO:3), and a variable light chain region including an amino acid sequence at least 80%, 85%, 90%, 95%, 98%, 99%, or more identical to a variable light chain amino acid sequence of clone 3D8 (SEQ ID NO:4), 1B11 (SEQ ID NO:5), or 3H2 (SEQ ID NO:6).

[0019] In various embodiments, the antibodies or antigen binding portions thereof specifically bind to an epitope that overlaps with an epitope bound by an antibody produced by clone 3D8, 1B11, or 3H2 and/or compete for binding to toxin A with an antibody produced by clone 3D8, 1B11, or 3H2.

[0020] A variable heavy chain region of the antibodies or antigen binding portions thereof can include one or more complementarity determining regions (CDRs) that are at least 80%, 85%, 90%, 95%, or 99%, or more identical to a CDR of the antibody produced by clone 3D8 (SEQ ID NOs:7-9), 1B11 (SEQ ID NOs:10-12), or 3H2 (SEQ ID NOs:13-15) (also shown in Table 1).

[0021] A variable light chain region of the antibodies or antigen binding portions thereof can include one or more CDRs that are at least 80%, 85%, 90%, 95%, or 99%, or more identical to a CDR of a variable light chain region of the antibody produced by clone 3D8 (SEQ ID NOs:16-18), 1B11 (SEQ ID NOs:19-21), or 3H2 (SEQ ID NOs:22-24) (also shown in Table 2).

[0022] A variable heavy chain region of the antibodies or antigen binding portions thereof can include one or more complementarity determining regions (CDRs) that are at least 80%, 85%, 90%, 95%, or 99%, or more identical to a CDR of the antibody produced by clone 3D8 (SEQ ID NOs:7-9), 1B11 (SEQ ID NOs:10-12), or 3H2 (SEQ ID NOs:13-15), and a variable light chain region of the antibodies or antigen binding portions thereof can include one or more CDRs that are at least 80%, 85%, 90%, 95%, 99%, or more identical to a CDR of a variable light chain region of the antibody produced by clone 3D8 (SEQ ID NOs:16-18), 1B11 (SEQ ID NOs:19-21), or 3H2 (SEQ ID NOs:22-24).

[0023] A variable heavy chain region of the antibodies or antigen binding portions thereof can include three CDRs that are at least 80%, 85%, 90%, 95%, or 99%, or more identical to a CDR of a variable heavy chain region of the antibody produced by clone 3D8 (SEQ ID NOs:7-9), 1B11 (SEQ ID NOs:10-12), or 3H2 (SEQ ID NOs:13-15).

[0024] In some embodiments, a variable light chain region of the antibodies or antigen binding portions thereof includes three CDRs that are at least 80%, 85%, 90%, 95%, 99%, or more identical to a CDR of a variable light chain region of the antibody produced by clone 3D8 (SEQ ID NOs:16-18), 1B11 (SEQ ID NOs:19-21), or 3H2 (SEQ ID NOs:22-24).

[0025] In some embodiments, a variable light chain region of the antibodies or antigen binding portions thereof includes one or more CDRs that are at least 80%, 85%, 90%, 95%, or 99%, or more identical to a CDR of a variable light chain region of the antibody produced by clone 3D8 (SEQ ID NOs:16-18), 1B11 (SEQ ID NOs:19-21), or 3H2 (SEQ ID NOs:22-24), and a variable heavy chain region of the anti-

bodies or antigen binding portions thereof includes three CDRs that are at least 80%, 85%, 90%, 95%, or 99%, or more identical to a CDR of a variable heavy chain region of the antibody produced by clone 3D8 (SEQ ID NOs:7-9), 1B11 (SEQ ID NOs:10-12), or 3H2 (SEQ ID NOs:13-15). The variable light chain region can include three CDRs that are at least 80%, 85%, 90%, 95%, or 99%, or more identical to a CDR of a variable light chain region of the antibody produced by clone 3D8 (SEQ ID NOs:16-18), 1B11 (SEQ ID NOs:19-21), or 3H2 (SEQ ID NOs:22-24).

[0026] In certain embodiments, a variable heavy chain region of the antibodies or antigen binding portions thereof includes three CDRs that are identical to a CDR of a variable heavy chain region of the antibody produced by clone 3D8 (SEQ ID NOs:7-9), 1B11 (SEQ ID NOs:10-12), or 3H2 (SEQ ID NOs:13-15), and a variable light chain region of the antibodies or antigen binding portions thereof includes three CDRs that are identical to a CDR of a variable light chain region of the antibody produced by clone 3D8 (SEQ ID NOs:16-18), 1B11 (SEQ ID NOs:19-21), or 3H2 (SEQ ID NOs:22-24), e.g., a variable light chain region and variable heavy chain region of the antibody or antigen binding portion thereof are identical to a variable light chain region and variable heavy chain region of the antibody produced by clone 3D8 (SEQ ID NO:1, SEQ ID NO:4), 1B11 (SEQ ID NO:2, SEQ ID NO:5), or 3H2 (SEQ ID NO:3, SEQ ID NO:6).

[0027] In some embodiments, the antibodies or antigen binding portions thereof neutralize toxin B in vitro, inhibit binding of toxin B to mammalian cells, and/or neutralize toxin B in vivo.

[0028] In some embodiments, the antibodies or antigen binding portions thereof specifically bind to an epitope in a C-terminal portion of toxin B (e.g., between amino acids 1777-2366 of toxin B). Other particular antibodies or antigen binding portions thereof, can specifically bind to an epitope within amino acid residues 1-100, 100-200, 200-300, 300-400, 400-500, 500-600, 600-700, 700-800, 900-1000, 1100-1200, 1200-1300, 1300-1400, 1400-1500, 1500-1600, 1600-1700, 1800-1900, 1900-200, 2100-2200 or 2200-2366 of toxin B, or any interval, portion or range thereof.

[0029] In certain embodiments, the antibodies or antigen binding portions thereof specifically bind to toxin B with a K_D of less than about 20×10^{-6} M. In a particular embodiment, the antibody, or antigen binding portion thereof, specifically binds to toxin B with a K_D of less than about 10×10^{-7} M, less than about 10×10^{-8} M, less than about 10×10^{-9} M, or less than about 10×10^{-10} M. In other particular embodiments, the antibody, or antigen binding portion thereof, specifically binds to toxin B with a K_D of less than about 50×10^{-10} M, less than about 20×10^{-10} M, less than about 15×10^{-10} M, less than about 8×10^{-10} M, or less than about 5×10^{-10} M.

[0030] In various other embodiments, the antibodies or antigen binding portions thereof include a variable heavy chain region including an amino acid sequence that is at least 80%, 85%, 90%, 95%, 98%, 99%, or more identical to a variable heavy chain region amino acid sequence of the antibody produced by clone 124-152 (i.e., the amino acid sequence shown in SEQ ID NO:54), 2A11, or 1G10.

[0031] In certain embodiments, the antibodies or antigen binding portions thereof include a variable light chain region comprising an amino acid sequence that is at least 80%, 85%, 90%, 95%, 98%, 99%, or more identical to a variable heavy chain region amino acid sequence of the antibody produced

by clone 124-152 (i.e., the amino acid sequence shown in SEQ ID NO:58), 2A11, or 1G10.

[0032] In certain embodiments, the antibodies or antigen binding portions thereof each include both a variable heavy chain region including an amino acid sequence at least 80%, 85%, 90%, 95%, 98%, 99%, or more identical to a variable heavy chain region amino acid sequence of the antibody produced by clone 124-152 (i.e., the amino acid sequence shown in SEQ ID NO:54), 2A11, or 1G10, and a variable light chain region including an amino acid sequence that is at least 80%, 85%, 90%, 95%, 98%, 99%, or more identical to a variable light chain amino acid sequence of the antibody produced by clone 124-152 (i.e., the amino acid sequence shown in SEQ ID NO:58), 2A11, or 1G10.

[0033] In various embodiments, the antibodies or antigen binding portions thereof specifically bind to an epitope that overlaps with an epitope bound by an antibody produced by clone 124-152, 2A11, or 1G10 and/or compete for binding to toxin B with an antibody produced by clone 124-152, 2A11, or 1G10.

[0034] A variable heavy chain region of the antibodies or antigen binding portions thereof can include one or more complementarity determining regions (CDRs) that are at least 80%, 85%, 90%, 95%, or 99%, or more identical to a CDR of the antibody produced by clone 124-152 (SEQ ID NOs: 62, 64, or 66), 2A11, or 1G10 (Table 3).

[0035] A variable light chain region of the antibodies or antigen binding portions thereof can include one or more complementarity determining regions (CDRs) that are at least 80%, 85%, 90%, 95%, or 99%, or more identical to a CDR of the antibody produced by clone 124-152 (SEQ ID NOs: 68, 70, or 72), 2A11, or 1G10 (Table 4).

[0036] A variable heavy chain region of the antibodies or antigen binding portions thereof can include one or more complementarity determining regions (CDRs) that are at least 80%, 85%, 90%, 95%, or 99%, or more identical to a CDR of the antibody produced by clone 124-152 (SEQ ID NOs: 62, 64, or 66), 2A11, or 1G10, and a variable light chain region of the antibodies or antigen binding portions thereof can include one or more CDRs that are at least 80%, 85%, 90%, 95%, 99%, or more identical to a CDR of a variable light chain region of the antibody produced by clone 124-152 (SEQ ID NOs: 68, 70, or 72), 2A11, or 1G10.

[0037] A variable heavy chain region of the antibodies or antigen binding portions thereof can include three CDRs that are at least 80%, 85%, 90%, 95%, or 99%, or more identical to a CDR of a variable heavy chain region of the antibody produced by clone 124-152 (SEQ ID NOs: 62, 64, or 66), 2A11, or 1G10.

[0038] In certain embodiments, the variable light chain region of the antibodies or antigen binding portions thereof includes three CDRs that are at least 80%, 85%, 90%, 95%, 99%, or more identical to a CDR of a variable light chain region of the antibody produced by clone 124-152 (SEQ ID NOs: 68, 70, or 72), 2A11, or 1G10.

[0039] In other embodiments, the variable light chain region of the antibodies or antigen binding portions thereof includes one or more CDRs that are at least 80%, 85%, 90%, 95%, or 99%, or more identical to a CDR of a variable light chain region of the antibody produced by clone 124-152 (SEQ ID NOs: 68, 70, or 72), 2A11, or 1G10, and a variable heavy chain region of the antibodies or antigen binding portions thereof includes three CDRs that are at least 80%, 85%, 90%, 95%, or 99%, or more identical to a CDR of a variable

heavy chain region of the antibody produced by clone 124-152 (SEQ ID NOs: 62, 64, or 66), 2A11, or 1G10. The variable light chain region can include three CDRs that are at least 80%, 85%, 90%, 95%, or 99%, or more identical to a CDR of a variable light chain region of the antibody produced by clone 124-152 (SEQ ID NOs: 68, 70, or 72), 2A11, or 1G10.

[0040] In still other embodiments, the variable heavy chain region of the antibodies or antigen binding portions thereof includes three CDRs that are identical to a CDR of a variable heavy chain region of the antibody produced by clone 124-152 (SEQ ID NOs: 62, 64, or 66), 2A11, or 1G10, and a variable light chain region of the antibodies or antigen binding portions thereof includes three CDRs that are identical to a CDR of a variable light chain region of the antibody produced by clone 124-152 (SEQ ID NOs: 68, 70, or 72), 2A11, or 1G10, e.g., a variable light chain region and variable heavy chain region of the antibody or antigen binding portion thereof are identical to a variable light chain region and variable heavy chain region of the antibody produced by clone 124-152 (SEQ ID NOs: 62, 64, or 66), 2A11, or 1G10.

[0041] The antibodies or antigen binding portions thereof can be full-length antibodies, can include an effector domain, e.g., an Fc domain, can be immunoglobulin gamma isotype antibodies, single-chain antibodies, or Fab fragments. The antibodies or antigen binding portions thereof can further include a pharmaceutically acceptable carrier and/or a label.

[0042] In various embodiments, compositions including the antibodies or antigen binding portions thereof are free of other human polypeptides (e.g., they contain less than 5% human polypeptides other than the antibodies or antigen binding portions thereof).

[0043] In yet another aspect, the invention features compositions including: (a) an isolated human monoclonal antibody or antigen binding portion thereof that specifically binds to an exotoxin of *C. difficile*; and (b) a polyclonal antibody or antigen binding portion thereof that specifically binds to an exotoxin of *C. difficile*.

[0044] In one embodiment, the human monoclonal antibody or antigen binding portion thereof specifically binds to *C. difficile* toxin A, and the polyclonal antibody or antigen binding portion thereof specifically binds to *C. difficile* toxin B. In one embodiment, the human monoclonal antibody or antigen binding portion thereof specifically binds to *C. difficile* toxin B, and the polyclonal antibody or antigen binding portion thereof specifically binds to *C. difficile* toxin A. The antibodies can include other features described herein.

[0045] In another aspect, the invention features isolated human monoclonal antibodies or antigen binding portions thereof that specifically bind to an exotoxin of *Clostridium difficile* (*C. difficile*), wherein the antibodies: (a) include a heavy chain variable region that is the product of or derived from a human VH 3-33 gene; and/or (b) include a light chain variable region that is the product of or derived from a human V κ gene selected from the group consisting of V κ L19, V κ L6 and V κ L15. The antibodies or antigen binding portions thereof can include other features described herein.

[0046] In another aspect, the invention features isolated human monoclonal antibodies or antigen binding portions thereof that specifically bind to an exotoxin of *Clostridium difficile* (*C. difficile*), wherein the antibodies: (a) include a heavy chain variable region that is the product of or derived from a human VH 5-51 gene; and/or (b) include a light chain variable region that is the product of or derived from a human

V κ A27 gene. The antibodies or antigen binding portions thereof also can include other features described herein.

[0047] In another aspect, the invention features isolated polypeptides that include an antigen binding portion of an antibody produced by hybridoma clone 3D8, 1B11, or 3H2 (also referred to herein as "3D8", "1B11", and "3H2").

[0048] In another aspect, the invention features isolated polypeptides that include an antigen binding portion of an antibody produced by hybridoma clone 124-152, 2A11, or 1G10 (also referred to herein as "124-152", "2A11", and "1G10").

[0049] In another aspect, the invention features isolated monoclonal antibodies or antigen binding portions thereof that specifically bind to an exotoxin of *C. difficile*, neutralize the toxin, inhibit, and/or protect from *C. difficile*-mediated disease. In one embodiment, the antibodies or antigen binding portions thereof are mammalian (e.g., human) antibodies or antigen binding portions thereof. The antibodies or antigen binding portions thereof can include other features described herein.

[0050] In another aspect, the invention features compositions including: (a) an isolated human monoclonal antibody or antigen binding portion thereof that specifically binds to *C. difficile* toxin A; and (b) an isolated human monoclonal antibody or antigen binding portion thereof that specifically binds to *C. difficile* toxin B.

[0051] In another aspect, the invention features isolated nucleic acids including a sequence encoding polypeptides at least 75%, 80%, 85%, 90%, 95%, 99%, or more identical to SEQ ID NOs: 1, 2, 3, 4, 5, or 6; e.g., wherein the nucleic acid sequence is at least 75%, 80%, 85%, 90%, 95%, 99%, or more identical to SEQ ID NOs: 38, 39, 40, 35, 36, or 37. The invention also features expression vectors including a nucleic acid encoding a polypeptide at least 75%, 80%, 85%, 90%, 95%, 99%, or more identical to SEQ ID NOs: 1, 2, 3, 4, 5, or 6; e.g., wherein the nucleic acid sequence is at least 75%, 80%, 85%, 90%, 95%, 99%, or more identical to SEQ ID NOs: 38, 39, 40, 35, 36, or 37, as well as host cells, e.g., bacterial cells, e.g., *E. coli* cells, including a nucleic acid encoding a polypeptide at least 75%, 80%, 85%, 90%, 95%, 99%, or more identical to SEQ ID NOs: 1, 2, 3, 4, 5, or 6; e.g., wherein the nucleic acid sequence is at least 75%, 80%, 85%, 90%, 95%, 99%, or more identical to SEQ ID NOs: 38, 39, 40, 35, 36, or 37.

[0052] In another aspect, the invention features isolated nucleic acids including a sequence encoding a polypeptide that is at least 75%, 80%, 85%, 90%, 95%, 99%, or more identical to SEQ ID NOs: 54, 56, 58, or 60, for example, wherein the nucleic acid sequence is at least 75%, 80%, 85%, 90%, 95%, 99%, or more identical to SEQ ID NOs: 55, 57, 59, or 61. The invention also features expression vectors including a nucleic acid encoding a polypeptide at least 75%, 80%, 85%, 90%, 95%, 99%, or more identical to SEQ ID NOs: 54, 56, 58, or 60, for example, wherein the nucleic acid sequence is at least 75%, 80%, 85%, 90%, 95%, 99%, or more identical to SEQ ID NOs: 55, 57, 59, or 61. The invention also provides host cells, e.g., bacterial cells, e.g., *E. coli* cells, that include a nucleic acid encoding a polypeptide that is at least 75%, 80%, 85%, 90%, 95%, 99%, or more identical to SEQ ID NOs: 54, 56, 58, or 60, for example, wherein the nucleic acid sequence is at least 75%, 80%, 85%, 90%, 95%, 99%, or more identical to SEQ ID NOs: 55, 57, 59, or 61.

[0053] The host cells can also be eukaryotic cells, e.g., yeast cells, mammalian cells, e.g., Chinese hamster ovary (CHO) cells, NS0 cells, or myeloma cells.

[0054] In another aspect, the invention features kits including an isolated human monoclonal antibody or antigen binding portion thereof that specifically binds to an exotoxin of *Clostridium difficile* (*C. difficile*), e.g., an antibody or antigen binding portion thereof described herein. The kit can include instructions for use in preventing or treating *C. difficile*-mediated disease.

[0055] The kit can further include a polyclonal antibody or antigen binding portion thereof that specifically binds an exotoxin of *C. difficile*. In one embodiment, the human monoclonal antibody or antigen binding portion thereof specifically binds to *C. difficile* toxin A. In one embodiment, the polyclonal antibody or antigen binding portion thereof specifically binds to *C. difficile* toxin B.

[0056] In another aspect, the invention features kits including: (a) an isolated human monoclonal antibody that specifically binds to *C. difficile* toxin A; and (b) an isolated human monoclonal antibody that specifically binds to *C. difficile* toxin B.

[0057] The invention also features methods of treating *C. difficile* disease in a subject by administering to the subject an isolated human monoclonal antibody or antigen binding portion thereof that specifically binds to an exotoxin of *Clostridium difficile* (*C. difficile*) in an amount effective to inhibit *C. difficile* disease, e.g., *C. difficile*-mediated colitis, antibiotic-associated colitis, *C. difficile*-mediated pseudomembranous colitis (PMC), or diarrhea, or relapse of *C. difficile*-mediated disease. The antibody or antigen binding portion thereof can be administered, e.g., intravenously, intramuscularly, or subcutaneously, to the subject.

[0058] The antibody or antigen binding portion thereof can be administered alone or in combination with another therapeutic agent, e.g., a second human monoclonal antibody or antigen binding portion thereof. In one example, the antibody or antigen binding portion thereof specifically binds to *C. difficile* toxin A, and the second human monoclonal antibody or antigen binding portion thereof specifically binds to *C. difficile* toxin B. In another example, the second agent is an antibiotic, e.g., vancomycin or metronidazole. The second agent can be polyclonal gamma-globulin (e.g., human gamma-globulin).

[0059] In a particular embodiment, an antibody or antigen binding portion thereof is administered which includes a variable light chain region and a variable heavy chain region identical to the variable light chain region and variable heavy chain region of the antibody produced by clone 3D8 (i.e., including a variable light chain region sequence identical to SEQ ID NO:4 and a variable heavy chain region sequence identical to SEQ ID NO:1).

[0060] In another embodiment, this antibody or antigen binding portion thereof is administered in combination with an antibody or antigen binding portion thereof which includes a variable light chain region and a variable heavy chain region identical to the variable light chain region and variable heavy chain region of the antibody produced by clone 124-152 (i.e., including a variable light chain region sequence identical to SEQ ID NO:58 and a variable heavy chain region sequence identical to SEQ ID NO:54).

[0061] In yet another embodiment, an antibody or antigen binding portion produced by clone 3D8 (i.e., including a variable light chain region sequence identical to SEQ ID

NO:4 and a variable heavy chain region sequence identical to SEQ ID NO:1), is administered in combination with an antibody or antigen binding portion thereof produced by clone 124-152 (i.e., including a variable light chain region sequence identical to SEQ ID NO:58 and a variable heavy chain region sequence identical to SEQ ID NO:54).

[0062] In another aspect, the invention features methods for making an antibody or antigen binding portion thereof that specifically binds to an exotoxin of *C. difficile*, by immunizing a transgenic non-human animal having a genome comprising a human heavy chain transgene and a human light chain transgene with a composition that includes an inactivated exotoxin, and isolating an antibody from the animal. The exotoxin can be inactivated, for example, by treatment with UDP-dialdehyde or by mutation (e.g., using recombinant methods). The method can further include evaluating binding of the antibody to the exotoxin.

[0063] The invention also features methods for making a human monoclonal antibody or antigen binding portion thereof by providing a nucleic acid encoding a human monoclonal antibody or antigen binding portion thereof that specifically binds to an exotoxin of *C. difficile*, and expressing the nucleic acid in a host cell.

[0064] In yet another aspect, the invention features a hybridoma or transfectoma including a nucleic acid encoding antigen binding portions (e.g., CDRs, or variable regions) of the antibody produced by clone 3D8, 1B11, or 3H2.

[0065] In yet another aspect, the invention features a hybridoma or transfectoma including a nucleic acid encoding antigen binding portions (e.g., CDRs, or variable regions) of the antibody produced by clone 124-152, 2A11, or 1G10.

[0066] In addition, the invention features a method for making a hybridoma that expresses an antibody that specifically binds to an exotoxin of *C. difficile* by immunizing a transgenic non-human animal having a genome that includes a human heavy chain transgene and a human light chain transgene, with a composition that includes the exotoxin, wherein the toxin is inactivated; isolating splenocytes from the animal; generating hybridomas from the splenocytes; and selecting a hybridoma that produces an antibody that specifically binds to the exotoxin.

[0067] Treatment of humans with human monoclonal antibodies offers several advantages. For example, the antibodies are likely to be less immunogenic in humans than non-human antibodies. The therapy is rapid; toxin inactivation can occur as soon as the antibody reaches sites of infection and directly neutralizes the disease-causing toxin(s). Human antibodies localize to appropriate sites in humans more efficiently than non-human antibodies. Furthermore, the treatment is specific for *C. difficile*, and is unlikely to disrupt normal gut flora, unlike traditional antibiotic therapies.

[0068] Other features and advantages of the invention will be apparent from the following detailed description, and from the claims.

BRIEF DESCRIPTION OF THE DRAWINGS

[0069] FIG. 1 is a table listing the amino acid sequences of the VH and VL chains encoded by mRNA sequences from each clone. Lowercase letters represent amino acids in the leader peptide. CDRs are underlined. Clone 3D8, which expresses 6 unique light chain V regions, only expressed the group I amino acid sequence.

[0070] FIG. 2A is a representation of the amino acid and nucleic acid sequences of the VL chain expressed by clone

3D8. The V-segment and J-segment genes are listed above the amino acid and nucleic acid sequences. The CDRs are overlined.

[0071] FIG. 2B is a representation of the amino acid and nucleic acid sequences of the VH chain expressed by clone 3D8. The V-segment, D-segment and J-segment genes are listed above the amino acid and nucleic acid sequences. The CDRs are overlined.

[0072] FIG. 3A is a representation of the amino acid and nucleic acid sequences of the VL chain expressed by clone 1B11. The V-segment and J-segment genes are listed above the amino acid and nucleic acid sequences. The CDRs are overlined.

[0073] FIG. 3B is a representation of the amino acid and nucleic acid sequences of the VH chain expressed by clone 1B11. The V-segment, D-segment, and J-segment genes are listed above the amino acid and nucleic acid sequences. The CDRs are overlined.

[0074] FIG. 4A is a representation of the amino acid and nucleic acid sequences of the VL chain expressed by clone 33.3H2 (referred to herein as 3H2; 33.3H2 and 3H2 are used interchangeably herein). The V-segment and J-segment genes are listed above the amino acid and nucleic acid sequences. The CDRs are overlined.

[0075] FIG. 4B is a representation of the amino acid and nucleic acid sequences of the VH chain expressed by clone 33.3H2. The V-segment and J-segment genes are listed above the amino acid and nucleic acid sequences. The CDRs are overlined.

[0076] FIG. 5 is a graph depicting the results of ELISA assays, which measured binding of anti-toxin A monoclonal antibodies to toxin A.

[0077] FIGS. 6A-B are a set of graphs depicting results of in vitro neutralization assays in the presence and absence of anti-toxin A monoclonal antibodies. FIG. 6A depicts results for assays performed with IMR-90 cells. FIG. 6B depicts results for assays performed with T-84 cells.

[0078] FIG. 7 is a schematic representation of the toxin A polypeptide, indicating fragments that were analyzed for epitope mapping studies.

[0079] FIG. 8A-B are schematic representations of toxin A fragments analyzed for epitope mapping studies.

[0080] FIG. 9 is a table listing the results of in vivo assays to determine mouse protection from lethal challenge with toxin A by anti-toxin A monoclonal antibodies.

[0081] FIG. 10 is a graph depicting the results of mouse ileal loop fluid accumulation assays to measure efficacy of anti-toxin antibody neutralization in vivo.

[0082] FIG. 11A is a schematic diagram of the timeline of administration of various agents to hamsters in a hamster relapse model.

[0083] FIG. 11B is a graph depicting the results of the assays as the percentage of hamsters surviving clindamycin treatment followed by *C. difficile* challenge.

[0084] FIG. 12 is a graph depicting results of hamster relapse assays as the percentage of hamsters surviving clindamycin treatment followed by *C. difficile* challenge.

[0085] FIG. 13 is a graph depicting results of assays in which in vitro neutralization of toxin A and toxin B was measured in the presence and absence of polyclonal antisera from goats immunized with toxoid B. "G330" refers to samples in which sera from goat #330 were tested. "G331" refers to samples in which sera from goat #331 were tested.

[0086] FIG. 14 is a schematic diagram of the timeline of administration of various agents to hamsters in a hamster relapse model.

[0087] FIG. 15 is a graph depicting the results of hamster relapse assays as the percentage of hamsters surviving clindamycin treatment followed by *C. difficile* challenge. Hamsters were treated with vancomycin, vancomycin and 3D8, vancomycin and antisera from goat #331, or vancomycin, 3D8, and antisera from goat #331.

[0088] FIG. 16 is a graph depicting the results of hamster relapse assays as the percentage of healthy animals after clindamycin treatment followed by *C. difficile* challenge. "Goat 331" refers to antisera from goat #331.

[0089] FIG. 17 is a graph depicting the results of hamster relapse assays as the percentage of hamsters surviving clindamycin treatment followed by *C. difficile* challenge. Hamsters were immunized with a fragment of toxin B prior to clindamycin treatment. Hamsters were treated with vancomycin, vancomycin and 3D8, or received no treatment.

[0090] FIG. 18 is a graph depicting the results of hamster relapse assays as the percentage of healthy animals after clindamycin treatment followed by *C. difficile* challenge. Hamsters were immunized with a fragment of toxin B prior to clindamycin treatment.

[0091] FIG. 19 is a schematic diagram of the timeline of administration of various agents to hamsters in a *C. difficile* direct challenge model. "331" refers to antisera from goat #331. "Clinda" refers to treatment with clindamycin.

[0092] FIG. 20 is a graph depicting the results of direct challenge assays as the percentage of hamsters surviving direct *C. difficile* challenge.

[0093] FIG. 21 is a graph depicting the results of direct challenge assays as the percentage of healthy animals after direct challenge with *C. difficile*.

[0094] FIG. 22 is a representation of the amino acid sequence of *C. difficile* toxin A.

[0095] FIG. 23 is a representation of the amino acid sequence of *C. difficile* toxin B.

[0096] FIG. 24 is a graph depicting the results of primary challenge assays as the percentage of hamsters surviving direct *C. difficile* challenge.

[0097] FIG. 25 is a graph depicting the results of primary challenge assays as the percentage of hamsters surviving direct *C. difficile* challenge.

[0098] FIG. 26 is a graph depicting the results of primary challenge assays as the percentage of hamsters surviving direct *C. difficile* challenge.

[0099] FIG. 27 is a graph depicting results of assays in which in vitro neutralization of toxin A and toxin B was measured in the presence of monoclonal antibodies to toxin B or goat polyclonal sera against toxin B.

[0100] FIG. 28 is a representation of the amino acid and nucleic acid sequences of the VH chain expressed by clone 124-152. The V-segment, D-segment and J-segment genes are listed above the amino acid and nucleic acid sequences. The CDRs are overlined.

[0101] FIG. 29 is a representation of the amino acid and nucleic acid sequences of the VL chain expressed by clone 124-152. The V-segment and J-segment genes are listed above the amino acid and nucleic acid sequences. The CDRs are overlined.

[0102] FIG. 30 is a representation of the amino acid and related germline sequence of the VH chain expressed by clone

124-152. The V-segment, D-segment and J-segment genes are listed above the amino acid sequences. The CDRs are overlined.

[0103] FIG. 31 is a representation of the amino acid and related germline sequences of the VL chain expressed by clone 124-152. The V-segment and J-segment genes are listed above the amino acid sequences. The CDRs are overlined.

[0104] FIG. 32 is a schematic representation of the toxin B polypeptide, indicating fragments that were analyzed for epitope mapping studies.

[0105] Like reference symbols in the various drawings indicate like elements.

DETAILED DESCRIPTION OF THE INVENTION

[0106] In order to provide a clear understanding of the specification and claims, the following definitions are conveniently provided below.

DEFINITIONS

[0107] The term “toxin A” refers to the toxin A protein encoded by *C. difficile*. The amino acid sequence of *C. difficile* toxin A (SEQ ID NO:41) is provided in GenBank® under accession number A37052, version GI 98593 (see also FIG. 22). “Toxin B” refers to the toxin B protein encoded by *C. difficile*. The amino acid sequence of *C. difficile* toxin B (SEQ ID NO: 42) is provided in GenBank® under accession number 570172, version GI 7476000 (see also FIG. 23). “Protein” is used interchangeably with “polypeptide.”

[0108] An “anti-*C. difficile* antibody” is an antibody that interacts with (e.g., binds to) a protein or other component produced by *C. difficile* bacteria. An “anti-toxin antibody” is an antibody that interacts with a toxin produced by *C. difficile* (e.g., toxin A or toxin B). An anti-toxin protein antibody may bind to an epitope, e.g., a conformational or a linear epitope, or to a fragment of the full-length toxin protein.

[0109] A “human antibody,” is an antibody that has variable and constant regions derived from human germline immunoglobulin sequences. The human antibodies described herein may include amino acid residues not encoded by human germline immunoglobulin sequences (e.g., mutations introduced by random or site-specific mutagenesis in vitro or by somatic mutation in vivo).

[0110] An anti-toxin antibody, or antigen binding portion thereof, can be administered alone or in combination with a second agent. The subject can be a patient infected with *C. difficile*, or having a symptom of *C. difficile*-associated disease (“CDAD”; e.g., diarrhea, colitis, abdominal pain) or a predisposition towards *C. difficile*-associated disease (e.g., undergoing treatment with antibiotics, or having experienced *C. difficile*-associated disease and at risk for relapse of the disease). The treatment can be to cure, heal, alleviate, relieve, alter, remedy, ameliorate, palliate, improve, or affect the infection and the disease associated with the infection, the symptoms of the disease, or the predisposition toward the disease.

[0111] An amount of an anti-toxin antibody effective to treat a CDAD, or a “therapeutically effective amount,” is an amount of the antibody that is effective, upon single or multiple dose administration to a subject, in inhibiting CDAD in a subject. A therapeutically effective amount of the antibody or antibody fragment may vary according to factors such as the disease state, age, sex, and weight of the individual, and the ability of the antibody or antibody portion to elicit a

desired response in the individual. A therapeutically effective amount is also one in which any toxic or detrimental effects of the antibody or antibody portion is outweighed by the therapeutically beneficial effects. The ability of an antibody to inhibit a measurable parameter can be evaluated in an animal model system predictive of efficacy in humans. For example, the ability of an anti-toxin antibody to protect mice from lethal challenge with *C. difficile* can predict efficacy in humans. Other animal models predictive of efficacy are described herein, such as the intestinal ligation model described in the Examples. Alternatively, this property of an antibody or antibody composition can be evaluated by examining the ability of the compound to modulate, such modulation in vitro by assays known to the skilled practitioner. In vitro assays include binding assays, such as ELISA, and neutralization assays.

[0112] An amount of an anti-toxin antibody effective to prevent a disorder, or a “a prophylactically effective amount,” of the antibody is an amount that is effective, upon single- or multiple-dose administration to the subject, in preventing or delaying the occurrence of the onset or recurrence of CDAD, or inhibiting a symptom thereof. However, if longer time intervals of protection are desired, increased doses can be administered.

[0113] The terms “agonize,” “induce,” “inhibit,” “potentiate,” “elevate,” “increase,” “decrease,” or the like, e.g., which denote quantitative differences between two states, refer to a difference, e.g., a statistically or clinically significant difference, between the two states.

[0114] As used herein, “specific binding” or “specifically binds to” refers to the ability of an antibody to: (1) bind to a toxin of *C. difficile* with an affinity of at least $1 \times 10^7 \text{ M}^{-1}$, and (2) bind to a toxin of *C. difficile* with an affinity that is at least two-fold greater than its affinity for a nonspecific antigen.

[0115] An “antibody” is a protein including at least one or two, heavy (H) chain variable regions (abbreviated herein as VHC), and at least one or two light (L) chain variable regions (abbreviated herein as VLC). The VHC and VLC regions can be further subdivided into regions of hypervariability, termed “complementarity determining regions” (“CDR”), interspersed with regions that are more conserved, termed “framework regions” (FR). The extent of the framework region and CDRs has been precisely defined (see, Kabat, E. A., et al. *Sequences of Proteins of Immunological Interest*, Fifth Edition, U.S. Department of Health and Human Services, NIH Publication No. 91-3242, 1991, and Chothia, C. et al., *J. Mol. Biol.* 196:901-917, 1987, which are incorporated herein by reference). Preferably, each VHC and VLC is composed of three CDRs and four FRs, arranged from amino-terminus to carboxy-terminus in the following order: FR1, CDR1, FR2, CDR2, FR3, CDR3, FR4.

[0116] The VHC or VLC chain of the antibody can further include all or part of a heavy or light chain constant region. In one embodiment, the antibody is a tetramer of two heavy immunoglobulin chains and two light immunoglobulin chains, wherein the heavy and light immunoglobulin chains are inter-connected by, e.g., disulfide bonds. The heavy chain constant region includes three domains, CH1, CH2 and CH3. The light chain constant region is comprised of one domain, CL. The variable region of the heavy and light chains contains a binding domain that interacts with an antigen. The constant regions of the antibodies typically mediate the binding of the antibody to host tissues or factors, including various cells of the immune system (e.g., effector cells) and the first compo-

ment (Clq) of the classical complement system. The term “antibody” includes intact immunoglobulins of types IgA, IgG, IgE, IgD, IgM (as well as subtypes thereof), wherein the light chains of the immunoglobulin may be of types kappa or lambda.

[0117] “Immunoglobulin” refers to a protein consisting of one or more polypeptides substantially encoded by immunoglobulin genes. The recognized human immunoglobulin genes include the kappa, lambda, alpha (IgA1 and IgA2), gamma (IgG1, IgG2, IgG3, IgG4), delta, epsilon, and mu constant region genes, as well as the myriad immunoglobulin variable region genes. Full-length immunoglobulin “light chains” (about 25 KD and 214 amino acids) are encoded by a variable region gene at the NH₂-terminus (about 110 amino acids) and a kappa or lambda constant region gene at the COOH-terminus. Full-length immunoglobulin “heavy chains” (about 50 KD and 446 amino acids), are similarly encoded by a variable region gene (about 116 amino acids) and one of the other aforementioned constant region genes, e.g., gamma (encoding about 330 amino acids). The term “immunoglobulin” includes an immunoglobulin having: CDRs from a human or non-human source. The framework of the immunoglobulin can be human, humanized, or non-human, e.g., a murine framework modified to decrease antigenicity in humans, or a synthetic framework, e.g., a consensus sequence.

[0118] As used herein, “isotype” refers to the antibody class (e.g., IgM or IgG₁) that is encoded by heavy chain constant region genes.

[0119] The term “antigen binding portion” of an antibody (or simply “antibody portion,” or “portion”), as used herein, refers to a portion of an antibody that specifically binds to a toxin of *C. difficile* (e.g., toxin A), e.g., a molecule in which one or more immunoglobulin chains is not full length, but which specifically binds to a toxin. Examples of binding portions encompassed within the term “antigen-binding portion” of an antibody include (i) a Fab fragment, a monovalent fragment consisting of the VLC, VHC, CL and CH1 domains; (ii) a F(ab)₂ fragment, a bivalent fragment comprising two Fab fragments linked by a disulfide bridge at the hinge region; (iii) a Fd fragment consisting of the VHC and CH1 domains; (iv) a Fv fragment consisting of the VLC and VHC domains of a single arm of an antibody, (v) a dAb fragment (Ward et al., *Nature* 341:544-546, 1989), which consists of a VHC domain; and (vi) an isolated complementarity determining region (CDR) having sufficient framework to specifically bind, e.g., an antigen binding portion of a variable region. An antigen binding portion of a light chain variable region and an antigen binding portion of a heavy chain variable region, e.g., the two domains of the Fv fragment, VLC and VHC, can be joined, using recombinant methods, by a synthetic linker that enables them to be made as a single protein chain in which the VLC and VHC regions pair to form monovalent molecules (known as single chain Fv (scFv); see e.g., Bird et al. (1988) *Science* 242:423-426; and Huston et al. (1988) *Proc. Natl. Acad. Sci. USA* 85:5879-5883). Such single chain antibodies are also encompassed within the term “antigen binding portion” of an antibody. These antibody portions are obtained using conventional techniques known to those with skill in the art, and the portions are screened for utility in the same manner as are intact antibodies.

[0120] The term “monospecific antibody” refers to an antibody that displays a single binding specificity and affinity for a particular target, e.g., epitope. This term includes a “mono-

clonal antibody” or “monoclonal antibody composition,” which as used herein refer to a preparation of antibodies or portions thereof with a single molecular composition.

[0121] The term “recombinant” antibody, as used herein, refers to antibodies that are prepared, expressed, created, or isolated by recombinant means, such as antibodies expressed using a recombinant expression vector transfected into a host cell, antibodies isolated from a recombinant, combinatorial antibody library, antibodies isolated from an animal (e.g., a mouse) that is transgenic for human immunoglobulin genes or antibodies prepared, expressed, created, or isolated by any other means that involves splicing of human immunoglobulin gene sequences to other DNA sequences. Such recombinant antibodies include humanized, CDR grafted, chimeric, in vitro generated (e.g., by phage display) antibodies, and may optionally include constant regions derived from human germline immunoglobulin sequences.

[0122] As used herein, the term “substantially identical” (or “substantially homologous”) refers to a first amino acid or nucleotide sequence that contains a sufficient number of identical or equivalent (e.g., with a similar side chain, e.g., conserved amino acid substitutions) amino acid residues or nucleotides to a second amino acid or nucleotide sequence such that the first and second amino acid or nucleotide sequences have similar activities. In the case of antibodies, the second antibody has the same specificity and has at least 50% of the affinity of the first antibody.

[0123] Calculations of “homology” between two sequences are performed as follows. The sequences are aligned for optimal comparison purposes (e.g., gaps can be introduced in one or both of a first and a second amino acid or nucleic acid sequence for optimal alignment and non-homologous sequences can be disregarded for comparison purposes). The length of a reference sequence aligned for comparison purposes is at least 50% of the length of the reference sequence. The amino acid residues or nucleotides at corresponding amino acid positions or nucleotide positions are then compared. When a position in the first sequence is occupied by the same amino acid residue or nucleotide as the corresponding position in the second sequence, then the molecules are identical at that position (as used herein amino acid or nucleic acid “identity” is equivalent to amino acid or nucleic acid “homology”). The percent identity between the two sequences is a function of the number of identical positions shared by the sequences, taking into account the number of gaps, and the length of each gap, which need to be introduced for optimal alignment of the two sequences.

[0124] The comparison of sequences and determination of percent homology between two sequences can be accomplished using a mathematical algorithm. The percent homology between two amino acid sequences is determined using the Needleman and Wunsch, *J. Mol. Biol.* 48:444-453, 1970, algorithm which has been incorporated into the GAP program in the GCG software package, using a Blossum 62 scoring matrix with a gap penalty of 12, a gap extend penalty of 4, and a frameshift gap penalty of 5.

[0125] As used herein, the term “hybridizes under low stringency, medium stringency, high stringency, or very high stringency conditions” describes conditions for hybridization and washing. Guidance for performing hybridization reactions can be found in *Current Protocols in Molecular Biology*, John Wiley & Sons, N.Y. 6.3.1-6.3.6, 1989, which is incorporated herein by reference. Aqueous and nonaqueous methods are described in that reference and either can be

used. Specific hybridization conditions referred to herein are as follows: 1) low stringency hybridization conditions: 6× sodium chloride/sodium citrate (SSC) at about 45° C., followed by two washes in 0.2×SSC, 0.1% SDS at least at 50° C. (the temperature of the washes can be increased to 55° C. for low stringency conditions); 2) medium stringency hybridization conditions: 6×SSC at about 45° C., followed by one or more washes in 0.2×SSC, 0.1% SDS at 60° C.; 3) high stringency hybridization conditions: 6×SSC at about 45° C., followed by one or more washes in 0.2×SSC, 0.1% SDS at 65° C.; and 4) very high stringency hybridization conditions: 0.5 M sodium phosphate, 7% SDS at 65° C., followed by one or more washes at 0.2×SSC, 1% SDS at 65° C.

[0126] It is understood that the antibodies and antigen binding portions thereof described herein may have additional conservative or non-essential amino acid substitutions, which do not have a substantial effect on the polypeptide functions. Whether or not a particular substitution will be tolerated, i.e., will not adversely affect desired biological properties, such as binding activity, can be determined as described in Bowie et al., *Science*, 247:1306-1310, 1990. A “conservative amino acid substitution” is one in which an amino acid residue is replaced with an amino acid residue having a similar side chain. Families of amino acid residues having similar side chains have been defined in the art. These families include amino acids with basic side chains (e.g., lysine, arginine, histidine), acidic side chains (e.g., aspartic acid, glutamic acid), uncharged polar side chains (e.g., asparagine, glutamine, serine, threonine, tyrosine, cysteine), nonpolar side chains (e.g., glycine, alanine, valine, leucine, isoleucine, proline, phenylalanine, methionine, tryptophan), beta-branched side chains (e.g., threonine, valine, isoleucine) and aromatic side chains (e.g., tyrosine, phenylalanine, tryptophan, histidine).

[0127] A “non-essential” amino acid residue is a residue that can be altered from the wild-type sequence of a polypeptide, such as a binding agent, e.g., an antibody, without substantially altering a biological activity, whereas an “essential” amino acid residue results in such a change.

[0128] Unless otherwise defined, all technical and scientific terms used herein have the same meaning as commonly understood by one of ordinary skill in the art to which this invention belongs. Although methods and materials similar or equivalent to those described herein can be used in the practice or testing of the present invention, suitable methods and materials are described below. All publications, patent applications, patents, and other references mentioned herein are incorporated by reference in their entirety. In case of conflict, the present specification, including definitions, will control. In addition, the materials, methods, and examples are illustrative only and not intended to be limiting.

Overview

[0129] *C. difficile* is a gram positive, toxin-producing bacterium that causes antibiotic-associated diarrhea and colitis in humans. Provided herein are methods and compositions for treatment and prevention of *C. difficile*-associated disease (CDAD). The compositions include antibodies that recognize proteins and other molecular components (e.g., lipids, carbohydrates, nucleic acids) of *C. difficile* bacteria, including antibodies that recognize toxins produced by *C. difficile* (e.g., toxin A and toxin B). In particular, human monoclonal antibodies are provided. In certain embodiments, these human monoclonal antibodies are produced in mice expressing

human immunoglobulin gene segments (described below). Combinations of anti-toxin antibodies are also provided.

[0130] The new methods include administering antibodies (and antigen-binding portions thereof) that bind to a *C. difficile* toxin to a subject to inhibit CDAD in the subject. For example, human monoclonal anti-toxin A antibodies described herein can neutralize toxin A and inhibit relapse of *C. difficile*-mediated disease. In other examples, combinations of anti-toxin A antibodies (e.g., anti-toxin A monoclonal antibodies) and anti-toxin B antibodies can be administered to inhibit primary disease and reduce the incidence of disease relapse. The human monoclonal antibodies may localize to sites of disease (e.g., the gut) in vivo.

1. Generation of Antibodies

Immunogens

[0131] In general, animals are immunized with antigens expressed by *C. difficile* to produce antibodies. For producing anti-toxin antibodies, animals are immunized with inactivated toxins, or toxoids. Toxins can be inactivated, e.g., by treatment with formaldehyde, glutaraldehyde, peroxide, or oxygen treatment (see, e.g., Relyveld et al., *Methods in Enzymology*, 93:24, 1983; Woodrow and Levine, eds., *New Generation Vaccines*, Marcel Dekker, Inc., New York, 1990). Mutant *C. difficile* toxins with reduced toxicity can be produced using recombinant methods (see, e.g., U.S. Pat. Nos. 5,085,862; 5,221,618; 5,244,657; 5,332,583; 5,358,868; and 5,433,945). For example, mutants containing deletions or point mutations in the toxin active site can be made. Recombinant fragments of the toxins can be used as immunogens. Another approach is to inactivate the toxin by treatment with UDP-dialdehyde (Genth et al., *Inf. and Immun.*, 68(3):1094-1101, 2000). This method preserves the native structure of the toxin more readily than other treatments, and thus can elicit antibodies more reactive to the native toxin. This method is also described in Example 1, below.

[0132] Anti-toxin antibodies that bind and neutralize toxin A can interact with specific epitopes of toxin A. For example, an anti-toxin A antibody can bind an epitope in an N-terminal region of toxin A (e.g., between amino acids 1-1033 of toxin A), or a C-terminal region (e.g., between amino acids 1853-2710 of toxin A). In one example, an antibody that binds and neutralizes toxin A binds to an epitope within amino acids 1853-2710 of toxin A.

[0133] Similarly, anti-toxin B antibodies can recognize a specific epitope of toxin B, e.g., an N-terminal epitope, or a C-terminal epitope. In one example, an antibody that binds and neutralizes toxin B binds to an epitope within amino acids 1777-2366 of toxin B.

Generation of Human Monoclonal Antibodies in HuMAb Mice

[0134] Monoclonal antibodies can be produced in a manner not possible with polyclonal antibodies. Polyclonal antisera vary from animal to animal, whereas monoclonal preparations exhibit a uniform antigenic specificity. Murine animal systems are useful to generate monoclonal antibodies, and immunization protocols, techniques for isolating and fusing splenocytes, and methods and reagents for producing hybridomas are well known. Monoclonal antibodies can be produced by a variety of techniques, including conventional monoclonal antibody methodology, e.g., the standard somatic

cell hybridization technique of Kohler and Milstein, *Nature*, 256: 495, 1975. See generally, Harlow, E. and Lane, D. *Antibodies: A Laboratory Manual*, Cold Spring Harbor Laboratory Press, Cold Spring Harbor, N. Y., 1988.

[0135] Although these standard techniques are known, it is desirable to use humanized or human antibodies rather than murine antibodies to treat human subjects, because humans mount an immune response to antibodies from mice and other species. The immune response to murine antibodies is called a human anti-mouse antibody or HAMA response (Schroff, R. et al., *Cancer Res.*, 45, 879-885, 1985) and is a condition that causes serum sickness in humans and results in rapid clearance of the murine antibodies from an individual's circulation. The immune response in humans has been shown to be against both the variable and the constant regions of murine immunoglobulins. Human monoclonal antibodies are safer for administration to humans than antibodies derived from other animals and human polyclonal antibodies.

[0136] One useful type of animal in which to generate human monoclonal antibodies is a transgenic mouse that expresses human immunoglobulin genes rather than its own mouse immunoglobulin genes. Such transgenic mice, e.g., "HuMAb™" mice, contain human immunoglobulin gene miniloci that encode unrearranged human heavy (μ and γ) and κ light chain immunoglobulin sequences, together with targeted mutations that inactivate the endogenous 1.1 and x chain loci (see e.g., Lonberg, N. et al., *Nature* 368(6474): 856-859, 1994, and U.S. Pat. No. 5,770,429). Accordingly, the mice exhibit reduced expression of mouse IgM or κ , and in response to immunization, the introduced human heavy and light chain transgenes undergo class switching and somatic mutation to generate high affinity human IgG κ monoclonal antibodies (Lonberg, N. et al., supra; reviewed in Lonberg, N. *Handbook of Experimental Pharmacology* 113: 49-101, 1994; Lonberg, N. and Huszar, D., *Intern. Rev. Immunol.*, 13: 65-93, 1995, and Harding, F. and Lonberg, N., *Ann. N.Y. Acad. Sci.*, 764:536-546, 1995).

[0137] The preparation of such transgenic mice is described in further detail in Taylor, L. et al., *Nucleic Acids Research*, 20:6287-6295, 1992; Chen, J. et al., *International Immunology* 5: 647-656, 1993; Tuaille et al., *Proc. Natl. Acad. Sci., USA* 90:3720-3724, 1993; Choi et al., *Nature Genetics*, 4:117-123, 1993; Chen, J. et al., *EMBO J.*, 12: 821-830, 1993; Tuaille et al., *J. Immunol.*, 152:2912-2920, 1994; Taylor, L. et al., *International Immunology*, 6: 579-591, 1994; and Fishwild, D. et al., *Nature Biotechnology*, 14: 845-851, 1996. See further, U.S. Pat. No. 5,545,806; U.S. Pat. No. 5,569,825, U.S. Pat. No. 5,625,126, U.S. Pat. No. 5,633,425, U.S. Pat. No. 5,661,016, U.S. Pat. No. 5,770,429, U.S. Pat. No. 5,789,650, U.S. Pat. No. 5,814,318, U.S. Pat. No. 5,874,299 and U.S. Pat. No. 5,877,397, all by Lonberg and Kay, and PCT Publication Nos. WO 01/14424, WO 98/24884, WO 94/25585, WO 93/1227, and WO 92/03918.

[0138] To generate fully human monoclonal antibodies to an antigen, HuMAb mice can be immunized with an immunogen, as described by Lonberg, N. et al. *Nature*, 368(6474): 856-859, 1994; Fishwild, D. et al., *Nature Biotechnology*, 14: 845-851, 1996 and WO 98/24884. Preferably, the mice will be 6-16 weeks of age upon the first immunization. For example, a purified preparation of inactivated toxin A can be used to immunize the HuMAb mice intraperitoneally. To generate antibodies against *C. difficile* proteins, lipids, and/or carbohydrate molecules, mice can be immunized with killed or nonviable *C. difficile* organisms.

[0139] HuMAb transgenic mice respond best when initially immunized intraperitoneally (IP) with antigen in complete Freund's adjuvant, followed by IP immunizations every other week (up to a total of 6) with antigen in incomplete Freund's adjuvant. The immune response can be monitored over the course of the immunization protocol with plasma samples being obtained by retroorbital bleeds. The plasma can be screened, for example by ELISA or flow cytometry, and mice with sufficient titers of anti-toxin human immunoglobulin can be used for fusions. Mice can be boosted intravenously with antigen 3 days before sacrifice and removal of the spleen. It is expected that 2-3 fusions for each antigen may need to be performed. Several mice are typically immunized for each antigen.

[0140] The mouse splenocytes can be isolated and fused with PEG to a mouse myeloma cell line based upon standard protocols. The resulting hybridomas are then screened for the production of antigen-specific antibodies. For example, single cell suspensions of splenic lymphocytes from immunized mice are fused to one-sixth the number of P3X63-Ag8.653 nonsecreting mouse myeloma cells (ATCC, CRL 1580) with 50% PEG. Cells are plated at approximately 2×10^5 in flat bottom microtiter plate, followed by a two week incubation in selective medium containing 20% fetal Clone Serum, 18% "653" conditioned media, 5% origin (IGEN), 4 mM L-glutamine, 1 mM L-glutamine, 1 mM sodium pyruvate, 5 mM HEPES, 0.055 mM 2-mercaptoethanol, 50 units/ml penicillin, 50 mg/ml streptomycin, 50 mg/ml gentamycin and $1 \times$ HAT (Sigma; the HAT is added 24 hours after the fusion). After two weeks, cells are cultured in medium in which the HAT is replaced with HT. Supernatants from individual wells are then screened by ELISA for human anti-toxin cell monoclonal IgM and IgG antibodies. The antibody secreting hybridomas are replated, screened again, and if still positive for human IgG, anti-toxin monoclonal antibodies, can be subcloned at least twice by limiting dilution. The stable subclones are then cultured in vitro to generate small amounts of antibody in tissue culture medium for characterization.

[0141] In one embodiment, the transgenic animal used to generate human antibodies to the toxin contains at least one, typically 2-10, and sometimes 25-50 or more copies of the transgene described in Example 12 of WO 98/24884 (e.g., pHc1 or pHc2) bred with an animal containing a single copy of a light chain transgene described in Examples 5, 6, 8, or 14 of WO 98/24884, and the offspring bred with the J_H deleted animal described in Example 10 of WO 98/24884, the contents of which are hereby expressly incorporated by reference. Animals are bred to homozygosity for each of these three traits. Such animals have the following genotype: a single copy (per haploid set of chromosomes) of a human heavy chain unrearranged mini-locus (described in Example 12 of WO 98/24884), a single copy (per haploid set of chromosomes) of a rearranged human K light chain construct (described in Example 14 of WO 98/24884), and a deletion at each endogenous mouse heavy chain locus that removes all of the functional J_H segments (described in Example 10 of WO 98/24884). Such animals are bred with mice that are homozygous for the deletion of the J_H segments (Examples 10 of WO 98/24884) to produce offspring that are homozygous for the J_H deletion and hemizygous for the human heavy and light chain constructs. The resultant animals are injected with antigens and used for production of human monoclonal antibodies against these antigens.

[0142] B cells isolated from such an animal are monospecific with regard to the human heavy and light chains because they contain only a single copy of each gene. Furthermore, they will be monospecific with regard to human or mouse heavy chains because both endogenous mouse heavy chain gene copies are nonfunctional by virtue of the deletion spanning the J_H region introduced as described in Examples 9 and 12 of WO 98/24884. Furthermore, a substantial fraction of the B cells will be monospecific with regards to the human or mouse light chains, because expression of the single copy of the rearranged human kappa light chain gene will allelically and isotypically exclude the rearrangement of the endogenous mouse kappa and lambda chain genes in a significant fraction of B-cells.

[0143] In one embodiment, the transgenic mouse will exhibit immunoglobulin production with a significant repertoire, ideally substantially similar to that of a native mouse. Thus, for example, in embodiments where the endogenous Ig genes have been inactivated, the total immunoglobulin levels will range from about 0.1 to 10 mg/ml of serum, e.g., 0.5 to 5 mg/ml, or at least about 1.0 mg/ml. When a transgene capable of effecting a switch to IgG from IgM has been introduced into the transgenic mouse, the adult mouse ratio of serum IgG to IgM is preferably about 10:1. The IgG to IgM ratio will be much lower in the immature mouse. In general, greater than about 10%, e.g., about 40 to 80% of the spleen and lymph node B cells will express exclusively human IgG protein.

[0144] The repertoire in the transgenic mouse will ideally approximate that shown in a non-transgenic mouse, usually at least about 10% as high, preferably 25 to 50% or more as high. Generally, at least about a thousand different immunoglobulins (ideally IgG), preferably 10^4 to 10^6 or more, will be produced, depending primarily on the number of different V, J, and D regions introduced into the mouse genome. Typically, the immunoglobulins will exhibit an affinity for preselected antigens of at least about $10^7 M^{-1}$, $10^9 M^{-1}$, $10^{10} M^{-1}$, $10^{11} M^{-1}$, $10^{12} M^{-1}$, or greater, e.g., up to $10^{13} M^{-1}$ or greater.

[0145] HuMAb mice can produce B cells that undergo class-switching via intratransgene switch recombination (cis-switching) and express immunoglobulins reactive with the toxin. The immunoglobulins can be human sequence antibodies, wherein the heavy and light chain polypeptides are encoded by human transgene sequences, which may include sequences derived by somatic mutation and V region recombinatorial joints, as well as germline-encoded sequences. These human sequence immunoglobulins can be referred to as being substantially identical to a polypeptide sequence encoded by a human VL or VH gene segment and a human JL or JH segment, even though other non-germline sequences may be present as a result of somatic mutation and differential V-J and V-D-J recombination joints. With respect to such human sequence antibodies, the variable regions of each chain are typically at least 80 percent encoded by human germline V, J, and, in the case of heavy chains, D, gene segments. Frequently at least 85 percent of the variable regions are encoded by human germline sequences present on the transgene. Often 90 or 95 percent or more of the variable region sequences are encoded by human germline sequences present on the transgene. However, since non-germline sequences are introduced by somatic mutation and VJ and VDJ joining, the human sequence antibodies will frequently have some variable region sequences (and less frequently constant region sequences) that are not encoded by human V, D, or J gene segments as found in the human transgene(s) in

the germline of the mice. Typically, such non-germline sequences (or individual nucleotide positions) will cluster in or near CDRs, or in regions where somatic mutations are known to cluster.

[0146] The human sequence antibodies that bind to the toxin can result from isotype switching, such that human antibodies comprising a human sequence gamma chain (such as gamma 1, gamma 2, or gamma 3) and a human sequence light chain (such as K) are produced. Such isotype-switched human sequence antibodies often contain one or more somatic mutation(s), typically in the variable region and often in or within about 10 residues of a CDR as a result of affinity maturation and selection of B cells by antigen, particularly subsequent to secondary (or subsequent) antigen challenge. These high affinity human sequence antibodies have binding affinities of at least about $1 \times 10^9 M^{-1}$, typically at least $5 \times 10^9 M^{-1}$, frequently more than $1 \times 10^{10} M^{-1}$, and sometimes $5 \times 10^{10} M^{-1}$ to $1 \times 10^{11} M^{-1}$ or greater.

[0147] Anti-toxin antibodies can also be raised in other mammals, including non-transgenic mice, humans, rabbits, and goats.

Anti-Toxin A Antibodies

[0148] Human monoclonal antibodies that specifically bind to toxin A include antibodies produced by the 3D8, 1B11, and 3H2 clones described herein. Antibodies with variable heavy chain and variable light chain regions that are at least 80%, or more, identical to the variable heavy and light chain regions of 3D8, 1B11, and 3H2 can also bind to toxin A. In related embodiments, anti-toxin A antibodies include, for example, the complementarity determining regions (CDR) of variable heavy chains and/or variable light chains of 3D8, 1B11, or 3H2. The CDRs of the variable heavy chain regions from these clones are shown in Table 1, below.

TABLE 1

Variable Heavy Chain CDR Amino Acid Sequences				
Clone	Chain	CDR	Amino Acid Sequence	SEQ ID NO:
3D8	H	CDR1	NYGMH	7
1B11	H	CDR1	SYGMH	10
3H2	H	CDR1	KYGMH	13
3D8	H	CDR2	LIWYDGSNEDYTSVKG	8
1B11	H	CDR2	VIWASGNKYYIESVEG	11
3H2	H	CDR2	VIWYDGTNKYYADSMKG	14
3D8	H	CDR3	WGMVRGVIDVFDI	9
1B11	H	CDR3	ANFDY	12
3H2	H	CDR3	DPPTANY	15

[0149] The CDRs of the variable light chain regions from these clones are shown in table 2, below.

TABLE 2

Variable Light Chain CDR Amino Acid Sequences				
Clone	Chain	CDR	Amino Acid Sequence	SEQ ID NO:
3D8	L	CDR1	RASQGISSWLA	16
1B11	L	CDR1	RASQSVSSYLA	19
3H2	L	CDR1	RASQGISSWLA	22
3D8	L	CDR2	AASSLQS	17
1B11	L	CDR2	DASNRAT	20
3H2	L	CDR2	AASSLQS	23
3D8	L	CDR3	QQANSFPWT	18
1B11	L	CDR3	QQRSNWSQFT	21
3H2	L	CDR3	QQYKSYPT	24

[0150] CDRs are the portions of immunoglobulins that determine specificity for a particular antigen. In certain embodiments, CDRs corresponding to the CDRs in tables 1 and 2 having sequence variations (e.g., conservative substitutions) may bind to toxin A. For example, CDRs, in which 1, 2, 3, 4, or 5 residues, or less than 20% of total residues in the CDR, are substituted or deleted can be present in an antibody (or antigen binding portion thereof) that binds toxin A.

[0151] Similarly, anti-toxin antibodies can have CDRs containing a consensus sequence, as sequence motifs conserved amongst multiple antibodies can be important for binding activity. For example, CDR1 of a variable light chain region of the antibodies or antigen binding portions thereof can include the amino acid sequence R-A-S-Q-X-X-S-S-X-L-A (SEQ ID NO: 25), CDR2 of a variable light chain region of the antibodies or antigen binding portions thereof can include the amino acid sequence A-S-X-X-X-S/T (SEQ ID NO: 26), and/or CDR3 of a variable light chain region of the antibodies or antigen binding portions thereof can include the amino acid sequence Q-Q-X-X-S/N-X-P/S (SEQ ID NO: 27), wherein X is any amino acid.

[0152] In some embodiments, CDR1 of a variable heavy chain region of the antibodies or antigen binding portions thereof includes the amino acid sequence Y-G-M-H (SEQ ID NO: 28), and/or CDR2 of a variable heavy chain region of the antibodies or antigen binding portions thereof includes the amino acid sequence I-W-X-X-G-X-X-Y-X-X-S-X-X-G (SEQ ID NO: 29), wherein X is any amino acid.

[0153] Human anti-toxin antibodies can include variable regions that are the product of, or derived from, specific human immunoglobulin genes. For example, the antibodies can include a variable heavy chain region that is the product of, or derived from a human VH3-33 gene. Numerous sequences for antibodies derived from this gene are available in GenBank® (see, e.g., Acc. No: AJ555951, GI No: 29836865; Acc. No: AJ556080, GI No: 29837087; Acc. No: AJ556038, GI No: 29837012, and other human VH3-33 rearranged gene segments provided in GenBank®). The antibodies can also, or alternatively, include a light chain variable region that is the product of, or derived from a human Vκ L19 gene (see, e.g., GenBank® Acc. No. AJ556049, GI No: 29837033 for a partial sequence of a rearranged human Vκ L19 gene segment). As known in the art, and described in

this section, above, variable immunoglobulin regions of recombined antibodies are derived by a process of recombination *in vivo* in which variability is introduced to genomic segments encoding the regions. Accordingly, variable regions derived from a human VH-33 or Vκ L19 gene can include nucleotides that are different than those in the gene found in non-lymphoid tissues. These nucleotide differences are typically concentrated in the CDRs.

Anti-Toxin B Antibodies

[0154] Human monoclonal antibodies that specifically bind to toxin B include antibodies produced by the 124-152, 2A11, and 1G10 clones described herein. Antibodies with variable heavy chain and variable light chain regions that are at least 80%, or more, identical to the variable heavy and light chain regions of -152, 2A11, and 1G10 can also bind to toxin B. In related embodiments, anti-toxin B antibodies include, for example, the complementarity determining regions (CDR) of variable heavy chains and/or variable light chains of -152, 2A11, or 1G10. The CDRs of the variable heavy chain regions from these clones are shown in Table 3, below.

TABLE 3

Variable Heavy Chain CDR Amino Acid Sequences					
Clone	Chain	CDR	Amino Acid Sequence	SEQ ID NO: (a.a.)	SEQ ID NO: (n.t.)
124-152	H	CDR1	SYWIG	62	63
124-152	H	CDR2	IFYPGDSSTRYSFQGG	64	65
124-152	H	CDR3	RRNWGNAPDI	66	67

[0155] The CDRs of the variable light chain regions from these clones are shown in Table 4, below.

TABLE 4

Variable Light Chain CDR Amino Acid Sequences					
Clone	Chain	CDR	Amino Acid Sequence	SEQ ID NO: (a.a.)	SEQ ID NO: (n.t.)
124-152	L	CDR1	RASQSVSSYLA	68	69
124-152	L	CDR2	GASSRAT	70	71
124-152	L	CDR3	QQYGSSTWT	72	73

[0156] CDRs are the portions of immunoglobulins that determine specificity for a particular antigen. In certain embodiments, CDRs corresponding to the CDRs in Tables 3 and 4 having sequence variations (e.g., conservative substitutions) may bind to toxin B. For example, CDRs, in which 1, 2, 3, 4, or 5 residues, or less than 20% of total residues in the CDR, are substituted or deleted can be present in an antibody (or antigen binding portion thereof) that binds toxin B.

[0157] Human anti-toxin B antibodies can include variable regions that are the product of, or derived from, specific human immunoglobulin genes (see FIGS. 28-31). For example, the antibodies can include a variable heavy chain region that is the product of, or derived from a human VH 5-51 gene. The antibodies can also, or alternatively, include a light chain variable region that is the product of, or derived from a

human $V\kappa$ A27 gene and/or JK1 gene. As known in the art, and described in this section, above, variable immunoglobulin regions of recombinant antibodies are derived by a process of recombination in vivo in which variability is introduced to genomic segments encoding the regions. Accordingly, variable regions derived from a human VH-5-51 or $V\kappa$ A27/JK1 gene can include nucleotides that are different than those in the gene found in non-lymphoid tissues. These nucleotide differences are typically concentrated in the CDRs.

2. Production and Modification of Antibodies

[0158] Many different forms of anti-toxin antibodies can be useful in the inhibition of CDAD. The antibodies can be of the various isotypes, including: IgG (e.g., IgG1, IgG2, IgG3, IgG4), IgM, IgA1, IgA2, IgD, or IgE. Preferably, the antibody is an IgG isotype, e.g., IgG1. The antibody molecules can be full-length (e.g., an IgG1 or IgG4 antibody) or can include only an antigen-binding fragment (e.g., a Fab, F(ab')₂, Fv or a single chain Fv fragment). These include monoclonal antibodies (e.g., human monoclonal antibodies), recombinant antibodies, chimeric antibodies, and humanized antibodies, as well as antigen-binding portions of the foregoing.

[0159] Anti-toxin antibodies or portions thereof useful in the present invention can also be recombinant antibodies produced by host cells transformed with DNA encoding immunoglobulin light and heavy chains of a desired antibody. Recombinant antibodies may be produced by known genetic engineering techniques. For example, recombinant antibodies can be produced by cloning a nucleotide sequence, e.g., a cDNA or genomic DNA, encoding the immunoglobulin light and heavy chains of the desired antibody. The nucleotide sequence encoding those polypeptides is then inserted into an expression vector so that both genes are operatively linked to their own transcriptional and translational expression control sequences. The expression vector and expression control sequences are chosen to be compatible with the expression host cell used. Typically, both genes are inserted into the same expression vector. Prokaryotic or eukaryotic host cells may be used.

[0160] Expression in eukaryotic host cells is preferred because such cells are more likely than prokaryotic cells to assemble and secrete a properly folded and immunologically active antibody. However, any antibody produced that is inactive due to improper folding can be renatured according to well known methods (Kim and Baldwin, *Ann. Rev. Biochem.*, 51:459-89, 1982). It is possible that the host cells will produce portions of intact antibodies, such as light chain dimers or heavy chain dimers, which also are antibody homologs according to the present invention.

[0161] The antibodies described herein also can be produced in a host cell transfectoma using, for example, a combination of recombinant DNA techniques and gene transfection methods as is well known in the art (Morrison, S., *Science*, 229:1202, 1985). For example, in one embodiment, the gene(s) of interest, e.g., human antibody genes, can be ligated into an expression vector such as a eukaryotic expression plasmid such as used in a GS gene expression system disclosed in WO 87/04462, WO 89/01036 and EP 338 841, or in other expression systems well known in the art. The purified plasmid with the cloned antibody genes can be introduced in eukaryotic host cells such as CHO-cells or NSO-cells or alternatively other eukaryotic cells like a plant derived cells, fungi or yeast cells. The method used to introduce these genes can be any method described in the art, such as elec-

troportion, lipofectine, lipofectamine or ballistic transfection, in which cells are bombarded with microparticles carrying the DNA of interest (Rodin, et al. *Immunol. Lett.*, 74(3): 197-200, 2000). After introducing these antibody genes in the host cells, cells expressing the antibody can be identified and selected. These cells represent the transfectomas which can then be amplified for their expression level and upscaled to produce antibodies. Recombinant antibodies can be isolated and purified from these culture supernatants and/or cells using standard techniques.

[0162] It will be understood that variations on the above procedures are useful in the present invention. For example, it may be desired to transform a host cell with DNA encoding either the light chain or the heavy chain (but not both) of an antibody. Recombinant DNA technology may also be used to remove some or all of the DNA encoding either or both of the light and heavy chains that is not necessary for binding, e.g., the constant region may be modified by, for example, deleting specific amino acids. The molecules expressed from such truncated DNA molecules are useful in the methods described herein. In addition, bifunctional antibodies can be produced in which one heavy and one light chain bind to a toxin, and the other heavy and light chain are specific for an antigen other than the toxin, or another epitope of the toxin.

[0163] Chimeric antibodies can be produced by recombinant DNA techniques known in the art. For example, a gene encoding the Fc constant region of a murine (or other species) monoclonal antibody molecule is digested with restriction enzymes to remove the region encoding the murine Fc, and the equivalent portion of a gene encoding a human Fc constant region is substituted (see Robinson et al., International Patent Publication PCT/US86/02269; Akira, et al., European Patent Application 184, 187; Taniguchi, M., European Patent Application 171,496; Morrison et al., European Patent Application 173,494; Neuberger et al., International Application WO 86/01533; Cabilly et al. U.S. Pat. No. 4,816,567; Cabilly et al., European Patent Application 125,023; Better et al. (1988 *Science*, 240:1041-1043); Liu et al. (1987) *PNAS*, 84:3439-3443; Liu et al., 1987, *J. Immunol.*, 139:3521-3526; Sun et al. (1987) *PNAS* 84:214-218; Nishimura et al., 1987, *Canc. Res.*, 47:999-1005; Wood et al. (1985) *Nature*, 314: 446-449; and Shaw et al., 1988, *J. Natl. Cancer Inst.*, 80:1553-1559). Chimeric antibodies can also be created by recombinant DNA techniques where DNA encoding murine V regions can be ligated to DNA encoding the human constant regions.

[0164] An antibody or an immunoglobulin chain can be humanized by methods known in the art. For example, once murine antibodies are obtained, variable regions can be sequenced. The location of the CDRs and framework residues can be determined (see, Kabat, E. A., et al. (1991) *Sequences of Proteins of Immunological Interest, Fifth Edition*, U.S. Department of Health and Human Services, NIH Publication No. 91-3242, and Chothia, C. et al. (1987) *J. Mol. Biol.*, 196:901-917). The light and heavy chain variable regions can, optionally, be ligated to corresponding constant regions. Indeed, it is understood that any of the antibodies described herein, including fully human antibodies, can be altered (e.g., by mutation, substitution) to contain a substitute constant region, e.g., Fc region, or portion(s) thereof to achieve, for example, a desired antibody structure, function (e.g., effector function), subtype, allotype, subclass, or the like. Anti-toxin antibodies can be sequenced using art-recognized techniques. CDR-grafted antibody molecules or immunoglobulins can be

produced by CDR-grafting or CDR substitution, wherein one, two, or all CDRs of an immunoglobulin chain can be replaced. See e.g., U.S. Pat. No. 5,225,539; Jones et al., 1986, *Nature*, 321:552-525; Verhoeyan et al., 1988, *Science*, 239: 1534; Beidler et al., 1988, *J. Immunol.*, 141:4053-4060; and Winter, U.S. Pat. No. 5,225,539.

[0165] Winter describes a CDR-grafting method that may be used to prepare the antibodies of the present invention (UK Patent Application GB 2188638A, filed on Mar. 26, 1987; Winter U.S. Pat. No. 5,225,539), the contents of which is expressly incorporated by reference. For example, all of the CDRs of a particular antibody may be replaced with at least a portion of a human CDR (e.g., a CDR from clone 3D8, as shown in Tables 1 and 2, and/or clone 124-152, as shown in Tables 3 and 4, above) or only some of the CDRs may be replaced. It is only necessary to replace the number of CDRs required for binding of the antibody to a predetermined antigen (e.g., an exotoxin of *C. difficile*).

[0166] Humanized antibodies can be generated by replacing sequences of the Fv variable region that are not directly involved in antigen binding with equivalent sequences from human Fv variable regions. General methods for generating humanized antibodies are provided by Morrison, S. L., 1985, *Science*, 229:1202-1207, by Oi et al., 1986, *BioTechniques*, 4:214, and by Queen et al. U.S. Pat. No. 5,585,089, U.S. Pat. No. 5,693,761 and U.S. Pat. No. 5,693,762. Those methods include isolating, manipulating, and expressing the nucleic acid sequences that encode all or part of immunoglobulin Fv variable regions from at least one of a heavy or light chain. Sources of such nucleic acid are well known to those skilled in the art and, for example, may be obtained from a hybridoma producing an antibody against a predetermined target, as described above. The recombinant DNA encoding the humanized antibody, or fragment thereof, can then be cloned into an appropriate expression vector. Other techniques for humanizing antibodies are described in Padlan et al. EP 519596 A1, published on Dec. 23, 1992.

[0167] Also within the scope of the invention are antibodies in which specific amino acids have been substituted, deleted, or added. In particular, preferred antibodies have amino acid substitutions in the framework region, such as to improve binding to the antigen. For example, a selected, small number of acceptor framework residues of the immunoglobulin chain can be replaced by the corresponding donor amino acids. Preferred locations of the substitutions include amino acid residues adjacent to the CDR, or which are capable of interacting with a CDR (see e.g., U.S. Pat. No. 5,585,089). Criteria for selecting amino acids from the donor are described in U.S. Pat. No. 5,585,089 (e.g., columns 12-16), the contents of which are hereby incorporated by reference. The acceptor framework can be a mature human antibody framework sequence or a consensus sequence.

[0168] A "consensus sequence" is a sequence formed from the most frequently occurring amino acids (or nucleotides) in a family of related sequences (See e.g., Winnaker, From Genes to Clones (Verlagsgesellschaft, Weinheim, Germany 1987). In a family of proteins, each position in the consensus sequence is occupied by the amino acid occurring most frequently at that position in the family. If two amino acids occur equally frequently, either can be included in the consensus sequence. A "consensus framework" of an immunoglobulin refers to a framework region in the consensus immunoglobulin sequence.

[0169] An anti-toxin antibody, or antigen-binding portion thereof, can be derivatized or linked to another functional molecule (e.g., another peptide or protein). For example, an antibody can be functionally linked (by chemical coupling, genetic fusion, noncovalent association or otherwise) to one or more other molecular entities, such as another antibody, a detectable agent, a cytotoxic agent, a pharmaceutical agent, and/or a protein or peptide that can mediate association with another molecule (such as a streptavidin core region or a polyhistidine tag).

[0170] One type of derivatized protein is produced by crosslinking two or more proteins (of the same type or of different types). Suitable crosslinkers include those that are heterobifunctional, having two distinct reactive groups separated by an appropriate spacer (e.g., m-maleimidobenzoyl-N-hydroxysuccinimide ester) or homobifunctional (e.g., disuccinimidyl suberate). Such linkers are available from Pierce Chemical Company, Rockford, Ill.

[0171] Useful detectable agents with which a protein can be derivatized (or labeled) include fluorescent compounds, various enzymes, prosthetic groups, luminescent materials, bioluminescent materials, and radioactive materials. Exemplary fluorescent detectable agents include fluorescein, fluorescein isothiocyanate, rhodamine, and, phycoerythrin. A protein or antibody can also be derivatized with detectable enzymes, such as alkaline phosphatase, horseradish peroxidase, β -galactosidase, acetylcholinesterase, glucose oxidase and the like. When a protein is derivatized with a detectable enzyme, it is detected by adding additional reagents that the enzyme uses to produce a detectable reaction product. For example, when the detectable agent horseradish peroxidase is present, the addition of hydrogen peroxide and diaminobenzidine leads to a colored reaction product, which is detectable. A protein can also be derivatized with a prosthetic group (e.g., streptavidin/biotin and avidin/biotin). For example, an antibody can be derivatized with biotin, and detected through indirect measurement of avidin or streptavidin binding.

[0172] Labeled proteins and antibodies can be used, for example, diagnostically and/or experimentally in a number of contexts, including (i) to isolate a predetermined antigen by standard techniques, such as affinity chromatography or immunoprecipitation; and (ii) to detect a predetermined antigen (e.g., a toxin, e.g., in a cellular lysate or a patient sample) in order to monitor protein levels in tissue as part of a clinical testing procedure, e.g., to determine the efficacy of a given treatment regimen.

[0173] An anti-toxin antibody or antigen-binding fragment thereof may be conjugated to another molecular entity, such as a label.

3. Screening Methods

[0174] Anti-toxin antibodies can be characterized for binding to the toxin by a variety of known techniques. Antibodies are typically characterized by ELISA first. Briefly, microtiter plates can be coated with the toxin or toxoid antigen in PBS, and then blocked with irrelevant proteins such as bovine serum albumin (BSA) diluted in PBS. Dilutions of plasma from toxin-immunized mice are added to each well and incubated for 1-2 hours at 37° C. The plates are washed with PBS/Tween 20 and then incubated with a goat-anti-human IgG Fc-specific polyclonal reagent conjugated to alkaline phosphatase for 1 hour at 37° C. After washing, the plates are

developed with ABTS substrate, and analyzed at OD of 405. Preferably, mice which develop the highest titers will be used for fusions.

[0175] An ELISA assay as described above can be used to screen for antibodies and, thus, hybridomas that produce antibodies that show positive reactivity with the toxin. Hybridomas that produce antibodies that bind, preferably with high affinity, to the toxin can then be subcloned and further characterized. One clone from each hybridoma, which retains the reactivity of the parent cells (by ELISA), can then be chosen for making a cell bank, and for antibody purification.

[0176] To purify the anti-toxin antibodies, selected hybridomas can be grown in roller bottles, two-liter spinner-flasks or other culture systems. Supernatants can be filtered and concentrated before affinity chromatography with protein A-Sepharose (Pharmacia, Piscataway, N.J.) to purify the protein. After buffer exchange to PBS, the concentration can be determined by spectrophotometric methods.

[0177] To determine if the selected monoclonal antibodies bind to unique epitopes, each antibody can be biotinylated using commercially available reagents (Pierce, Rockford, Ill.). Biotinylated MAb binding can be detected with a streptavidin labeled probe. Anti-toxin antibodies can be further tested for reactivity with the toxin by Western blotting.

[0178] Other assays to measure activity of the anti-toxin antibodies include neutralization assays. In vitro neutralization assays can measure the ability of an antibody to inhibit a cytopathic effect on cells in culture (see Example 3, below). In vivo assays to measure toxin neutralization are described in Examples 5, 6, and 7, below.

4. Pharmaceutical Compositions and Kits

[0179] In another aspect, the present invention provides compositions, e.g., pharmaceutically acceptable compositions, which include an antibody molecule described herein or antigen binding portion thereof, formulated together with a pharmaceutically acceptable carrier.

[0180] "Pharmaceutically acceptable carriers" include any and all solvents, dispersion media, isotonic and absorption delaying agents, and the like that are physiologically compatible. The carriers can be suitable for intravenous, intramuscular, subcutaneous, parenteral, rectal, spinal, or epidermal administration (e.g., by injection or infusion).

[0181] The compositions of this invention may be in a variety of forms. These include, for example, liquid, semi-solid and solid dosage forms, such as liquid solutions (e.g., injectable and infusible solutions), dispersions or suspensions, liposomes and suppositories. The preferred form depends on the intended mode of administration and therapeutic application. Useful compositions are in the form of injectable or infusible solutions. A useful mode of administration is parenteral (e.g., intravenous, subcutaneous, intraperitoneal, intramuscular). For example, the antibody or antigen binding portion thereof can be administered by intravenous infusion or injection. In another embodiment, the antibody or antigen binding portion thereof is administered by intramuscular or subcutaneous injection.

[0182] The phrases "parenteral administration" and "administered parenterally" as used herein mean modes of administration other than enteral and topical administration, usually by injection, and include, without limitation, intravenous, intramuscular, intraarterial, intrathecal, intracapsular, intraorbital, intracardiac, intradermal, intraperitoneal, tran-

stracheal, subcutaneous, subcuticular, intraarticular, subcapsular, subarachnoid, intraspinal, epidural, and intrasternal injection and infusion.

[0183] Therapeutic compositions typically should be sterile and stable under the conditions of manufacture and storage. The composition can be formulated as a solution, micro-emulsion, dispersion, liposome, or other ordered structure suitable to high antibody concentration. Sterile injectable solutions can be prepared by incorporating the active compound (i.e., antibody or antibody portion) in the required amount in an appropriate solvent with one or a combination of ingredients enumerated above, as required, followed by filtered sterilization. Generally, dispersions are prepared by incorporating the active compound into a sterile vehicle that contains a basic dispersion medium and the required other ingredients from those enumerated above. In the case of sterile powders for the preparation of sterile injectable solutions, the useful methods of preparation are vacuum drying and freeze-drying that yields a powder of the active ingredient plus any additional desired ingredient from a previously sterile-filtered solution thereof. The proper fluidity of a solution can be maintained, for example, by the use of a coating such as lecithin, by the maintenance of the required particle size in the case of dispersion and by the use of surfactants. Prolonged absorption of injectable compositions can be brought about by including in the composition an agent that delays absorption, for example, monostearate salts and gelatin.

[0184] The antibodies and antibody portions described herein can be administered by a variety of methods known in the art, and for many therapeutic applications. As will be appreciated by the skilled artisan, the route and/or mode of administration will vary depending upon the desired results.

[0185] In certain embodiments, an antibody, or antibody portion thereof may be orally administered, for example, with an inert diluent or an assimilable edible carrier. The compound (and other ingredients, if desired) may also be enclosed in a hard or soft shell gelatin capsule, compressed into tablets, or incorporated directly into the subject's diet. For oral therapeutic administration, the compounds may be incorporated with excipients and used in the form of ingestible tablets, buccal tablets, troches, capsules, elixirs, suspensions, syrups, wafers, and the like. To administer a compound of the invention by other than parenteral administration, it may be necessary to coat the compound with, or co-administer the compound with, a material to prevent its inactivation. Therapeutic compositions can be administered with medical devices known in the art.

[0186] Dosage regimens are adjusted to provide the optimum desired response (e.g., a therapeutic response). For example, a single bolus may be administered, several divided doses may be administered over time, or the dose may be proportionally reduced or increased as indicated by the exigencies of the therapeutic situation. It is especially advantageous to formulate parenteral compositions in dosage unit form for ease of administration and uniformity of dosage. Dosage unit form as used herein refers to physically discrete units suited as unitary dosages for the subjects to be treated; each unit contains a predetermined quantity of active compound calculated to produce the desired therapeutic effect in association with the required pharmaceutical carrier. The specification for the dosage unit forms of the invention are dictated by and directly dependent on (a) the unique characteristics of the active compound and the particular therapeutic

effect to be achieved, and (b) the limitations inherent in the art of compounding such an active compound for the treatment of sensitivity in individuals.

[0187] An exemplary, non-limiting range for a therapeutically or prophylactically effective amount of an antibody or antibody portion of the invention is 0.1-60 mg/kg, e.g., 0.5-25 mg/kg, 1-2 mg/kg, or 0.75-10 mg/kg. It is to be further understood that for any particular subject, specific dosage regimens should be adjusted over time according to the individual need and the professional judgment of the person administering or supervising the administration of the compositions, and that dosage ranges set forth herein are exemplary only and are not intended to limit the scope or practice of the claimed composition.

[0188] Also within the scope of the invention are kits including an anti-toxin antibody or antigen binding portion thereof. The kits can include one or more other elements including: instructions for use; other reagents, e.g., a label, a therapeutic agent, or an agent useful for chelating, or otherwise coupling, an antibody to a label or therapeutic agent, or other materials for preparing the antibody for administration; pharmaceutically acceptable carriers; and devices or other materials for administration to a subject.

[0189] Various combinations of antibodies can be packaged together. For example, a kit can include antibodies that bind to toxin A (e.g., antibodies that include the variable heavy and light chain regions of 3D8) and antibodies that bind to toxin B (e.g., human monoclonal anti-toxin B antibodies, e.g., 124-152, 2A11, and/or 1G10, or polyclonal antisera reactive with toxin B). The antibodies can be mixed together, or packaged separately within the kit.

[0190] Instructions for use can include instructions for therapeutic application including suggested dosages and/or modes of administration, e.g., in a patient with a symptom of CDAD. Other instructions can include instructions on coupling of the antibody to a chelator, a label or a therapeutic agent, or for purification of a conjugated antibody, e.g., from unreacted conjugation components.

[0191] The kit can include a detectable label, a therapeutic agent, and/or a reagent useful for chelating or otherwise coupling a label or therapeutic agent to the antibody. Coupling agents include agents such as N-hydroxysuccinimide (NHS). In such cases the kit can include one or more of a reaction vessel to carry out the reaction or a separation device, e.g., a chromatographic column, for use in separating the finished product from starting materials or reaction intermediates.

[0192] The kit can further contain at least one additional reagent, such as a diagnostic or therapeutic agent, e.g., a diagnostic or therapeutic agent as described herein, and/or one or more additional anti-toxin or anti-*C. difficile* antibodies (or portions thereof), formulated as appropriate, in one or more separate pharmaceutical preparations.

[0193] Other kits can include optimized nucleic acids encoding anti-toxin antibodies, and instructions for expression of the nucleic acids.

5. Therapeutic Methods and Compositions

[0194] The new proteins and antibodies have in vitro and in vivo therapeutic, prophylactic, and diagnostic utilities. For example, these antibodies can be administered to cells in culture, e.g., in vitro or ex vivo, or to a subject, e.g., in vivo, to treat, inhibit, prevent relapse, and/or diagnose *C. difficile* and disease associated with *C. difficile*.

[0195] As used herein, the term “subject” is intended to include human and non-human animals. The term “non-human animals” includes all vertebrates, e.g., mammals and non-mammals, such as non-human primates, chickens, mice, dogs, cats, pigs, cows, and horses.

[0196] The proteins and antibodies can be used on cells in culture, e.g., in vitro or ex vivo. For example, cells can be cultured in vitro in culture medium and the contacting step can be effected by adding the anti-toxin antibody or fragment thereof, to the culture medium. The methods can be performed on virions or cells present in a subject, as part of an in vivo (e.g., therapeutic or prophylactic) protocol. For in vivo embodiments, the contacting step is effected in a subject and includes administering an anti-toxin antibody or portion thereof to the subject under conditions effective to permit binding of the antibody, or portion, to any toxin expressed by bacteria in the subject, e.g., in the gut.

[0197] Methods of administering antibody molecules are described herein. Suitable dosages of the molecules used will depend on the age and weight of the subject and the particular drug used. The antibody molecules can be used as competitive agents for ligand binding to inhibit or reduce an undesirable interaction, e.g., to inhibit binding of toxins to the gastrointestinal epithelium.

[0198] The anti-toxin antibodies (or antigen binding portions thereof) can be administered in combination with other anti-*C. difficile* antibodies (e.g., other monoclonal antibodies, polyclonal gamma-globulin). Combinations of antibodies that can be used include an anti-toxin A antibody or antigen binding portion thereof and an anti-toxin B antibody or antigen binding portion thereof. The anti-toxin A antibody can be 3D8, an antibody that includes the variable regions of 3D8, or an antibody with variable regions at least 90% identical to the variable regions of 3D8. The anti-toxin B antibody can be 124-152, 2A11, 1G10, or an antibody with variable regions at least 90% identical to the variable regions of the foregoing, e.g., 124-152. Combinations of anti-toxin A (e.g., 3D8) and anti-toxin B antibodies (e.g., 124-152) can provide potent inhibition of CDAD.

[0199] It is understood that any of the agents of the invention, for example, anti-toxin A or anti-toxin B antibodies, or fragments thereof, can be combined, for example in different ratios or amounts, for improved therapeutic effect. Indeed, the agents of the invention can be formulated as a mixture, or chemically or genetically linked using art recognized techniques thereby resulting in covalently linked antibodies (or covalently linked antibody fragments), having both anti-toxin A and anti-toxin B binding properties. The combined formulation may be guided by a determination of one or more parameters such as the affinity, avidity, or biological efficacy of the agent alone or in combination with another agent. The agents of the invention can also be administered in combination with other agents that enhance access, half-life, or stability of the therapeutic agent in targeting, clearing, and/or sequestering *C. difficile* or an antigen thereof.

[0200] Such combination therapies are preferably additive and even synergistic in their therapeutic activity, e.g., in the inhibition, prevention (e.g., of relapse), and/or treatment of *C. difficile*-related diseases or disorders (see, e.g., Example 16 which shows the efficacy of single and combined antibody therapies). Administering such combination therapies can decrease the dosage of the therapeutic agent (e.g., antibody or

antibody fragment mixture, or cross-linked or genetically fused bispecific antibody or antibody fragment) needed to achieve the desired effect.

[0201] Immunogenic compositions that contain an immunogenically effective amount of a toxin, or fragments thereof, are described herein, and can be used in generating anti-toxin antibodies. Immunogenic epitopes in a toxin sequence can be identified according to methods known in the art, and proteins, or fragments containing those epitopes can be delivered by various means, in a vaccine composition. Suitable compositions can include, for example, lipopeptides (e.g., Vitiello et al., *J. Clin. Invest.* 95:341 (1995)), peptide compositions encapsulated in poly(DL-lactide-co-glycolide) ("PLG") microspheres (see, e.g., Eldridge et al., *Molec. Immunol.* 28:287-94 (1991); Alonso et al., *Vaccine* 12:299-306 (1994); Jones et al., *Vaccine* 13:675-81 (1995)), peptide compositions contained in immune stimulating complexes (ISCOMS) (see, e.g., Takahashi et al., *Nature* 344:873-75 (1990); Hu et al., *Clin. Exp. Immunol.* 113:235-43 (1998)), and multiple antigen peptide systems (MAPs) (see, e.g., Tam, *Proc. Natl. Acad. Sci. U.S.A.* 85:5409-13 (1988); Tam, *J. Immunol. Methods* 196:17-32 (1996)).

[0202] Useful carriers that can be used with immunogenic compositions of the invention are well known, and include, for example, thyroglobulin, albumins such as human serum albumin, tetanus toxoid, polyamino acids such as poly L-lysine, poly L-glutamic acid, influenza, hepatitis B virus core protein, and the like. The compositions can contain a physiologically tolerable (i.e., acceptable) diluent such as water, or saline, typically phosphate buffered saline. The compositions and vaccines also typically include an adjuvant. Adjuvants such as incomplete Freund's adjuvant, aluminum phosphate, aluminum hydroxide, or alum are examples of materials well known in the art. Additionally, CTL responses can be primed by conjugating toxins (or fragments, inactive derivatives or analogs thereof) to lipids, such as tripalmitoyl-S-glycerylcysteinyl-seryl-serine (P₃CSS).

[0203] The anti-toxin antibodies can be administered in combination with other agents, such as compositions to treat CDAD. For example, therapeutics that can be administered in combination with anti-toxin antibodies include antibiotics used to treat CDAD, such as vancomycin, metronidazole, or bacitracin. The antibodies can be used in combination with probiotic agents such as *Saccharomyces boulardii*. The antibodies can also be administered in combinations with a *C. difficile* vaccine, e.g., a toxoid vaccine.

6. Other Methods

[0204] An anti-toxin antibody (e.g., monoclonal antibody) can be used to isolate toxins by standard techniques, such as affinity chromatography or immunoprecipitation. Moreover, an anti-toxin antibody can be used to detect the toxin (e.g., in a stool sample), e.g., to screen samples for the presence of *C. difficile*. Anti-toxin antibodies can be used diagnostically to monitor levels of the toxin in tissue as part of a clinical testing procedure, e.g., to, for example, determine the efficacy of a given treatment regimen.

Exemplification

[0205] Throughout the examples, the following materials and methods were used unless otherwise stated.

Materials and Methods

[0206] In general, the practice of the present invention employs, unless otherwise indicated, conventional techniques of chemistry, molecular biology, recombinant DNA technology, immunology (especially, e.g., antibody technology), and standard techniques in polypeptide preparation. See, e.g., Sambrook, Fritsch and Maniatis, *Molecular Cloning: Cold Spring Harbor Laboratory Press* (1989); *Antibody Engineering Protocols (Methods in Molecular Biology)*, 510, Paul, S., Humana Pr (1996); *Antibody Engineering: A Practical Approach (Practical Approach Series, 169)*, McCafferty, Ed., Irl Pr (1996); *Antibodies: A Laboratory Manual*, Harlow et al., C.S.H.L. Press, Pub. (1999); and *Current Protocols in Molecular Biology*, eds. Ausubel et al., John Wiley & Sons (1992).

EXAMPLES

[0207] The invention is further described in the following examples, which do not limit the scope of the invention described in the claims.

Example 1

Generation of Anti-Toxin A Monoclonal Antibodies

[0208] *C. difficile* toxin A was obtained either from Techlab, Inc. (Blacksburg, Va.), or by recombinant production. The toxin was purified and inactivated prior to immunization. Inactivation was performed by treatment with reactive UDP-dialdehyde, which results in alkylation of catalytic residues while preserving native toxin structure. For the detailed protocol, see Genth et al., *Inf and Immun.* 68(3):1094-1101, 2000. Briefly, purified toxin A was incubated with UDP-2', 3'-dialdehyde (0.1-1.0 mM) in buffer for 18 hours at 37° C., filtered through a 100 kDa-cutoff filter to remove unreacted UDP-2',3'-dialdehyde, and washed with buffer. Inactivated toxin A (toxoid A) was used for immunization.

[0209] HCo7 transgenic mice, generated as described above in the section entitled "Generation of Human Monoclonal Antibodies in HuMAb Mice" and supplied by Medarex, Milpitas, Calif., were immunized intraperitoneally 6-12 times each with 10 µg of toxoid in RIBI adjuvant. In the HCo7 transgenic mice, the endogenous mouse kappa light chain gene has been homozygously disrupted as described in Chen et al. (1993) *EMBO J.* 12:811-820 and the endogenous mouse heavy chain gene has been homozygously disrupted as described in Example 1 of PCT Publication WO 01/09187. The HCo7 transgenic mice carry a human kappa light chain transgene, KC05, as described in Fishwild et al. (1996) *Nature Biotechnology* 14:845-851, and the HCo7 human heavy chain transgene as described in U.S. Pat. Nos. 5,545,806; 5,625,825; and 5,545,807. Serum was collected from each mouse and tested for reactivity to toxin A by ELISA and neutralization of cytotoxicity on IMR-90 cells. Mice that tested positive for toxin A-reactive and neutralizing antiserum were injected with 5-10 µg toxoid A through the tail vein. Mice were sacrificed and spleens were isolated for fusion to hybridomas approximately 3 days after tail vein injection was performed.

[0210] Clonal hybridomas were generated and screened by ELISA. Percentages of kappa/gamma light chain positive, antigen-specific, and neutralizing clones identified by screening clones generated from four separate hybridoma fusions are listed in Table 5.

TABLE 5

Fusion	% kappa/gamma positive	% antigen specific	% neutralizing
1	5.7 (94/1632)	3.4 (56/1632)	0.7 (12/1632)
2	0.2 (1/384)	0 (0/384)	0 (0/384)
3		1.8 (14/768)	0.39 (3/768)
4		4.4 (43/960)	1.7 (17/960)

[0211] Three hybridoma clones were selected for further analysis: 3D8, 1B11, and 33.3H2. CDNAs from each clone were amplified by RT-PCR from mRNA, cloned, and sequenced. One heavy chain V region consensus sequence was found for each clone. All three clones utilized a VH region derived from the same germline V region gene (VH 3-33), but utilized different J sequences. The amino acid sequences of the VH and VL regions from each clone are shown in FIG. 1 (SEQ ID NOs: 1-6). The complementarity determining regions (CDRs) are overlined in the Figure.

[0212] Sequence analysis of the kappa V (V_{κ} light chain) genes revealed that HuMAb 1B11 and 33.3H2 each express one consensus kappa chain V sequence. The 1B11 hybridoma expressed a V_{κ} light chain derived from the V_{κ} L6 germline gene, whereas the 33.3H2 hybridoma expresses a V_{κ} light chain derived from the V_{κ} L15 germline gene. Upon analysis of the V_{κ} clones from HuMAb 3D8, 6 (I-VI) light chains were expressed at the mRNA level (FIG. 1). To determine which of the light chains were expressed at the protein level, mass spectroscopy and N-terminal sequencing of the purified 3D8 antibody were performed. When light chains were isolated from cellular protein and analyzed by mass spectroscopy, a single light chain was seen with a mass of 23,569 Daltons. This corresponded to the light chain with the group I amino acid sequence depicted in FIG. 1, which is derived from the V_{κ} L19 germline gene. N-terminal sequencing of the light chain confirmed this result. FIGS. 2A, 3A, and 4A depict the nucleotide and the amino acid sequences of the V_{κ} of each 3D8 (group I; SEQ ID NOs: 4, and 30-34), 1B11 (SEQ ID NO: 5), and 33.3H2 (SEQ ID NO:6) respectively. The CDRs are overlined and the germline V_{κ} and J_{κ} are shown.

[0213] Thus, the 3D8 antibody comprises a heavy chain variable region that is the product of or derived from a human VH 3-33 gene and a light chain variable region that is the product of or derived from a human V_{κ} L19 gene. The 1B11 antibody comprises a heavy chain variable region that is the product of or derived from a human VH 3-33 gene and a light chain variable region that is the product of or derived from a human V_{κ} L6 gene. The 33.3H2 antibody comprises a heavy chain variable region that is the product of or derived from a human VH 3-33 gene and a light chain variable region that is the product of or derived from a human V_{κ} L15 gene.

[0214] The antibodies 3D8 and 1B11 express human IgG1 constant regions, and antibody 33.3H2 expresses human IgG3 constant regions. The antibodies described in Examples 2-7 were isolated from these hybridomas, and thus express the variable sequences shown in FIG. 1 along with human constant regions. DNA encoding the antigen binding portion of each clone was cloned into a vector to be expressed as a human antibody for administration to humans.

Example 2

Binding Activity of Anti-Toxin A Antibodies

[0215] Binding of each antibody to toxin A was determined by ELISA using standard techniques. The results of this assay

are depicted in FIG. 5. Antibodies produced by 3D8, 1B11, and 33.3H2 were compared to a fourth human monoclonal antibody with toxin A binding activity, 8E6. FIG. 5 shows that the antibodies bind toxin A with comparable affinities.

[0216] The affinity of the 3D8 and 1B11 antibodies for toxin A was also measured with Biacore® instrument, which detects biomolecular binding interactions with surface plasmon resonance technology. Each antibody was added to protein A-coated sensor chips, and toxin A was allowed to flow over the chip to measure binding. 3D8 had a K_D of 14.6×10^{-10} M. 1B11 had a K_D of 7.38×10^{-10} M. Thus, the antibodies bind with high affinity to toxin A. These binding constants indicate that the antibodies have affinities suitable for use in human therapy.

Example 3

Toxin Neutralization by Anti-Toxin A Antibodies

[0217] Antibodies expressed by 1B11, 3D8, and 33.3H2 hybridomas were tested for toxin A neutralization activity in vitro. Cells were incubated in the presence of varying concentrations of toxin A, which causes cells to round up and lose adherence to cell culture dishes. Cytopathic effect (CPE) was determined by visual inspection of cells. A CPE score from 0-4 was determined, based on the results of the visual inspection (4=100% cytotoxicity, 0=0% toxicity). The results of these assays are depicted in FIGS. 6A and 6B. Neutralization of toxicity against a human lung fibroblast cell line, IMR-90, and a human gut epithelial cell line, T-84, was determined. FIG. 6A shows that all of the antibodies had neutralizing capacity towards IMR-90 cells. The relative neutralizing activity of toxin A cytotoxicity on IMR-90 cells was 1B11>3H2>3D8. Interestingly, the relative neutralizing activity was 3D8 \geq 1B11>3H2 against T-84 cells, which are human colonic epithelial cells (FIG. 6A). T-84 cells are believed to be more sensitive to toxin A than other cell types. T-84 cells may provide a more relevant target cell to determine toxin A cytotoxicity.

Example 4

Epitope Mapping of Anti-Toxin A Antibodies

[0218] The epitope of toxin A bound by each monoclonal antibody was determined by western blotting. Recombinant *E. coli* clones were constructed which express four fragments of toxin A representing the enzymatic domain (i.e., amino acids 1-659 of toxin A), the receptor binding domain (i.e., amino acids 1853-2710 of toxin A), and the two regions in between (i.e., amino acids 660-1255 and 1256-1852 of toxin A). The appropriate segments of the toxin A gene were PCR-amplified from genomic DNA prepared from *C. difficile* strain ATCC 43255. The fragments were cloned using a pET vector and transformed into BL21 DE3 cells for expression. The vector provides inducible expression and affinity domains for purification (i.e., a His-tag) and detection (i.e., a V5 epitope tag). Expression was induced with IPTG and fragments were purified by affinity chromatography. Binding to four different fragments of toxin A was measured: fragment 1 corresponded to amino acids 1-659; fragment 2 corresponded to amino acids 660-1255; fragment 3 corresponded to amino acids 1256-1852; and fragment 4 corresponded to amino acids 1853-2710 (FIG. 7). 1B11 reacted with fragments 1 and 2. 33.3H2 reacted with fragment 2. 3D8 and another human monoclonal antibody, 6B4, reacted with fragment 4 (the

receptor binding domain). A polyclonal antiserum from rabbits immunized with toxoid A reacted with all four fragments.

[0219] The 1B11 and 33.3H2 epitopes were mapped in further detail. To map the 1B11 epitope, subfragments of fragment 1 (amino acids 1-659) corresponding to amino acids 1-540, 1-415, 1-290, and 1-165, were generated (FIG. 8A). 1B11 bound to fragment 1 and to the fragment containing amino acids 1-540. 1B11 did not bind to the other subfragments. Therefore, the epitope bound by 1B11 maps between amino acids 415-540 of toxin A.

[0220] To map the 33.3H2 epitope, subfragments of fragment 2 (amino acids 660-1255) corresponding to amino acids 660-1146, 660-1033, 660-920, and 660-807, were generated (FIG. 8B). 33.3H2 bound to the fragments corresponding to amino acids 660-1255, 660-1146, and 660-1033. 33.3H2 did not bind to the other subfragments. Therefore, the epitope bound by 33.3H2 maps between amino acids 920-1033 of toxin A.

Example 5

Protection of Mice from Lethal Toxin A Challenge by Administration of Anti-Toxin A Antibodies

[0221] Each antibody was tested for the ability to protect mice from challenge with a lethal dose of toxin A. Swiss Webster female mice, each weighing 10-20 grams, were injected intraperitoneally with up to 250 μ g of 3D8, 1B11, or 33.3H2, or a control antibody (anti-respiratory syncytial virus antibody, MedImmune) prior to challenge with toxin A. Approximately 24 hours after injection, mice were challenged with a dose of toxin A greater than 10 times the lethal dose (LD₅₀), typically 100 ng. Animals were observed for signs of toxicity for the next 7 days. The results of these experiments are summarized in FIG. 9. The data is expressed as percentage survival. Numbers in parenthesis refer to antibody dose, if a dose other than 250 μ g was given. FIG. 9 shows that each of the antibodies was able to protect mice from lethal toxin A challenge to some extent. The percentage of mice surviving when treated with 3D8 ranged from 10-100 percent. The percentage of mice surviving when treated with 33.3H2 ranged from 20-100 percent. The percentage of mice surviving when treated with 1B11 ranged from 0-60 percent. The relative ability of these monoclonals to protect mice was 3H2 \geq 3D8>1B11.

Example 6

Neutralization of Toxin A Enterotoxicity in Ligated Mouse Intestinal Loops with Anti-Toxin A Antibodies

[0222] 3D8 and 33.3H2 antibodies were tested for neutralization of toxin A enterotoxicity in a mouse ileal loop model. This model measures toxin A-induced fluid accumulation in mouse intestine. To perform these experiments, each mouse was starved for 16 hours, anesthetized, and the ileum next to the cecum was exposed. A loop of 3 to 5 centimeters was doubly ligated at each end and injected with 10 μ g of toxin A. The ileal loop was returned to the abdominal cavity, the wound was closed, and the animal was allowed to recover. Four hours after surgery, the animal was euthanized and the loop was removed from the animal. The length of each segment was remeasured, and the intraluminal fluid was extracted. The volume of the fluid and the volume-to-length (V:L) ratio in milliliters per centimeter was calculated for

each loop. Test mice were injected with antibody parenterally 1-2 days before surgery. The results of these experiments are depicted in FIG. 10. Injection with toxin A increased the weight to length ratio of intestinal fluid by 50%. Both 3D8 and 33.3H2 prevented this increase in fluid accumulation. Mice administered either antibody had a weight to length ratio comparable to mice that did not receive any toxin A injection. Therefore, 3D8 and 33.3H2 protect from intestinal fluid accumulation in vivo.

[0223] These results indicate that the anti-toxin A monoclonal antibodies protect from toxin A-mediated enterotoxicity in vivo. The mouse ligated loop data shows that these monoclonal antibodies can protect from mucosal damage when administered systemically.

Example 7

Protection of Hamsters from *C. difficile* Relapse with Anti-Toxin A Antibodies

[0224] 3D8 was tested in a hamster relapse model. Hamsters are sensitive to the toxic effects of *C. difficile* toxins, and typically die within 2-3 days of receiving a single dose of clindamycin in the presence of *C. difficile*. To test the efficacy of 3D8 in hamsters, a relapse model was used. In this model, hamsters were given a dose of clindamycin and a dose of *C. difficile* B1 spores one day later. One set of control hamsters received no additional antibiotic or antibody. A second set of control hamsters were treated with 10 mg/kg/day vancomycin. Vancomycin is an antibiotic used in the treatment of *C. difficile* disease. As shown in FIG. 11A, a test set of hamsters received 10 mg/kg/day vancomycin and 2 mg/kg/day of a rabbit polyclonal antiserum raised against toxin A each day for seven days after *C. difficile* exposure, as indicated by the arrows in the figure. A second test set of hamsters received 10 mg/kg/day vancomycin and 50 mg/kg/day 3D8 at the same time intervals. Hamster survival was plotted versus time and is shown in FIG. 11B.

[0225] FIG. 11B shows that all of the hamsters that received only clindamycin and *C. difficile* (diamonds) died within two days of challenge with the bacteria. Twelve percent (2/17) of hamsters treated with vancomycin (squares) survived challenge with bacteria; eighty-eight percent (15/17) died within eight days. Forty-one percent (7/17) of hamsters treated with vancomycin and 3D8 (crosses) survived challenge; fifty-nine (10/17) percent died within seven days. Sixty-four percent (7/11) of hamsters treated with vancomycin and polyclonal rabbit serum (triangles) survived the challenge with bacteria; thirty-six percent (4/11) died within nine days. These data are also depicted in FIG. 12 as the percentage of total survivors in each treatment group. As shown in the figure, the percentage of survivors was highest (sixty-four percent) in the group receiving vancomycin and polyclonal rabbit serum. The group receiving 3D8 and vancomycin had the second highest rate of survival (forty-one percent). Only twelve percent of vancomycin-treated hamsters survived. Those with no treatment all died. These data show that polyclonal and monoclonal anti-toxin antibodies protect from relapse of *C. difficile* disease in vivo when administered after infection.

Example 8

Production of Anti-Toxin A Antibodies for Administration in Humans

[0226] Nucleic acid sequences encoding the variable heavy chain and light chains of the 3D8 antibody were cloned into a

pIE-Ugamma1F vector using standard recombinant DNA methodology. The vector was amplified in *E. coli*, purified, and transfected into CHO-dg44 cells. Transfected cells were plated at 4×10^5 cells per well in a 96-well dish and selected for vector transfection with G418. One clone, designated 1D3, was originally selected by G418 resistance, then assayed along with other transfectomas for production of IgG. 1D3 had a higher level of IgG production relative to other transfectants during several rounds of expansion. The expression of the 3D8 antibody was amplified by growth in the presence of increasing concentrations of methotrexate. A culture capable of growth in 175 nM methotrexate was chosen for cloning single cells for further development. Plating the culture in 96 well plates at low density allowed generation of cultures arising from a single cell or clones. The cultures were screened for production of human IgG, and the cell that produced the highest level of IgG was selected for further use. The methotrexate-amplified clone was expanded to produce a cell bank including multiple frozen vials of cells.

[0227] To prepare antibodies from transfected cells, cells from a clone isolated in the previous steps are cultured and expanded as inoculum for a bioreactor. The bioreactor typically holds a 500 liter volume of culture medium. The cells are cultured in the bioreactor until cell viability drops, which indicates a maximal antibody concentration has been produced in the culture. The cells are removed by filtration. The filtrate is applied to a protein A column. Antibodies bind to the column, and are eluted with a low pH wash. Next, the antibodies are applied to a Q-Sepharose column to remove residual contaminants, such as CHO cell proteins, DNA, and other contaminants (e.g., viral contaminants, if present). Antibodies are eluted from the Q-Sepharose column, nano-filtered, concentrated, and washed in a buffer such as PBS. The preparation is then aseptically aliquoted into vials for administration.

Example 9

Preparation and Characterization of Polyclonal Anti-Toxin B Antibodies

[0228] Two Nubian goats (#330 and #331) were injected intramuscularly with 50 μ g UDP dialdehyde-inactivated toxin B (Techlab) and complete Freund's adjuvant. Booster doses of 25 μ g toxoid B with Freund's incomplete adjuvant were given intramuscularly at two-week intervals. Test bleeds were obtained after 4 immunizations. ELISA reactivity and neutralization of cytotoxicity against both toxin A and toxin B were assayed to measure the specificity and cross reactivity of the sera.

[0229] Both animals responded well to toxin B and to a lesser extent to toxin A as measured by ELISA. Sera from goat #331 had less toxin A cross-reactivity and was chosen for the majority of the subsequent experiments. Neutralization of cytotoxicity to IMR-90 cells was determined as described in Example 3. The results of cytotoxicity neutralization are depicted in FIG. 13, which shows that sera from both animals exhibited good toxin B neutralizing antibody titers and very low, but detectable, toxin A neutralizing antibody titers. The ability of the goat sera to protect mice from a lethal intraperitoneal challenge with toxin B (100 ng) was also confirmed (data not shown).

Example 10

Protection of Hamsters from *C. difficile* Relapse with Anti-Toxin A and Anti-Toxin B Antibodies

[0230] Groups of hamsters (n=20) were challenged with clindamycin and *C. difficile*, and then treated with vancomycin as described in the hamster model of relapse in Example 7. Antibodies (either 3D8, serum from goat #331, or 3D8 and serum from goat #331) were given twice daily after vancomycin treatment (FIG. 14). Animals were monitored for survival (FIG. 15) or illness (FIG. 16). Antibody doses were 1 ml twice daily for serum from goat #331 and 3 mg for 3D8 given twice daily. Animals receiving vancomycin only (i.e., no antibody treatment) served as a negative controls. As observed previously, 3D8 and vancomycin treatment alone demonstrated a partial protective effect, in which 10 out of 20 animals were protected from lethality (FIG. 15). Fifty percent of animals in this group remained healthy (FIG. 16). Six out of 20 animals receiving vancomycin treatment alone were protected (FIG. 15). Thirty percent remained healthy (FIG. 16). Partial protection (9/20 animals protected) was also observed when the goat serum was used alone (FIG. 15). Forty percent remained healthy. Protection was increased to nearly 100% when both goat serum and 3D8 were given together (18/20) and disease onset was delayed (FIG. 15). Ninety percent of these animals remained healthy (FIG. 16). Clearly, protection from illness followed a pattern similar to protection from lethality. These data demonstrate that 3D8 can be fully protective in the hamster disease model when toxin B is also neutralized.

Example 11

Protection of Hamsters from *C. difficile* Relapse in Hamsters Immunized with Toxin B

[0231] Hamsters were immunized intraperitoneally with 10 μ g of the COOH-terminal fragment of toxin B (corresponding to amino acids 1777-2366 of toxin B) expressed in *E. coli* and using RIBI as adjuvant. Animals received 7 doses of toxin B antigen. Neutralizing antibody responses were observed in the animals that were tested. Groups of immunized hamsters were challenged with clindamycin and *C. difficile* then treated with vancomycin as described in the hamster model of relapse in Example 7. Antibody (3D8, 3 mg/dose) was given twice daily after vancomycin treatment to 19 animals and compared to a negative control group (n=20) that received no treatment (FIGS. 17 and 18). Six animals were challenged without vancomycin treatment to ensure that hamsters immunized with toxin B antigen were susceptible to *C. difficile* infection. Animals were monitored for survival (FIG. 17) or illness (FIG. 18). FIG. 17 shows that immunized animals that were not given 3D8 relapsed at a similar rate to that observed previously (65% relapse). Toxin B-immunized animals receiving 3D8 were more fully protected from relapse than observed previously (10% relapse, as compared to approximately 50% relapse in animals not previously immunized with toxin B in other experiments).

[0232] FIG. 18 shows that some of the immunized animals receiving 3D8 became ill but recovered from their diarrhea. Thirty five percent of immunized animals receiving vancomycin alone remained healthy. In experiments in which toxin B reactive sera were not present in animals, virtually all animals that had diarrhea later died. These data provide fur-

ther evidence that 3D8 can be fully protective in the hamster disease model when toxin B is also neutralized. Neutralization of toxin B in addition to toxin A was required for optimal protection from *C. difficile* disease in this model.

Example 12

Protection of Hamsters from Primary *C. difficile* Challenge Using 3D8 in Hamsters Treated with Goat Anti-Toxin B Sera

[0233] Prevention of relapse of *C. difficile* disease in the hamsters was easier to demonstrate than protection from direct challenge (i.e., challenge without vancomycin administration). Experiments with rabbit sera demonstrated only weak protection from direct challenge and 3D8 had no detectable affect on direct challenge. Since 3D8 was more protective in a background of toxin B neutralizing antibodies, it was determined whether the combined administration of 3D8 and anti-toxin B antisera could prevent disease due to direct challenge. Groups of 5 hamsters were challenged after receiving once daily doses of 3D8 (3 mg), combined 3D8 (3 mg) and goat #331 (1 ml) sera, or no antibodies for the 3 days prior to challenge as depicted in FIG. 19. The data in FIG. 20 shows that animals receiving no antibodies or either 3D8 or goat sera alone all died with 48 hours of *C. difficile* challenge. Most animals (80%) receiving both 3D8 and goat sera survived and the affected animals survived for 10 days after challenge. FIG. 21 shows that animals treated with 3D8 and goat sera became ill but recovered. These data provide further evidence that 3D8 can be fully protective in the hamster disease model when toxin B is also neutralized. Neutralization of toxin B in addition to toxin A was required for optimal protection from *C. difficile* disease in this model.

[0234] The successful protection of hamsters directly challenged with *C. difficile* offers several advantages to the screening of new toxin B candidates. Smaller numbers of animals can be used since 100% of untreated animals die. Antibodies, such as monoclonal antibodies (e.g., human monoclonal antibodies) can be screened directly in hamsters because the procedure requires 100 mg or less of the test antibody. Other modes of testing, such as the relapse model, require the effort of producing gram quantities due to the low attack rate in the relapse model, which necessitates testing larger numbers of animals. Direct challenge experiments are also shorter in duration with a definitive read out within 3-4 days of *C. difficile* challenge compared to 7-10 in the relapse model. In addition, the elimination of vancomycin treatment from the screening method reduces the number of times animals are handled.

Example 13

Generation of Anti-Toxin B Monoclonal Antibodies

[0235] *C. difficile* toxin B was obtained either from Techlab, Inc. (Blacksburg, Va.), or by recombinant production. The toxin was purified and inactivated prior to immunization. Inactivation was performed by treatment with reactive UDP-dialdehyde, which results in alkylation of catalytic residues while preserving native toxin structure. Briefly, purified toxin B was incubated with UDP-2',3'-dialdehyde (0.1-1.0 mM) in buffer for 18 hours at 37° C., filtered through a 100 kDa-cutoff filter to remove unreacted UDP-2',3'-dialdehyde, and washed with buffer. Inactivated toxin B (toxoid B) or recombinant toxin B fragments were used as immunogens. A

toxin B receptor binding domain (amino acid residues 1777-2366) was expressed in *E. coli* as a fusion protein containing an immunotag (hexahistidine) for affinity purification using nickel chelate affinity chromatography (designated fragment 4; see Example 11).

[0236] Hco12 transgenic mice, generated as described above in the section entitled "Generation of Human Monoclonal Antibodies in HuMAb Mice" and supplied by Medarex, Milpitas, Calif., were immunized intraperitoneally 6-12 times each with 10 µg of toxoid in RIBI adjuvant. In the Hco12 transgenic mice, the endogenous mouse kappa light chain gene has been homozygously disrupted as described in Chen et al. (1993) *EMBO J.* 12:811-820 and the endogenous mouse heavy chain gene has been homozygously disrupted as described in Example 1 of PCT Publication WO 01/09187. The Hco12 transgenic mice carry a human kappa light chain transgene, KCo5, as described in Fishwild et al. (1996) *Nature Biotechnology* 14:845-851, and the Hco12 human heavy chain transgene as described in U.S. Pat. Nos. 5,545,806; 5,625,825; and 5,545,807. Serum was collected from each mouse and tested for reactivity to toxin B by ELISA and neutralization of cytotoxicity on IMR-90 cells. Mice that tested positive for toxin B-reactive and neutralizing antiserum were injected with 5-10 µg toxoid B or fragment 4 through the tail vein. Mice were sacrificed and spleens were isolated for fusion to hybridomas approximately 3 days after tail vein injection was performed.

[0237] Clonal hybridomas were generated and screened by ELISA. Three hybridoma clones were selected for further analysis: 124-152; 2A11; and 1G10. In particular, cDNAs from the 124-152 clone were amplified by RT-PCR from mRNA, cloned, and sequenced. The heavy chain V region was determined to be derived from the germline sequence VH 5-51, the D region derived from the germline sequence 7-27, and the J sequence from the germline region JH3b. The light chain (kappa) regions were determined to be derived from A27 and the J region from JK1. The isotype of the 124-152 clone was determined to be IgG1. The amino acid sequences of the VH and VL regions of the 124-152 clone are shown in FIGS. 27-28. The complementarity determining regions (CDRs) are indicated in the Figures. The related germline sequences of the VH and VL regions are shown in FIGS. 30-31.

[0238] The antibodies 124-152; 2A11; and 1G10 were isolated from corresponding hybridomas and tested for their binding characteristics (infra). DNA encoding the 124-152 clone was cloned into a vector to be expressed as a human antibody for administration to humans.

Example 14

Binding Activity of Anti-Toxin B Antibodies

[0239] Binding of each antibody to toxin B was determined by Biacore using standard techniques. The results of this assay are depicted in Table 6. Antibodies produced by 124-152; 2A11; and 1G10 were compared to appropriate controls.

[0240] In particular, the affinity of the 124-152; 2A11; and 1G10 antibodies for toxin B was measured with Biacore® instrument, which detects biomolecular binding interactions with surface plasmon resonance technology. Each antibody was added to protein A-coated sensor chips, and toxin B was allowed to flow over the chip to measure binding. 124-152 had a K_D of 1.64×10^{-10} M; 2A11 had a K_D of 0.24×10^{-10} M; and 1G10 had a K_D of 2.98×10^{-10} M. Thus, the antibodies

bind with high affinity to toxin B. These binding constants indicate that the antibodies have affinities suitable for use in vivo application, for example, human therapy.

TABLE 6

Sample ID	$K_D \times 10^{-10}$ (M)	$k_a \times 10^5$ (1/Ms)	$k_d \times 10^{-5}$ (1/s)
2A11	0.24	21	5.07
124.152	1.64	34.5	56.4
51.1G10	2.98	1.31	3.89

Example 15

Toxin Neutralization by Anti-Toxin B Antibodies

[0241] Antibodies expressed by 124-152; 2A11; and 1G10 hybridomas were tested for toxin B neutralization activity in vitro. Cells were incubated in the presence of varying concentrations of a monoclonal antibody specific to toxin B which would prevent cells from rounding up after exposure to toxin B. Cytopathic effect (CPE) was determined by visual inspection of cells. A CPE score from 0-4 was determined, based on the results of the visual inspection (4=100% cytotoxicity, 0=0% toxicity). The results of these assays are depicted in FIG. 27. Neutralization of toxicity against a human lung fibroblast cell line, IMR-90. FIG. 27 shows that all of the antibodies had neutralizing capacity towards IMR-90 cells. The relative neutralizing activity of toxin A cytotoxicity on IMR-90 cells was 124-152>1G10>2A11.

Example 16

Protection of Hamsters from Primary *C. difficile* Challenge Using Anti-Toxin B Antibodies

[0242] Protection from direct challenge of an inoculum of *C. difficile* (clindamycin on day -1 and *C. difficile* spores on day 0 (1/100,000 dilution) was performed over a period of 4 to 10 days in the presence or absence of anti-toxin B antibodies. Groups of 5 hamsters were challenged after receiving once daily doses of 3D8 (20 mg total over 4 days), combined 3D8 (Id.) and goat #331 (3 ml) sera, 3D8 in combination with anti-toxin B antibodies 124-152 (18 mg total over 4 days), 2A11 (20 mg total over 4 days), or 1G10 (20 mg total over 4 days) or no antibodies for 3 days prior to challenge as depicted in FIG. 24. The data in FIG. 24 shows that animals receiving no antibodies or either 3D8 or goat sera alone all died within 72 hours of *C. difficile* challenge whereas animals

receiving 3D8 and an anti-toxin B antibody, and preferably in combination with 124-152, had a 40% survival rate (FIG. 24). A 10 day study similar to the foregoing (but using a more dilute *C. difficile* inoculum) was performed with increasing amounts of the anti-toxin B antibody 124-152 (0.56 mg, 1.7 mg, or 5.0 mg given at days -3, -2, -1, and 0). Animals receiving both 3D8 and goat sera survived and most animals (60%-70%) survived for 10 days after challenge if given 3D8 in combination with 124-152. Even the lowest dosage of the anti-toxin B antibody 124-152 (0.56 mg in combination with 3D8) was highly effective (70% survival; see FIG. 25). Results show that 124-152 and 3D8, alone, are less effective than when used in combination where a more than additive, indeed, synergistic therapeutic result is achieved (FIGS. 24-26). These data provide further evidence that the anti-toxin B antibody is highly effective, especially in combination with the anti-toxin A antibody 3D8. Neutralization of toxin B in addition to toxin A was determined to provide for protection from *C. difficile* disease in this model.

Example 17

Epitope Mapping of Anti-Toxin B Antibodies

[0243] The epitope of toxin B bound by each monoclonal antibody was determined by western blotting. Recombinant *E. coli* clones were constructed which express fragments of toxin B representing different domains of toxin B. The appropriate segments of the toxin B gene were PCR-amplified from DNA prepared from an appropriate *C. difficile* strain. The fragments were cloned into an expression vector and expressed in *E. coli*. Human monoclonal antibody 152 was used to probe toxin B fragment in western blots in order to map the binding epitope. Toxin B protein fragments were isolated from *E. coli* containing a portion of the toxin B genes and separated using SDS-PAGE. After electrophoresis, the toxin B fragments were transferred to nitrocellulose and probed with monoclonal antibody 152 followed by alkaline phosphatase conjugated goat anti human to detect MAb 152 binding. HuMab 152 was determined to bind to the —COOH fragment portion of toxin B between amino acids 1777 and 2366 (see, for example, FIG. 32).

Other Embodiments

[0244] A number of embodiments of the invention have been described. Nevertheless, it will be understood that various modifications may be made without departing from the spirit and scope of the invention. Accordingly, other embodiments are within the scope of the following claims.

SEQUENCE LISTING

<160> NUMBER OF SEQ ID NOS: 83

<210> SEQ ID NO 1

<211> LENGTH: 122

<212> TYPE: PRT

<213> ORGANISM: Homo sapiens

<400> SEQUENCE: 1

Gln Val Gln Leu Val Glu Ser Gly Gly Gly Val Val Gln Pro Gly Arg
1 5 10 15

Ser Leu Arg Leu Ser Cys Ala Ala Ser Gly Phe Ser Phe Ser Asn Tyr

-continued

```

                20          25          30
Gly Met His Trp Val Arg Gln Ala Pro Gly Lys Gly Leu Glu Trp Val
    35          40          45
Ala Leu Ile Trp Tyr Asp Gly Ser Asn Glu Asp Tyr Thr Asp Ser Val
    50          55          60
Lys Gly Arg Phe Thr Ile Ser Arg Asp Asn Ser Lys Asn Thr Leu Tyr
    65          70          75          80
Leu Gln Met Asn Ser Leu Arg Ala Glu Asp Thr Ala Val Tyr Tyr Cys
    85          90          95
Ala Arg Trp Gly Met Val Arg Gly Val Ile Asp Val Phe Asp Ile Trp
    100         105         110
Gly Gln Gly Thr Val Val Thr Val Ser Ser
    115          120

```

```

<210> SEQ ID NO 2
<211> LENGTH: 114
<212> TYPE: PRT
<213> ORGANISM: Homo sapiens

```

```

<400> SEQUENCE: 2

```

```

Gln Met Gln Leu Val Glu Ser Gly Gly Gly Val Val Gln Pro Gly Arg
1          5          10          15
Ser Leu Arg Leu Ser Cys Glu Ala Ser Gly Phe Ser Phe Asn Ser Tyr
    20          25          30
Gly Met His Trp Val Arg Gln Ala Pro Gly Lys Gly Leu Glu Trp Val
    35          40          45
Ser Val Ile Trp Ala Ser Gly Asn Lys Lys Tyr Tyr Ile Glu Ser Val
    50          55          60
Glu Gly Arg Phe Thr Ile Ser Arg Asp Asn Ser Lys Asn Thr Leu Tyr
    65          70          75          80
Leu Gln Met Asn Ser Leu Arg Ala Glu Asp Thr Ala Val Tyr Tyr Cys
    85          90          95
Ala Arg Ala Asn Phe Asp Tyr Trp Gly Gln Gly Thr Leu Val Thr Val
    100         105         110
Ser Ser

```

```

<210> SEQ ID NO 3
<211> LENGTH: 116
<212> TYPE: PRT
<213> ORGANISM: Homo sapiens

```

```

<400> SEQUENCE: 3

```

```

Gln Val Gln Leu Val Glu Ser Gly Gly Gly Val Val Gln Pro Gly Arg
1          5          10          15
Ser Leu Arg Leu Ser Cys Ala Ala Ser Gly Phe Thr Phe Asn Lys Tyr
    20          25          30
Gly Met His Trp Val Arg Gln Ala Pro Gly Lys Gly Leu Glu Trp Val
    35          40          45
Ala Val Ile Trp Tyr Asp Gly Thr Asn Lys Tyr Tyr Ala Asp Ser Met
    50          55          60
Lys Gly Arg Phe Thr Ile Ser Arg Asp Asn Ser Lys Asn Met Leu Tyr
    65          70          75          80
Leu Gln Met Asn Ser Leu Arg Ala Glu Asp Thr Ala Val Tyr Tyr Cys
    85          90          95

```


-continued

```

Asp Arg Val Thr Ile Thr Cys Arg Ala Ser Gln Gly Ile Ser Ser Trp
      20                25                30
Leu Ala Trp Tyr Gln Gln Lys Pro Glu Lys Ala Pro Lys Ser Leu Ile
      35                40                45
Tyr Ala Ala Ser Ser Leu Gln Ser Gly Val Pro Ser Arg Phe Ser Gly
      50                55                60
Ser Gly Ser Gly Thr Asp Phe Thr Leu Thr Ile Ser Ser Leu Gln Pro
      65                70                75                80
Glu Asp Phe Ala Thr Tyr Tyr Cys Gln Gln Tyr Lys Ser Tyr Pro Val
      85                90                95
Thr Phe Gly Gly Gly Thr Lys Val Glu Ile Lys
      100                105

```

```

<210> SEQ ID NO 7
<211> LENGTH: 5
<212> TYPE: PRT
<213> ORGANISM: Homo sapiens

```

```

<400> SEQUENCE: 7

```

```

Asn Tyr Gly Met His
1          5

```

```

<210> SEQ ID NO 8
<211> LENGTH: 17
<212> TYPE: PRT
<213> ORGANISM: Homo sapiens

```

```

<400> SEQUENCE: 8

```

```

Leu Ile Trp Tyr Asp Gly Ser Asn Glu Asp Tyr Thr Asp Ser Val Lys
1          5                10                15

```

```

Gly

```

```

<210> SEQ ID NO 9
<211> LENGTH: 13
<212> TYPE: PRT
<213> ORGANISM: Homo sapiens

```

```

<400> SEQUENCE: 9

```

```

Trp Gly Met Val Arg Gly Val Ile Asp Val Phe Asp Ile
1          5                10

```

```

<210> SEQ ID NO 10
<211> LENGTH: 5
<212> TYPE: PRT
<213> ORGANISM: Homo sapiens

```

```

<400> SEQUENCE: 10

```

```

Ser Tyr Gly Met His
1          5

```

```

<210> SEQ ID NO 11
<211> LENGTH: 17
<212> TYPE: PRT
<213> ORGANISM: Homo sapiens

```

```

<400> SEQUENCE: 11

```

```

Val Ile Trp Ala Ser Gly Asn Lys Lys Tyr Tyr Ile Glu Ser Val Glu
1          5                10                15

```

```

Gly

```

-continued

<210> SEQ ID NO 12
<211> LENGTH: 5
<212> TYPE: PRT
<213> ORGANISM: Homo sapiens

<400> SEQUENCE: 12

Ala Asn Phe Asp Tyr
1 5

<210> SEQ ID NO 13
<211> LENGTH: 5
<212> TYPE: PRT
<213> ORGANISM: Homo sapiens

<400> SEQUENCE: 13

Lys Tyr Gly Met His
1 5

<210> SEQ ID NO 14
<211> LENGTH: 17
<212> TYPE: PRT
<213> ORGANISM: Homo sapiens

<400> SEQUENCE: 14

Val Ile Trp Tyr Asp Gly Thr Asn Lys Tyr Tyr Ala Asp Ser Met Lys
1 5 10 15

Gly

<210> SEQ ID NO 15
<211> LENGTH: 7
<212> TYPE: PRT
<213> ORGANISM: Homo sapiens

<400> SEQUENCE: 15

Asp Pro Pro Thr Ala Asn Tyr
1 5

<210> SEQ ID NO 16
<211> LENGTH: 11
<212> TYPE: PRT
<213> ORGANISM: Homo sapiens

<400> SEQUENCE: 16

Arg Ala Ser Gln Gly Ile Ser Ser Trp Leu Ala
1 5 10

<210> SEQ ID NO 17
<211> LENGTH: 7
<212> TYPE: PRT
<213> ORGANISM: Homo sapiens

<400> SEQUENCE: 17

Ala Ala Ser Ser Leu Gln Ser
1 5

<210> SEQ ID NO 18
<211> LENGTH: 9
<212> TYPE: PRT
<213> ORGANISM: Homo sapiens

<400> SEQUENCE: 18

-continued

Gln Gln Ala Asn Ser Phe Pro Trp Thr
1 5

<210> SEQ ID NO 19
<211> LENGTH: 11
<212> TYPE: PRT
<213> ORGANISM: Homo sapiens

<400> SEQUENCE: 19

Arg Ala Ser Gln Ser Val Ser Ser Tyr Leu Ala
1 5 10

<210> SEQ ID NO 20
<211> LENGTH: 7
<212> TYPE: PRT
<213> ORGANISM: Homo sapiens

<400> SEQUENCE: 20

Asp Ala Ser Asn Arg Ala Thr
1 5

<210> SEQ ID NO 21
<211> LENGTH: 10
<212> TYPE: PRT
<213> ORGANISM: Homo sapiens

<400> SEQUENCE: 21

Gln Gln Arg Ser Asn Trp Ser Gln Phe Thr
1 5 10

<210> SEQ ID NO 22
<211> LENGTH: 11
<212> TYPE: PRT
<213> ORGANISM: Homo sapiens

<400> SEQUENCE: 22

Arg Ala Ser Gln Gly Ile Ser Ser Trp Leu Ala
1 5 10

<210> SEQ ID NO 23
<211> LENGTH: 7
<212> TYPE: PRT
<213> ORGANISM: Homo sapiens

<400> SEQUENCE: 23

Ala Ala Ser Ser Leu Gln Ser
1 5

<210> SEQ ID NO 24
<211> LENGTH: 9
<212> TYPE: PRT
<213> ORGANISM: Homo sapiens

<400> SEQUENCE: 24

Gln Gln Tyr Lys Ser Tyr Pro Val Thr
1 5

<210> SEQ ID NO 25
<211> LENGTH: 11
<212> TYPE: PRT
<213> ORGANISM: Homo sapiens
<220> FEATURE:

-continued

<221> NAME/KEY: MOD_RES
<222> LOCATION: (5)..(6)
<223> OTHER INFORMATION: Any amino acid
<220> FEATURE:
<221> NAME/KEY: MOD_RES
<222> LOCATION: (9)..(9)
<223> OTHER INFORMATION: Any amino acid

<400> SEQUENCE: 25

Arg Ala Ser Gln Xaa Xaa Ser Ser Xaa Leu Ala
1 5 10

<210> SEQ ID NO 26
<211> LENGTH: 6
<212> TYPE: PRT
<213> ORGANISM: Homo sapiens
<220> FEATURE:
<221> NAME/KEY: MOD_RES
<222> LOCATION: (3)..(5)
<223> OTHER INFORMATION: Any amino acid
<220> FEATURE:
<221> NAME/KEY: MOD_RES
<222> LOCATION: (6)..(6)
<223> OTHER INFORMATION: Ser or Thr

<400> SEQUENCE: 26

Ala Ser Xaa Xaa Xaa Xaa
1 5

<210> SEQ ID NO 27
<211> LENGTH: 7
<212> TYPE: PRT
<213> ORGANISM: Homo sapiens
<220> FEATURE:
<221> NAME/KEY: MOD_RES
<222> LOCATION: (3)..(4)
<223> OTHER INFORMATION: Any amino acid
<220> FEATURE:
<221> NAME/KEY: MOD_RES
<222> LOCATION: (5)..(5)
<223> OTHER INFORMATION: Ser or Asn
<220> FEATURE:
<221> NAME/KEY: MOD_RES
<222> LOCATION: (6)..(6)
<223> OTHER INFORMATION: Any amino acid
<220> FEATURE:
<221> NAME/KEY: MOD_RES
<222> LOCATION: (7)..(7)
<223> OTHER INFORMATION: Pro or Ser

<400> SEQUENCE: 27

Gln Gln Xaa Xaa Xaa Xaa Xaa
1 5

<210> SEQ ID NO 28
<211> LENGTH: 4
<212> TYPE: PRT
<213> ORGANISM: Homo sapiens

<400> SEQUENCE: 28

Tyr Gly Met His
1

<210> SEQ ID NO 29
<211> LENGTH: 15
<212> TYPE: PRT
<213> ORGANISM: Homo sapiens
<220> FEATURE:

-continued

```

<221> NAME/KEY: MOD_RES
<222> LOCATION: (3)..(4)
<223> OTHER INFORMATION: Any amino acid
<220> FEATURE:
<221> NAME/KEY: MOD_RES
<222> LOCATION: (6)..(8)
<223> OTHER INFORMATION: Any amino acid
<220> FEATURE:
<221> NAME/KEY: MOD_RES
<222> LOCATION: (10)..(11)
<223> OTHER INFORMATION: Any amino acid
<220> FEATURE:
<221> NAME/KEY: MOD_RES
<222> LOCATION: (13)..(14)
<223> OTHER INFORMATION: Any amino acid

```

<400> SEQUENCE: 29

```

Ile Trp Xaa Xaa Gly Xaa Xaa Xaa Tyr Xaa Xaa Ser Xaa Xaa Gly
1           5                10                15

```

```

<210> SEQ ID NO 30
<211> LENGTH: 107
<212> TYPE: PRT
<213> ORGANISM: Homo sapiens

```

<400> SEQUENCE: 30

```

Asp Ile Gln Met Thr Gln Ser Pro Ser Ser Leu Ser Ala Ser Val Gly
1           5                10                15

Asp Arg Val Thr Ile Thr Cys Arg Ala Ser Gln Gly Ile Ser Ser Trp
           20                25                30

Leu Ala Trp Tyr Gln Gln Lys Pro Glu Lys Ala Pro Lys Ser Leu Ile
           35                40                45

Tyr Ala Ala Ser Ser Leu Gln Ser Gly Val Pro Ser Arg Phe Ser Gly
50                55                60

Ser Gly Ser Gly Thr Asp Phe Thr Leu Thr Ile Ser Ser Leu Gln Pro
65                70                75                80

Glu Asp Phe Ala Thr Tyr Tyr Cys Gln Gln Tyr Asn Ser Tyr Pro Trp
           85                90                95

Thr Phe Gly Gln Gly Thr Lys Val Glu Ile Lys
           100                105

```

```

<210> SEQ ID NO 31
<211> LENGTH: 107
<212> TYPE: PRT
<213> ORGANISM: Homo sapiens

```

<400> SEQUENCE: 31

```

Val Ile Trp Met Thr Gln Ser Pro Ser Leu Leu Ser Ala Ser Thr Gly
1           5                10                15

Asp Arg Val Thr Ile Ser Cys Arg Met Ser Gln Gly Ile Ser Ser Tyr
           20                25                30

Leu Ala Trp Tyr Gln Gln Lys Pro Gly Lys Ala Pro Glu Leu Leu Ile
           35                40                45

Tyr Ala Ala Ser Thr Leu Gln Ser Gly Val Pro Ser Arg Phe Ser Gly
50                55                60

Ser Gly Ser Gly Thr Asp Phe Thr Leu Thr Ile Ser Ser Leu Gln Pro
65                70                75                80

Glu Asp Phe Ala Thr Tyr Tyr Cys Gln Gln Tyr Asn Ser Tyr Pro Trp
           85                90                95

```

-continued

Thr Phe Gly Gln Gly Thr Lys Val Glu Ile Lys
100 105

<210> SEQ ID NO 32
<211> LENGTH: 107
<212> TYPE: PRT
<213> ORGANISM: Homo sapiens

<400> SEQUENCE: 32

Asp Ile Gln Met Thr Gln Ser Pro Ser Ser Val Ser Ala Ser Val Gly
1 5 10 15
Asp Arg Val Thr Ile Thr Cys Arg Ala Ser Gln Gly Ile Ser Ser Trp
20 25 30
Leu Ala Trp Tyr Gln His Lys Pro Gly Lys Ala Pro Lys Leu Leu Ile
35 40 45
Tyr Ala Ala Ser Ser Leu Gln Ser Gly Val Pro Ser Arg Phe Ser Gly
50 55 60
Ser Gly Ser Gly Thr Asp Phe Thr Leu Thr Ile Ser Ser Leu Gln Pro
65 70 75 80
Glu Asp Phe Ala Thr Tyr Tyr Cys Gln Gln Tyr Asn Ser Tyr Pro Trp
85 90 95
Thr Phe Gly Gln Gly Thr Lys Val Glu Ile Lys
100 105

<210> SEQ ID NO 33
<211> LENGTH: 107
<212> TYPE: PRT
<213> ORGANISM: Homo sapiens

<400> SEQUENCE: 33

Asp Ile Gln Met Thr Gln Ser Pro Ser Ser Val Ser Ala Ser Val Gly
1 5 10 15
Asp Arg Val Thr Ile Thr Cys Arg Ala Ser Gln Gly Ile Ser Ser Trp
20 25 30
Leu Ala Trp Tyr Gln Gln Lys Pro Glu Lys Ala Pro Lys Ser Leu Ile
35 40 45
Tyr Ala Ala Ser Ser Leu Gln Ser Gly Val Pro Ser Arg Phe Ser Gly
50 55 60
Ser Gly Ser Gly Thr Asp Phe Thr Leu Thr Ile Ser Ser Leu Gln Pro
65 70 75 80
Glu Asp Phe Ala Thr Tyr Tyr Cys Gln Gln Tyr Asn Ser Tyr Pro Trp
85 90 95
Thr Phe Gly Gln Gly Thr Lys Val Glu Ile Lys
100 105

<210> SEQ ID NO 34
<211> LENGTH: 107
<212> TYPE: PRT
<213> ORGANISM: Homo sapiens

<400> SEQUENCE: 34

Asp Ile Gln Met Thr Gln Ser Leu Ser Ser Leu Ser Ala Ser Val Gly
1 5 10 15
Asp Arg Val Thr Ile Thr Cys Arg Ala Ser Gln Gly Ile Ser Ser Trp
20 25 30
Leu Ala Trp Tyr Gln Gln Lys Pro Glu Lys Ala Pro Lys Ser Leu Ile

-continued

35	40	45	
Tyr Ala Ala Ser Ser Leu Gln Ser Gly Val Pro Ser Arg Phe Ser Gly			
50	55	60	
Ser Gly Ser Gly Thr Asp Phe Thr Leu Thr Ile Ser Ser Leu Gln Pro			
65	70	75	80
Glu Asp Phe Ala Thr Tyr Tyr Cys Gln Gln Ala Asn Ser Phe Pro Trp			
	85	90	95
Thr Phe Gly Gln Gly Thr Lys Val Glu Ile Lys			
	100	105	
<210> SEQ ID NO 35			
<211> LENGTH: 321			
<212> TYPE: DNA			
<213> ORGANISM: Homo sapiens			
<220> FEATURE:			
<221> NAME/KEY: CDS			
<222> LOCATION: (1)..(321)			
<400> SEQUENCE: 35			
gac atc cag atg acc cag tct cca tct tcc gtg tct gca tct gta gga			48
Asp Ile Gln Met Thr Gln Ser Pro Ser Ser Val Ser Ala Ser Val Gly			
1	5	10	15
gac aga gtc acc atc act tgt cgg gcg agt cag ggt att agc agc tgg			96
Asp Arg Val Thr Ile Thr Cys Arg Ala Ser Gln Gly Ile Ser Ser Trp			
	20	25	30
tta gcc tgg tat cag cat aaa cca ggg aaa gcc cct aag ctc ctg atc			144
Leu Ala Trp Tyr Gln His Lys Pro Gly Lys Ala Pro Lys Leu Leu Ile			
	35	40	45
tat gct gca tcc agt ttg caa agt ggg gtc cca tca agg ttc agc ggc			192
Tyr Ala Ala Ser Ser Leu Gln Ser Gly Val Pro Ser Arg Phe Ser Gly			
50	55	60	
agt gga tct ggg aca gat ttc act ctc acc atc agc agc ctg cag cct			240
Ser Gly Ser Gly Thr Asp Phe Thr Leu Thr Ile Ser Ser Leu Gln Pro			
65	70	75	80
gaa gat ttt gca act tac tat tgt caa cag gct aat agt ttc cct tgg			288
Glu Asp Phe Ala Thr Tyr Tyr Cys Gln Gln Ala Asn Ser Phe Pro Trp			
	85	90	95
acg ttc ggc caa ggg acc aag gtg gaa atc aaa			321
Thr Phe Gly Gln Gly Thr Lys Val Glu Ile Lys			
	100	105	
<210> SEQ ID NO 36			
<211> LENGTH: 324			
<212> TYPE: DNA			
<213> ORGANISM: Homo sapiens			
<220> FEATURE:			
<221> NAME/KEY: CDS			
<222> LOCATION: (1)..(324)			
<400> SEQUENCE: 36			
gaa att gtg ttg aca cag tct cca gcc acc ctg tct ttg tct cca ggg			48
Glu Ile Val Leu Thr Gln Ser Pro Ala Thr Leu Ser Leu Ser Pro Gly			
1	5	10	15
gaa aga gcc acc ctc tcc tgc agg gcc agt cag agt gtt agc agc tac			96
Glu Arg Ala Thr Leu Ser Cys Arg Ala Ser Gln Ser Val Ser Ser Tyr			
	20	25	30
tta gcc tgg tac caa cag aaa cct ggc cag gct ccc agg ctc ctc atc			144
Leu Ala Trp Tyr Gln Gln Lys Pro Gly Gln Ala Pro Arg Leu Leu Ile			
	35	40	45

-continued

tat gat gca tcc aac agg gcc act ggc atc cca gcc agg ttc agt ggc	192
Tyr Asp Ala Ser Asn Arg Ala Thr Gly Ile Pro Ala Arg Phe Ser Gly	
50 55 60	

agt ggg tct ggg aca gac ttc act ctc acc atc agc agc cta gag cct	240
Ser Gly Ser Gly Thr Asp Phe Thr Leu Thr Ile Ser Ser Leu Glu Pro	
65 70 75 80	

gaa gat ttt gca gtt tat tac tgt cag cag cgt agc aac tgg tct caa	288
Glu Asp Phe Ala Val Tyr Tyr Cys Gln Gln Arg Ser Asn Trp Ser Gln	
85 90 95	

ttc act ttc ggc cct ggg acc aaa gtg gat atc aaa	324
Phe Thr Phe Gly Pro Gly Thr Lys Val Asp Ile Lys	
100 105	

<210> SEQ ID NO 37
 <211> LENGTH: 321
 <212> TYPE: DNA
 <213> ORGANISM: Homo sapiens
 <220> FEATURE:
 <221> NAME/KEY: CDS
 <222> LOCATION: (1)..(321)

<400> SEQUENCE: 37

gac atc cag atg acc cag tct cca tcc tca ctg tct gca tct gta gga	48
Asp Ile Gln Met Thr Gln Ser Pro Ser Ser Leu Ser Ala Ser Val Gly	
1 5 10 15	

gac aga gtc acc atc act tgt cgg gcg agt cag ggt att agc agc tgg	96
Asp Arg Val Thr Ile Thr Cys Arg Ala Ser Gln Gly Ile Ser Ser Trp	
20 25 30	

tta gcc tgg tat cag cag aaa cca gag aaa gcc cct aag tcc ctg atc	144
Leu Ala Trp Tyr Gln Gln Lys Pro Glu Lys Ala Pro Lys Ser Leu Ile	
35 40 45	

tat gct gca tcc agt ttg caa agt ggg gtc cca tca agg ttc agc ggc	192
Tyr Ala Ala Ser Ser Leu Gln Ser Gly Val Pro Ser Arg Phe Ser Gly	
50 55 60	

agt gga tct ggg aca gat ttc act ctc acc atc agc agc ctg cag cct	240
Ser Gly Ser Gly Thr Asp Phe Thr Leu Thr Ile Ser Ser Leu Gln Pro	
65 70 75 80	

gaa gat ttt gca act tat tac tgc caa cag tat aag agt tac ccg gtc	288
Glu Asp Phe Ala Thr Tyr Tyr Cys Gln Gln Tyr Lys Ser Tyr Pro Val	
85 90 95	

act ttc ggc gga ggg acc aag gtg gag atc aaa	321
Thr Phe Gly Gly Gly Thr Lys Val Glu Ile Lys	
100 105	

<210> SEQ ID NO 38
 <211> LENGTH: 366
 <212> TYPE: DNA
 <213> ORGANISM: Homo sapiens
 <220> FEATURE:
 <221> NAME/KEY: CDS
 <222> LOCATION: (1)..(366)

<400> SEQUENCE: 38

cag gtg cag ctg gtg gag tct ggg gga ggc gtg gtc cag cct ggc agg	48
Gln Val Gln Leu Val Glu Ser Gly Gly Gly Val Val Gln Pro Gly Arg	
1 5 10 15	

tcc ctg aga ctc tcc tgt cgg gcg tct gga ttc agc ttc agt aac tat	96
Ser Leu Arg Leu Ser Cys Ala Ala Ser Gly Phe Ser Phe Ser Asn Tyr	
20 25 30	

ggc atg cac tgg gtc cgc cag gct cca ggc aag ggg ctg gag tgg gtg	144
Gly Met His Trp Val Arg Gln Ala Pro Gly Lys Gly Leu Glu Trp Val	

-continued

35	40	45	
gca ctt ata tgg tat gat gga agt aat gag gac tat aca gac tcc gtg			192
Ala Leu Ile Trp Tyr Asp Gly Ser Asn Glu Asp Tyr Thr Asp Ser Val			
50	55	60	
aag ggc cga ttc acc atc tcc aga gac aat tcc aag aac acg ctg tat			240
Lys Gly Arg Phe Thr Ile Ser Arg Asp Asn Ser Lys Asn Thr Leu Tyr			
65	70	75	80
ctg caa atg aac agc ctg aga gcc gag gac acg gct gtg tat tac tgt			288
Leu Gln Met Asn Ser Leu Arg Ala Glu Asp Thr Ala Val Tyr Tyr Cys			
85	90	95	
gcg aga tgg ggg atg gtt cgg gga gtt atc gat gtt ttt gat atc tgg			336
Ala Arg Trp Gly Met Val Arg Gly Val Ile Asp Val Phe Asp Ile Trp			
100	105	110	
ggc caa ggg aca gtg gtc acc gtc tct tca			366
Gly Gln Gly Thr Val Val Thr Val Ser Ser			
115	120		
<210> SEQ ID NO 39			
<211> LENGTH: 342			
<212> TYPE: DNA			
<213> ORGANISM: Homo sapiens			
<220> FEATURE:			
<221> NAME/KEY: CDS			
<222> LOCATION: (1)..(342)			
<400> SEQUENCE: 39			
cag atg cag ctg gtg gag tct ggg ggc ggc gtg gtc cag cct ggg agg			48
Gln Met Gln Leu Val Glu Ser Gly Gly Gly Val Val Gln Pro Gly Arg			
1	5	10	15
tcc ctg aga ctc tcc tgt gaa gcg tct gga ttc tcc ttc aat agc tat			96
Ser Leu Arg Leu Ser Cys Glu Ala Ser Gly Phe Ser Phe Asn Ser Tyr			
20	25	30	
ggc atg cac tgg gtc cgc cag gct cca ggc aag ggg ctg gag tgg gtg			144
Gly Met His Trp Val Arg Gln Ala Pro Gly Lys Gly Leu Glu Trp Val			
35	40	45	
tca gtc ata tgg gcc agt gga aat aag aaa tat tat ata gaa tcc gtg			192
Ser Val Ile Trp Ala Ser Gly Asn Lys Lys Tyr Tyr Ile Glu Ser Val			
50	55	60	
gag ggc cga ttc acc atc tcc aga gac aat tcc aag aac acg ctg tat			240
Glu Gly Arg Phe Thr Ile Ser Arg Asp Asn Ser Lys Asn Thr Leu Tyr			
65	70	75	80
ctg caa atg aac agc ctg aga gcc gag gac acg gct gtg tat tac tgt			288
Leu Gln Met Asn Ser Leu Arg Ala Glu Asp Thr Ala Val Tyr Tyr Cys			
85	90	95	
gcg aga gcc aat ttt gac tac tgg ggc cag gga acc ctg gtc acc gtc			336
Ala Arg Ala Asn Phe Asp Tyr Trp Gly Gln Gly Thr Leu Val Thr Val			
100	105	110	
tcc tca			342
Ser Ser			
<210> SEQ ID NO 40			
<211> LENGTH: 348			
<212> TYPE: DNA			
<213> ORGANISM: Homo sapiens			
<220> FEATURE:			
<221> NAME/KEY: CDS			
<222> LOCATION: (1)..(348)			
<400> SEQUENCE: 40			
cag gtg cag ctg gtg gag tct ggg gga ggc gtg gtc cag cct ggg agg			48

-continued

Gln	Val	Gln	Leu	Val	Glu	Ser	Gly	Gly	Gly	Val	Val	Gln	Pro	Gly	Arg	
1				5					10					15		
tcc	ctg	aga	ctc	tcc	tgt	gca	gcg	tct	gga	ttc	acc	ttc	aat	aaa	tat	96
Ser	Leu	Arg	Leu	Ser	Cys	Ala	Ala	Ser	Gly	Phe	Thr	Phe	Asn	Lys	Tyr	
			20					25					30			
ggc	atg	cac	tgg	gtc	cgc	cag	gct	cca	ggc	aag	ggg	ctg	gag	tgg	gtg	144
Gly	Met	His	Trp	Val	Arg	Gln	Ala	Pro	Gly	Lys	Gly	Leu	Glu	Trp	Val	
		35				40						45				
gca	gtt	ata	tgg	tat	gat	gga	act	aat	aaa	tac	tat	gca	gac	tcc	atg	192
Ala	Val	Ile	Trp	Tyr	Asp	Gly	Thr	Asn	Lys	Tyr	Tyr	Ala	Asp	Ser	Met	
	50					55					60					
aag	ggc	cga	ttc	acc	atc	tcc	aga	gac	aat	tcc	aag	aat	atg	ctg	tat	240
Lys	Gly	Arg	Phe	Thr	Ile	Ser	Arg	Asp	Asn	Ser	Lys	Asn	Met	Leu	Tyr	
65					70					75				80		
ctg	caa	atg	aac	agc	cta	aga	gcc	gag	gac	acg	gct	gtg	tat	tac	tgt	288
Leu	Gln	Met	Asn	Ser	Leu	Arg	Ala	Glu	Asp	Thr	Ala	Val	Tyr	Tyr	Cys	
				85					90					95		
gcg	aga	gat	ccc	ccc	act	gct	aac	tac	tgg	ggc	cag	gga	acc	ctg	gtc	336
Ala	Arg	Asp	Pro	Pro	Thr	Ala	Asn	Tyr	Trp	Gly	Gln	Gly	Thr	Leu	Val	
			100					105					110			
acc	gtc	tcc	tca													348
Thr	Val	Ser	Ser													
			115													

<210> SEQ ID NO 41
 <211> LENGTH: 2710
 <212> TYPE: PRT
 <213> ORGANISM: Clostridium difficile

<400> SEQUENCE: 41

Met	Ser	Leu	Ile	Ser	Lys	Glu	Glu	Leu	Ile	Lys	Leu	Ala	Tyr	Ser	Ile	
1				5					10					15		
Arg	Pro	Arg	Glu	Asn	Glu	Tyr	Lys	Thr	Ile	Leu	Thr	Asn	Leu	Asp	Glu	
			20					25					30			
Tyr	Asn	Lys	Leu	Thr	Thr	Asn	Asn	Asn	Glu	Asn	Lys	Tyr	Leu	Gln	Leu	
		35					40					45				
Lys	Lys	Leu	Asn	Glu	Ser	Ile	Asp	Val	Phe	Met	Asn	Lys	Tyr	Lys	Thr	
	50					55					60					
Ser	Ser	Arg	Asn	Arg	Ala	Leu	Ser	Asn	Leu	Lys	Lys	Asp	Ile	Leu	Lys	
65					70					75				80		
Glu	Val	Ile	Leu	Ile	Lys	Asn	Ser	Asn	Thr	Ser	Pro	Val	Glu	Lys	Asn	
				85					90					95		
Leu	His	Phe	Val	Trp	Ile	Gly	Gly	Glu	Val	Ser	Asp	Ile	Ala	Leu	Glu	
			100					105					110			
Tyr	Ile	Lys	Gln	Trp	Ala	Asp	Ile	Asn	Ala	Glu	Tyr	Asn	Ile	Lys	Leu	
		115					120					125				
Trp	Tyr	Asp	Ser	Glu	Ala	Phe	Leu	Val	Asn	Thr	Leu	Lys	Lys	Ala	Ile	
	130					135					140					
Val	Glu	Ser	Ser	Thr	Thr	Glu	Ala	Leu	Gln	Leu	Leu	Glu	Glu	Glu	Ile	
145					150					155					160	
Gln	Asn	Pro	Gln	Phe	Asp	Asn	Met	Lys	Phe	Tyr	Lys	Lys	Arg	Met	Glu	
				165					170					175		
Phe	Ile	Tyr	Asp	Arg	Gln	Lys	Arg	Phe	Ile	Asn	Tyr	Tyr	Lys	Ser	Gln	
		180						185						190		
Ile	Asn	Lys	Pro	Thr	Val	Pro	Thr	Ile	Asp	Asp	Ile	Ile	Lys	Ser	His	

-continued

195					200					205					
Leu	Val	Ser	Glu	Tyr	Asn	Arg	Asp	Glu	Thr	Val	Leu	Glu	Ser	Tyr	Arg
210					215					220					
Thr	Asn	Ser	Leu	Arg	Lys	Ile	Asn	Ser	Asn	His	Gly	Ile	Asp	Ile	Arg
225					230					235					240
Ala	Asn	Ser	Leu	Phe	Thr	Glu	Gln	Glu	Leu	Leu	Asn	Ile	Tyr	Ser	Gln
				245					250					255	
Glu	Leu	Leu	Asn	Arg	Gly	Asn	Leu	Ala	Ala	Ala	Ser	Asp	Ile	Val	Arg
			260					265						270	
Leu	Leu	Ala	Leu	Lys	Asn	Phe	Gly	Gly	Val	Tyr	Leu	Asp	Val	Asp	Met
		275					280						285		
Leu	Pro	Gly	Ile	His	Ser	Asp	Leu	Phe	Lys	Thr	Ile	Ser	Arg	Pro	Ser
	290					295					300				
Ser	Ile	Gly	Leu	Asp	Arg	Trp	Glu	Met	Ile	Lys	Leu	Glu	Ala	Ile	Met
305					310					315					320
Lys	Tyr	Lys	Lys	Tyr	Ile	Asn	Asn	Tyr	Thr	Ser	Glu	Asn	Phe	Asp	Lys
				325					330					335	
Leu	Asp	Gln	Gln	Leu	Lys	Asp	Asn	Phe	Lys	Leu	Ile	Ile	Glu	Ser	Lys
			340					345						350	
Ser	Glu	Lys	Ser	Glu	Ile	Phe	Ser	Lys	Leu	Glu	Asn	Leu	Asn	Val	Ser
		355					360						365		
Asp	Leu	Glu	Ile	Lys	Ile	Ala	Phe	Ala	Leu	Gly	Ser	Val	Ile	Asn	Gln
370						375						380			
Ala	Leu	Ile	Ser	Lys	Gln	Gly	Ser	Tyr	Leu	Thr	Asn	Leu	Val	Ile	Glu
385					390					395					400
Gln	Val	Lys	Asn	Arg	Tyr	Gln	Phe	Leu	Asn	Gln	His	Leu	Asn	Pro	Ala
				405					410					415	
Ile	Glu	Ser	Asp	Asn	Asn	Phe	Thr	Asp	Thr	Thr	Lys	Ile	Phe	His	Asp
			420					425						430	
Ser	Leu	Phe	Asn	Ser	Ala	Thr	Ala	Glu	Asn	Ser	Met	Phe	Leu	Thr	Lys
		435					440						445		
Ile	Ala	Pro	Tyr	Leu	Gln	Val	Gly	Phe	Met	Pro	Glu	Ala	Arg	Ser	Thr
450						455					460				
Ile	Ser	Leu	Ser	Gly	Pro	Gly	Ala	Tyr	Ala	Ser	Ala	Tyr	Tyr	Asp	Phe
465					470					475					480
Ile	Asn	Leu	Gln	Glu	Asn	Thr	Ile	Glu	Lys	Thr	Leu	Lys	Ala	Ser	Asp
				485					490					495	
Leu	Ile	Glu	Phe	Lys	Phe	Pro	Glu	Asn	Asn	Leu	Ser	Gln	Leu	Thr	Glu
			500					505						510	
Gln	Glu	Ile	Asn	Ser	Leu	Trp	Ser	Phe	Asp	Gln	Ala	Ser	Ala	Lys	Tyr
			515					520						525	
Gln	Phe	Glu	Lys	Tyr	Val	Arg	Asp	Tyr	Thr	Gly	Gly	Ser	Leu	Ser	Glu
530						535								540	
Asp	Asn	Gly	Val	Asp	Phe	Asn	Lys	Asn	Thr	Ala	Leu	Asp	Lys	Asn	Tyr
545						550					555				560
Leu	Leu	Asn	Asn	Lys	Ile	Pro	Ser	Asn	Asn	Val	Glu	Glu	Ala	Gly	Ser
				565					570					575	
Lys	Asn	Tyr	Val	His	Tyr	Ile	Ile	Gln	Leu	Gln	Gly	Asp	Asp	Ile	Ser
			580						585					590	
Tyr	Glu	Ala	Thr	Cys	Asn	Leu	Phe	Ser	Lys	Asn	Pro	Lys	Asn	Ser	Ile
			595						600					605	

-continued

Ile Ile Gln Arg Asn Met Asn Glu Ser Ala Lys Ser Tyr Phe Leu Ser
 610 615 620
 Asp Asp Gly Glu Ser Ile Leu Glu Leu Asn Lys Tyr Arg Ile Pro Glu
 625 630 635 640
 Arg Leu Lys Asn Lys Glu Lys Val Lys Val Thr Phe Ile Gly His Gly
 645 650 655
 Lys Asp Glu Phe Asn Thr Ser Glu Phe Ala Arg Leu Ser Val Asp Ser
 660 665 670
 Leu Ser Asn Glu Ile Ser Ser Phe Leu Asp Thr Ile Lys Leu Asp Ile
 675 680 685
 Ser Pro Lys Asn Val Glu Val Asn Leu Leu Gly Cys Asn Met Phe Ser
 690 695 700
 Tyr Asp Phe Asn Val Glu Glu Thr Tyr Pro Gly Lys Leu Leu Leu Ser
 705 710 715 720
 Ile Met Asp Lys Ile Thr Ser Thr Leu Pro Asp Val Asn Lys Asn Ser
 725 730 735
 Ile Thr Ile Gly Ala Asn Gln Tyr Glu Val Arg Ile Asn Ser Glu Gly
 740 745 750
 Arg Lys Glu Leu Leu Ala His Ser Gly Lys Trp Ile Asn Lys Glu Glu
 755 760 765
 Ala Ile Met Ser Asp Leu Ser Ser Lys Glu Tyr Ile Phe Phe Asp Ser
 770 775 780
 Ile Asp Asn Lys Leu Lys Ala Lys Ser Lys Asn Ile Pro Gly Leu Ala
 785 790 795 800
 Ser Ile Ser Glu Asp Ile Lys Thr Leu Leu Leu Asp Ala Ser Val Ser
 805 810 815
 Pro Asp Thr Lys Phe Ile Leu Asn Asn Leu Lys Leu Asn Ile Glu Ser
 820 825 830
 Ser Ile Gly Asp Tyr Ile Tyr Tyr Glu Lys Leu Glu Pro Val Lys Asn
 835 840 845
 Ile Ile His Asn Ser Ile Asp Asp Leu Ile Asp Glu Phe Asn Leu Leu
 850 855 860
 Glu Asn Val Ser Asp Glu Leu Tyr Glu Leu Lys Lys Leu Asn Asn Leu
 865 870 875 880
 Asp Glu Lys Tyr Leu Ile Ser Phe Glu Asp Ile Ser Lys Asn Asn Ser
 885 890 895
 Thr Tyr Ser Val Arg Phe Ile Asn Lys Ser Asn Gly Glu Ser Val Tyr
 900 905 910
 Val Glu Thr Glu Lys Glu Ile Phe Ser Lys Tyr Ser Glu His Ile Thr
 915 920 925
 Lys Glu Ile Ser Thr Ile Lys Asn Ser Ile Ile Thr Asp Val Asn Gly
 930 935 940
 Asn Leu Leu Asp Asn Ile Gln Leu Asp His Thr Ser Gln Val Asn Thr
 945 950 955 960
 Leu Asn Ala Ala Phe Phe Ile Gln Ser Leu Ile Asp Tyr Ser Ser Asn
 965 970 975
 Lys Asp Val Leu Asn Asp Leu Ser Thr Ser Val Lys Val Gln Leu Tyr
 980 985 990
 Ala Gln Leu Phe Ser Thr Gly Leu Asn Thr Ile Tyr Asp Ser Ile Gln
 995 1000 1005

-continued

Leu Val 1010	Asn Leu Ile Ser 1015	Ala Val Asn Asp 1020	Thr Ile Asn Val
Leu Pro 1025	Thr Ile Thr Glu Gly 1030	Ile Pro Ile Val Ser 1035	Thr Ile Leu
Asp Gly 1040	Ile Asn Leu Gly Ala 1045	Ala Ile Lys Glu Leu 1050	Leu Asp Glu
His Asp 1055	Pro Leu Leu Lys Lys 1060	Glu Leu Glu Ala Lys 1065	Val Gly Val
Leu Ala 1070	Ile Asn Met Ser Leu 1075	Ser Ile Ala Ala Thr 1080	Val Ala Ser
Ile Val 1085	Gly Ile Gly Ala Glu 1090	Val Thr Ile Phe Leu 1095	Leu Pro Ile
Ala Gly 1100	Ile Ser Ala Gly Ile 1105	Pro Ser Leu Val Asn 1110	Asn Glu Leu
Ile Leu 1115	His Asp Lys Ala Thr 1120	Ser Val Val Asn Tyr 1125	Phe Asn His
Leu Ser 1130	Glu Ser Lys Lys Tyr 1135	Gly Pro Leu Lys Thr 1140	Glu Asp Asp
Lys Ile 1145	Leu Val Pro Ile Asp 1150	Asp Leu Val Ile Ser 1155	Glu Ile Asp
Phe Asn 1160	Asn Asn Ser Ile Lys 1165	Leu Gly Thr Cys Asn 1170	Ile Leu Ala
Met Glu 1175	Gly Gly Ser Gly His 1180	Thr Val Thr Gly Asn 1185	Ile Asp His
Phe Phe 1190	Ser Ser Pro Ser Ile 1195	Ser Ser His Ile Pro 1200	Ser Leu Ser
Ile Tyr 1205	Ser Ala Ile Gly Ile 1210	Glu Thr Glu Asn Leu 1215	Asp Phe Ser
Lys Lys 1220	Ile Met Met Leu Pro 1225	Asn Ala Pro Ser Arg 1230	Val Phe Trp
Trp Glu 1235	Thr Gly Ala Val Pro 1240	Gly Leu Arg Ser Leu 1245	Glu Asn Asp
Gly Thr 1250	Arg Leu Leu Asp Ser 1255	Ile Arg Asp Leu Tyr 1260	Pro Gly Lys
Phe Tyr 1265	Trp Arg Phe Tyr Ala 1270	Phe Phe Asp Tyr Ala 1275	Ile Thr Thr
Leu Lys 1280	Pro Val Tyr Glu Asp 1285	Thr Asn Ile Lys Ile 1290	Lys Leu Asp
Lys Asp 1295	Thr Arg Asn Phe Ile 1300	Met Pro Thr Ile Thr 1305	Thr Asn Glu
Ile Arg 1310	Asn Lys Leu Ser Tyr 1315	Ser Phe Asp Gly Ala 1320	Gly Gly Thr
Tyr Ser 1325	Leu Leu Leu Ser Ser 1330	Tyr Pro Ile Ser Thr 1335	Asn Ile Asn
Leu Ser 1340	Lys Asp Asp Leu Trp 1345	Ile Phe Asn Ile Asp 1350	Asn Glu Val
Arg Glu 1355	Ile Ser Ile Glu Asn 1360	Gly Thr Ile Lys Lys 1365	Gly Lys Leu
Ile Lys 1370	Asp Val Leu Ser Lys 1375	Ile Asp Ile Asn Lys 1380	Asn Lys Leu
Ile Ile	Gly Asn Gln Thr Ile	Asp Phe Ser Gly Asp	Ile Asp Asn

-continued

1385	1390	1395
Lys Asp Arg Tyr Ile Phe Leu Thr Cys Glu Leu Asp Asp Lys Ile 1400 1405 1410		
Ser Leu Ile Ile Glu Ile Asn Leu Val Ala Lys Ser Tyr Ser Leu 1415 1420 1425		
Leu Leu Ser Gly Asp Lys Asn Tyr Leu Ile Ser Asn Leu Ser Asn 1430 1435 1440		
Thr Ile Glu Lys Ile Asn Thr Leu Gly Leu Asp Ser Lys Asn Ile 1445 1450 1455		
Ala Tyr Asn Tyr Thr Asp Glu Ser Asn Asn Lys Tyr Phe Gly Ala 1460 1465 1470		
Ile Ser Lys Thr Ser Gln Lys Ser Ile Ile His Tyr Lys Lys Asp 1475 1480 1485		
Ser Lys Asn Ile Leu Glu Phe Tyr Asn Asp Ser Thr Leu Glu Phe 1490 1495 1500		
Asn Ser Lys Asp Phe Ile Ala Glu Asp Ile Asn Val Phe Met Lys 1505 1510 1515		
Asp Asp Ile Asn Thr Ile Thr Gly Lys Tyr Tyr Val Asp Asn Asn 1520 1525 1530		
Thr Asp Lys Ser Ile Asp Phe Ser Ile Ser Leu Val Ser Lys Asn 1535 1540 1545		
Gln Val Lys Val Asn Gly Leu Tyr Leu Asn Glu Ser Val Tyr Ser 1550 1555 1560		
Ser Tyr Leu Asp Phe Val Lys Asn Ser Asp Gly His His Asn Thr 1565 1570 1575		
Ser Asn Phe Met Asn Leu Phe Leu Asp Asn Ile Ser Phe Trp Lys 1580 1585 1590		
Leu Phe Gly Phe Glu Asn Ile Asn Phe Val Ile Asp Lys Tyr Phe 1595 1600 1605		
Thr Leu Val Gly Lys Thr Asn Leu Gly Tyr Val Glu Phe Ile Cys 1610 1615 1620		
Asp Asn Asn Lys Asn Ile Asp Ile Tyr Phe Gly Glu Trp Lys Thr 1625 1630 1635		
Ser Ser Ser Lys Ser Thr Ile Phe Ser Gly Asn Gly Arg Asn Val 1640 1645 1650		
Val Val Glu Pro Ile Tyr Asn Pro Asp Thr Gly Glu Asp Ile Ser 1655 1660 1665		
Thr Ser Leu Asp Phe Ser Tyr Glu Pro Leu Tyr Gly Ile Asp Arg 1670 1675 1680		
Tyr Ile Asn Lys Val Leu Ile Ala Pro Asp Leu Tyr Thr Ser Leu 1685 1690 1695		
Ile Asn Ile Asn Thr Asn Tyr Tyr Ser Asn Glu Tyr Tyr Pro Glu 1700 1705 1710		
Ile Ile Val Leu Asn Pro Asn Thr Phe His Lys Lys Val Asn Ile 1715 1720 1725		
Asn Leu Asp Ser Ser Ser Phe Glu Tyr Lys Trp Ser Thr Glu Gly 1730 1735 1740		
Ser Asp Phe Ile Leu Val Arg Tyr Leu Glu Glu Ser Asn Lys Lys 1745 1750 1755		
Ile Leu Gln Lys Ile Arg Ile Lys Gly Ile Leu Ser Asn Thr Gln 1760 1765 1770		

-continued

Ser	Phe	Asn	Lys	Met	Ser	Ile	Asp	Phe	Lys	Asp	Ile	Lys	Lys	Leu
1775						1780					1785			
Ser	Leu	Gly	Tyr	Ile	Met	Ser	Asn	Phe	Lys	Ser	Phe	Asn	Ser	Glu
1790						1795					1800			
Asn	Glu	Leu	Asp	Arg	Asp	His	Leu	Gly	Phe	Lys	Ile	Ile	Asp	Asn
1805						1810					1815			
Lys	Thr	Tyr	Tyr	Tyr	Asp	Glu	Asp	Ser	Lys	Leu	Val	Lys	Gly	Leu
1820						1825					1830			
Ile	Asn	Ile	Asn	Asn	Ser	Leu	Phe	Tyr	Phe	Asp	Pro	Ile	Glu	Phe
1835						1840					1845			
Asn	Leu	Val	Thr	Gly	Trp	Gln	Thr	Ile	Asn	Gly	Lys	Lys	Tyr	Tyr
1850						1855					1860			
Phe	Asp	Ile	Asn	Thr	Gly	Ala	Ala	Leu	Thr	Ser	Tyr	Lys	Ile	Ile
1865						1870					1875			
Asn	Gly	Lys	His	Phe	Tyr	Phe	Asn	Asn	Asp	Gly	Val	Met	Gln	Leu
1880						1885					1890			
Gly	Val	Phe	Lys	Gly	Pro	Asp	Gly	Phe	Glu	Tyr	Phe	Ala	Pro	Ala
1895						1900					1905			
Asn	Thr	Gln	Asn	Asn	Asn	Ile	Glu	Gly	Gln	Ala	Ile	Val	Tyr	Gln
1910						1915					1920			
Ser	Lys	Phe	Leu	Thr	Leu	Asn	Gly	Lys	Lys	Tyr	Tyr	Phe	Asp	Asn
1925						1930					1935			
Asn	Ser	Lys	Ala	Val	Thr	Gly	Trp	Arg	Ile	Ile	Asn	Asn	Glu	Lys
1940						1945					1950			
Tyr	Tyr	Phe	Asn	Pro	Asn	Asn	Ala	Ile	Ala	Ala	Val	Gly	Leu	Gln
1955						1960					1965			
Val	Ile	Asp	Asn	Asn	Lys	Tyr	Tyr	Phe	Asn	Pro	Asp	Thr	Ala	Ile
1970						1975					1980			
Ile	Ser	Lys	Gly	Trp	Gln	Thr	Val	Asn	Gly	Ser	Arg	Tyr	Tyr	Phe
1985						1990					1995			
Asp	Thr	Asp	Thr	Ala	Ile	Ala	Phe	Asn	Gly	Tyr	Lys	Thr	Ile	Asp
2000						2005					2010			
Gly	Lys	His	Phe	Tyr	Phe	Asp	Ser	Asp	Cys	Val	Val	Lys	Ile	Gly
2015						2020					2025			
Val	Phe	Ser	Thr	Ser	Asn	Gly	Phe	Glu	Tyr	Phe	Ala	Pro	Ala	Asn
2030						2035					2040			
Thr	Tyr	Asn	Asn	Asn	Ile	Glu	Gly	Gln	Ala	Ile	Val	Tyr	Gln	Ser
2045						2050					2055			
Lys	Phe	Leu	Thr	Leu	Asn	Gly	Lys	Lys	Tyr	Tyr	Phe	Asp	Asn	Asn
2060						2065					2070			
Ser	Lys	Ala	Val	Thr	Gly	Trp	Gln	Thr	Ile	Asp	Ser	Lys	Lys	Tyr
2075						2080					2085			
Tyr	Phe	Asn	Thr	Asn	Thr	Ala	Glu	Ala	Ala	Thr	Gly	Trp	Gln	Thr
2090						2095					2100			
Ile	Asp	Gly	Lys	Lys	Tyr	Tyr	Phe	Asn	Thr	Asn	Thr	Ala	Glu	Ala
2105						2110					2115			
Ala	Thr	Gly	Trp	Gln	Thr	Ile	Asp	Gly	Lys	Lys	Tyr	Tyr	Phe	Asn
2120						2125					2130			
Thr	Asn	Thr	Ala	Ile	Ala	Ser	Thr	Gly	Tyr	Thr	Ile	Ile	Asn	Gly
2135						2140					2145			

-continued

Lys	His	Phe	Tyr	Phe	Asn	Thr	Asp	Gly	Ile	Met	Gln	Ile	Gly	Val
2150						2155					2160			
Phe	Lys	Gly	Pro	Asn	Gly	Phe	Glu	Tyr	Phe	Ala	Pro	Ala	Asn	Thr
2165						2170					2175			
Asp	Ala	Asn	Asn	Ile	Glu	Gly	Gln	Ala	Ile	Leu	Tyr	Gln	Asn	Glu
2180						2185					2190			
Phe	Leu	Thr	Leu	Asn	Gly	Lys	Lys	Tyr	Tyr	Phe	Gly	Ser	Asp	Ser
2195						2200					2205			
Lys	Ala	Val	Thr	Gly	Trp	Arg	Ile	Ile	Asn	Asn	Lys	Lys	Tyr	Tyr
2210						2215					2220			
Phe	Asn	Pro	Asn	Asn	Ala	Ile	Ala	Ala	Ile	His	Leu	Cys	Thr	Ile
2225						2230					2235			
Asn	Asn	Asp	Lys	Tyr	Tyr	Phe	Ser	Tyr	Asp	Gly	Ile	Leu	Gln	Asn
2240						2245					2250			
Gly	Tyr	Ile	Thr	Ile	Glu	Arg	Asn	Asn	Phe	Tyr	Phe	Asp	Ala	Asn
2255						2260					2265			
Asn	Glu	Ser	Lys	Met	Val	Thr	Gly	Val	Phe	Lys	Gly	Pro	Asn	Gly
2270						2275					2280			
Phe	Glu	Tyr	Phe	Ala	Pro	Ala	Asn	Thr	His	Asn	Asn	Asn	Ile	Glu
2285						2290					2295			
Gly	Gln	Ala	Ile	Val	Tyr	Gln	Asn	Lys	Phe	Leu	Thr	Leu	Asn	Gly
2300						2305					2310			
Lys	Lys	Tyr	Tyr	Phe	Asp	Asn	Asp	Ser	Lys	Ala	Val	Thr	Gly	Trp
2315						2320					2325			
Gln	Thr	Ile	Asp	Gly	Lys	Lys	Tyr	Tyr	Phe	Asn	Leu	Asn	Thr	Ala
2330						2335					2340			
Glu	Ala	Ala	Thr	Gly	Trp	Gln	Thr	Ile	Asp	Gly	Lys	Lys	Tyr	Tyr
2345						2350					2355			
Phe	Asn	Leu	Asn	Thr	Ala	Glu	Ala	Ala	Thr	Gly	Trp	Gln	Thr	Ile
2360						2365					2370			
Asp	Gly	Lys	Lys	Tyr	Tyr	Phe	Asn	Thr	Asn	Thr	Phe	Ile	Ala	Ser
2375						2380					2385			
Thr	Gly	Tyr	Thr	Ser	Ile	Asn	Gly	Lys	His	Phe	Tyr	Phe	Asn	Thr
2390						2395					2400			
Asp	Gly	Ile	Met	Gln	Ile	Gly	Val	Phe	Lys	Gly	Pro	Asn	Gly	Phe
2405						2410					2415			
Glu	Tyr	Phe	Ala	Pro	Ala	Asn	Thr	Asp	Ala	Asn	Asn	Ile	Glu	Gly
2420						2425					2430			
Gln	Ala	Ile	Leu	Tyr	Gln	Asn	Lys	Phe	Leu	Thr	Leu	Asn	Gly	Lys
2435						2440					2445			
Lys	Tyr	Tyr	Phe	Gly	Ser	Asp	Ser	Lys	Ala	Val	Thr	Gly	Leu	Arg
2450						2455					2460			
Thr	Ile	Asp	Gly	Lys	Lys	Tyr	Tyr	Phe	Asn	Thr	Asn	Thr	Ala	Val
2465						2470					2475			
Ala	Val	Thr	Gly	Trp	Gln	Thr	Ile	Asn	Gly	Lys	Lys	Tyr	Tyr	Phe
2480						2485					2490			
Asn	Thr	Asn	Thr	Ser	Ile	Ala	Ser	Thr	Gly	Tyr	Thr	Ile	Ile	Ser
2495						2500					2505			
Gly	Lys	His	Phe	Tyr	Phe	Asn	Thr	Asp	Gly	Ile	Met	Gln	Ile	Gly
2510						2515					2520			
Val	Phe	Lys	Gly	Pro	Asp	Gly	Phe	Glu	Tyr	Phe	Ala	Pro	Ala	Asn

-continued

2525	2530	2535
Thr Asp Ala Asn Asn Ile Glu Gly Gln Ala Ile Arg Tyr Gln Asn		
2540	2545	2550
Arg Phe Leu Tyr Leu His Asp Asn Ile Tyr Tyr Phe Gly Asn Asn		
2555	2560	2565
Ser Lys Ala Ala Thr Gly Trp Val Thr Ile Asp Gly Asn Arg Tyr		
2570	2575	2580
Tyr Phe Glu Pro Asn Thr Ala Met Gly Ala Asn Gly Tyr Lys Thr		
2585	2590	2595
Ile Asp Asn Lys Asn Phe Tyr Phe Arg Asn Gly Leu Pro Gln Ile		
2600	2605	2610
Gly Val Phe Lys Gly Ser Asn Gly Phe Glu Tyr Phe Ala Pro Ala		
2615	2620	2625
Asn Thr Asp Ala Asn Asn Ile Glu Gly Gln Ala Ile Arg Tyr Gln		
2630	2635	2640
Asn Arg Phe Leu His Leu Leu Gly Lys Ile Tyr Tyr Phe Gly Asn		
2645	2650	2655
Asn Ser Lys Ala Val Thr Gly Trp Gln Thr Ile Asn Gly Lys Val		
2660	2665	2670
Tyr Tyr Phe Met Pro Asp Thr Ala Met Ala Ala Ala Gly Gly Leu		
2675	2680	2685
Phe Glu Ile Asp Gly Val Ile Tyr Phe Phe Gly Val Asp Gly Val		
2690	2695	2700
Lys Ala Pro Gly Ile Tyr Gly		
2705	2710	

<210> SEQ ID NO 42

<211> LENGTH: 2367

<212> TYPE: PRT

<213> ORGANISM: Clostridium difficile

<400> SEQUENCE: 42

Met Ser Leu Val Asn Arg Lys Gln Leu Glu Lys Met Ala Asn Val Arg			
1	5	10	15
Phe Arg Val Gln Glu Asp Glu Tyr Val Ala Ile Leu Asp Ala Leu Glu			
	20	25	30
Glu Tyr His Asn Met Ser Glu Asn Thr Val Val Glu Lys Tyr Leu Lys			
	35	40	45
Leu Lys Asp Ile Asn Ser Leu Thr Asp Thr Tyr Ile Asp Thr Tyr Lys			
	50	55	60
Lys Ser Gly Arg Asn Lys Ala Leu Lys Lys Phe Lys Glu Tyr Leu Val			
	65	70	75
Ile Glu Ile Leu Glu Leu Lys Asn Ser Asn Leu Thr Pro Val Glu Lys			
	85	90	95
Asn Leu His Phe Ile Trp Ile Gly Gly Gln Ile Asn Asp Thr Ala Ile			
	100	105	110
Asn Tyr Ile Asn Gln Trp Lys Asp Val Asn Ser Asp Tyr Asn Val Asn			
	115	120	125
Val Phe Tyr Asp Ser Asn Ala Phe Leu Ile Asn Thr Leu Lys Lys Thr			
	130	135	140
Ile Ile Glu Ser Ala Ser Asn Asp Thr Leu Glu Ser Phe Arg Glu Asn			
	145	150	155
			160

-continued

Leu	Asn	Asp	Pro	Glu	Phe	Asn	His	Thr	Ala	Phe	Phe	Arg	Lys	Arg	Met
				165					170					175	
Gln	Ile	Ile	Tyr	Asp	Lys	Gln	Gln	Asn	Phe	Ile	Asn	Tyr	Tyr	Lys	Ala
			180					185					190		
Gln	Lys	Glu	Glu	Asn	Pro	Asp	Leu	Ile	Ile	Asp	Asp	Ile	Val	Lys	Thr
		195					200					205			
Tyr	Leu	Ser	Asn	Glu	Tyr	Ser	Lys	Asp	Ile	Asp	Glu	Leu	Asn	Ala	Tyr
	210					215					220				
Ile	Glu	Glu	Ser	Leu	Asn	Lys	Val	Thr	Glu	Asn	Ser	Gly	Asn	Asp	Val
225					230					235					240
Arg	Asn	Phe	Glu	Glu	Phe	Lys	Thr	Gly	Glu	Val	Phe	Asn	Leu	Tyr	Glu
				245					250					255	
Gln	Glu	Ser	Val	Glu	Arg	Trp	Asn	Leu	Ala	Gly	Ala	Ser	Asp	Ile	Leu
			260					265					270		
Arg	Val	Ala	Ile	Leu	Lys	Asn	Ile	Gly	Gly	Val	Tyr	Leu	Asp	Val	Asp
		275					280					285			
Met	Leu	Pro	Gly	Ile	His	Pro	Asp	Leu	Phe	Lys	Asp	Ile	Asn	Lys	Pro
	290					295					300				
Asp	Ser	Val	Lys	Thr	Ala	Val	Asp	Trp	Glu	Glu	Met	Gln	Leu	Glu	Ala
305					310					315					320
Ile	Met	Lys	His	Lys	Glu	Tyr	Ile	Pro	Glu	Tyr	Thr	Ser	Lys	His	Phe
				325					330					335	
Asp	Thr	Leu	Asp	Glu	Glu	Val	Gln	Ser	Ser	Phe	Glu	Ser	Val	Leu	Ala
			340					345					350		
Ser	Lys	Ser	Asp	Lys	Ser	Glu	Ile	Phe	Leu	Pro	Leu	Gly	Asp	Ile	Glu
		355					360					365			
Val	Ser	Pro	Leu	Glu	Val	Lys	Ile	Ala	Phe	Ala	Lys	Gly	Ser	Ile	Ile
	370					375					380				
Asn	Gln	Ala	Leu	Ile	Ser	Ala	Lys	Asp	Ser	Tyr	Cys	Ser	Asp	Leu	Leu
385					390					395					400
Ile	Lys	Gln	Ile	Gln	Asn	Arg	Tyr	Lys	Ile	Leu	Asn	Asp	Thr	Leu	Gly
				405					410					415	
Pro	Ile	Ile	Ser	Gln	Gly	Asn	Asp	Phe	Asn	Thr	Thr	Met	Asn	Asn	Phe
			420					425					430		
Gly	Glu	Ser	Leu	Gly	Ala	Ile	Ala	Asn	Glu	Glu	Asn	Ile	Ser	Phe	Ile
		435					440					445			
Ala	Lys	Ile	Gly	Ser	Tyr	Leu	Arg	Val	Gly	Phe	Tyr	Pro	Glu	Ala	Asn
	450					455					460				
Thr	Thr	Ile	Thr	Leu	Ser	Gly	Pro	Thr	Ile	Tyr	Ala	Gly	Ala	Tyr	Lys
465					470					475					480
Asp	Leu	Leu	Thr	Phe	Lys	Glu	Met	Ser	Ile	Asp	Thr	Ser	Ile	Leu	Ser
				485					490					495	
Ser	Glu	Leu	Arg	Asn	Phe	Glu	Phe	Pro	Lys	Val	Asn	Ile	Ser	Gln	Ala
			500					505					510		
Thr	Glu	Gln	Glu	Lys	Asn	Ser	Leu	Trp	Gln	Phe	Asn	Glu	Glu	Arg	Ala
		515					520						525		
Lys	Ile	Gln	Phe	Glu	Glu	Tyr	Lys	Lys	Asn	Tyr	Phe	Glu	Gly	Ala	Leu
	530					535					540				
Gly	Glu	Asp	Asp	Asn	Leu	Asp	Phe	Ser	Gln	Asn	Thr	Val	Thr	Asp	Lys
545					550					555					560
Glu	Tyr	Leu	Leu	Glu	Lys	Ile	Ser	Ser	Ser	Thr	Lys	Ser	Ser	Glu	Gly

-continued

565					570					575					
Gly	Tyr	Val	His	Tyr	Ile	Val	Gln	Leu	Gln	Gly	Asp	Lys	Ile	Ser	Tyr
			580					585					590		
Glu	Ala	Ala	Cys	Asn	Leu	Phe	Ala	Lys	Asn	Pro	Tyr	Asp	Ser	Ile	Leu
		595					600					605			
Phe	Gln	Arg	Asn	Ile	Glu	Asp	Ser	Glu	Val	Ala	Tyr	Tyr	Tyr	Asn	Pro
	610					615					620				
Thr	Asp	Ser	Glu	Ile	Gln	Glu	Ile	Asp	Lys	Tyr	Arg	Ile	Pro	Asp	Arg
	625				630					635					640
Ile	Ser	Asp	Arg	Pro	Lys	Ile	Lys	Leu	Thr	Phe	Ile	Gly	His	Gly	Lys
				645					650					655	
Ala	Glu	Phe	Asn	Thr	Asp	Ile	Phe	Ala	Gly	Leu	Asp	Val	Asp	Ser	Leu
		660						665					670		
Ser	Ser	Glu	Ile	Glu	Thr	Ala	Ile	Gly	Leu	Ala	Lys	Glu	Asp	Ile	Ser
		675					680					685			
Pro	Lys	Ser	Ile	Glu	Ile	Asn	Leu	Leu	Gly	Cys	Asn	Met	Phe	Ser	Tyr
	690					695					700				
Ser	Val	Asn	Val	Glu	Glu	Thr	Tyr	Pro	Gly	Lys	Leu	Leu	Leu	Arg	Val
	705				710					715					720
Lys	Asp	Lys	Val	Ser	Glu	Leu	Met	Pro	Ser	Met	Ser	Gln	Asp	Ser	Ile
			725						730					735	
Ile	Val	Ser	Ala	Asn	Gln	Tyr	Glu	Val	Arg	Ile	Asn	Ser	Glu	Gly	Arg
		740						745					750		
Arg	Glu	Leu	Leu	Asp	His	Ser	Gly	Glu	Trp	Ile	Asn	Lys	Glu	Glu	Ser
		755					760					765			
Ile	Ile	Lys	Asp	Ile	Ser	Ser	Lys	Glu	Tyr	Ile	Ser	Phe	Asn	Pro	Lys
	770					775					780				
Glu	Asn	Lys	Ile	Ile	Val	Lys	Ser	Lys	Asn	Leu	Pro	Glu	Leu	Ser	Thr
	785				790					795					800
Leu	Leu	Gln	Glu	Ile	Arg	Asn	Asn	Ser	Asn	Ser	Ser	Asp	Ile	Glu	Leu
			805						810					815	
Glu	Glu	Lys	Val	Met	Leu	Ala	Glu	Cys	Glu	Ile	Asn	Val	Ile	Ser	Asn
			820					825					830		
Ile	Glu	Thr	Gln	Val	Val	Glu	Glu	Arg	Ile	Glu	Glu	Ala	Lys	Ser	Leu
		835					840					845			
Thr	Ser	Asp	Ser	Ile	Asn	Tyr	Ile	Lys	Asn	Glu	Phe	Lys	Leu	Ile	Glu
	850					855					860				
Ser	Ile	Ser	Glu	Ala	Leu	Cys	Asp	Leu	Lys	Gln	Gln	Asn	Glu	Leu	Glu
	865				870					875					880
Asp	Ser	His	Phe	Ile	Ser	Phe	Glu	Asp	Ile	Ser	Glu	Thr	Asp	Glu	Gly
			885						890					895	
Phe	Ser	Ile	Arg	Phe	Ile	Asn	Lys	Glu	Thr	Gly	Glu	Ser	Ile	Phe	Val
			900					905						910	
Glu	Thr	Glu	Lys	Thr	Ile	Phe	Ser	Glu	Tyr	Ala	Asn	His	Ile	Thr	Glu
		915					920					925			
Glu	Ile	Ser	Lys	Ile	Lys	Gly	Thr	Ile	Phe	Asp	Thr	Val	Asn	Gly	Lys
	930					935						940			
Leu	Val	Lys	Lys	Val	Asn	Leu	Asp	Thr	Thr	His	Glu	Val	Asn	Thr	Leu
	945				950					955					960
Asn	Ala	Ala	Phe	Phe	Ile	Gln	Ser	Leu	Ile	Glu	Tyr	Asn	Ser	Ser	Lys
			965						970						975

-continued

Glu Ser Leu Ser Asn Leu Ser Val Ala Met Lys Val Gln Val Tyr Ala
 980 985 990

Gln Leu Phe Ser Thr Gly Leu Asn Thr Ile Thr Asp Ala Ala Lys Val
 995 1000 1005

Val Glu Leu Val Ser Thr Ala Leu Asp Glu Thr Ile Asp Leu Leu
 1010 1015 1020

Pro Thr Leu Ser Glu Gly Leu Pro Ile Ile Ala Thr Ile Ile Asp
 1025 1030 1035

Gly Val Ser Leu Gly Ala Ala Ile Lys Glu Leu Ser Glu Thr Ser
 1040 1045 1050

Asp Pro Leu Leu Arg Gln Glu Ile Glu Ala Lys Ile Gly Ile Met
 1055 1060 1065

Ala Val Asn Leu Thr Thr Ala Thr Thr Ala Ile Ile Thr Ser Ser
 1070 1075 1080

Leu Gly Ile Ala Ser Gly Phe Ser Ile Leu Leu Val Pro Leu Ala
 1085 1090 1095

Gly Ile Ser Ala Gly Ile Pro Ser Leu Val Asn Asn Glu Leu Val
 1100 1105 1110

Leu Arg Asp Lys Ala Thr Lys Val Val Asp Tyr Phe Lys His Val
 1115 1120 1125

Ser Leu Val Glu Thr Glu Gly Val Phe Thr Leu Leu Asp Asp Lys
 1130 1135 1140

Val Met Met Gln Gln Asp Asp Leu Val Ile Ser Glu Ile Asp Phe
 1145 1150 1155

Asn Asn Asn Ser Ile Val Leu Gly Lys Cys Glu Ile Trp Arg Met
 1160 1165 1170

Glu Gly Gly Ser Gly His Thr Val Thr Asp Asp Ile Asp His Phe
 1175 1180 1185

Phe Ser Ala Pro Ser Ile Thr Tyr Arg Glu Pro His Leu Ser Ile
 1190 1195 1200

Tyr Asp Val Leu Glu Val Gln Lys Glu Glu Leu Asp Leu Ser Lys
 1205 1210 1215

Asp Leu Met Val Leu Pro Asn Ala Pro Asn Arg Val Phe Ala Trp
 1220 1225 1230

Glu Thr Gly Trp Thr Pro Gly Leu Arg Ser Leu Glu Asn Asp Gly
 1235 1240 1245

Thr Lys Leu Leu Asp Arg Ile Arg Asp Asn Tyr Glu Gly Glu Phe
 1250 1255 1260

Tyr Trp Arg Tyr Phe Ala Phe Ile Ala Asp Ala Leu Ile Thr Thr
 1265 1270 1275

Leu Lys Pro Arg Tyr Glu Asp Thr Asn Ile Arg Ile Asn Leu Asp
 1280 1285 1290

Ser Asn Thr Arg Ser Phe Ile Val Pro Ile Ile Thr Thr Glu Tyr
 1295 1300 1305

Ile Arg Glu Lys Leu Ser Tyr Ser Phe Tyr Gly Ser Gly Gly Thr
 1310 1315 1320

Tyr Ala Leu Pro Leu Ser Gln Tyr Asn Met Gly Ile Asn Ile Glu
 1325 1330 1335

Leu Ser Glu Ser Asp Val Trp Ile Ile Asp Val Asp Asn Val Val
 1340 1345 1350

-continued

Arg	Asp	Val	Thr	Ile	Glu	Ser	Asp	Lys	Ile	Lys	Lys	Gly	Asp	Leu
1355						1360					1365			
Ile	Glu	Gly	Ile	Leu	Ser	Thr	Leu	Ser	Ile	Glu	Glu	Asn	Lys	Ile
1370						1375					1380			
Ile	Leu	Asn	Ser	His	Glu	Ile	Asn	Phe	Ser	Gly	Glu	Val	Asn	Gly
1385						1390					1395			
Ser	Asn	Gly	Phe	Val	Ser	Leu	Thr	Phe	Ser	Ile	Leu	Glu	Gly	Ile
1400						1405					1410			
Asn	Ala	Ile	Ile	Glu	Val	Asp	Leu	Leu	Ser	Lys	Ser	Tyr	Lys	Leu
1415						1420					1425			
Leu	Ile	Ser	Gly	Glu	Leu	Lys	Ile	Leu	Met	Leu	Asn	Ser	Asn	His
1430						1435					1440			
Ile	Gln	Gln	Lys	Ile	Asp	Tyr	Ile	Gly	Phe	Asn	Ser	Glu	Leu	Gln
1445						1450					1455			
Lys	Asn	Ile	Pro	Tyr	Ser	Phe	Val	Asp	Ser	Glu	Gly	Lys	Glu	Asn
1460						1465					1470			
Gly	Phe	Ile	Asn	Gly	Ser	Thr	Lys	Glu	Gly	Leu	Phe	Val	Ser	Glu
1475						1480					1485			
Leu	Pro	Asp	Val	Val	Leu	Ile	Ser	Lys	Val	Tyr	Met	Asp	Asp	Ser
1490						1495					1500			
Lys	Pro	Ser	Phe	Gly	Tyr	Tyr	Ser	Asn	Asn	Leu	Lys	Asp	Val	Lys
1505						1510					1515			
Val	Ile	Thr	Lys	Asp	Asn	Val	Asn	Ile	Leu	Thr	Gly	Tyr	Tyr	Leu
1520						1525					1530			
Lys	Asp	Asp	Ile	Lys	Ile	Ser	Leu	Ser	Leu	Thr	Leu	Gln	Asp	Glu
1535						1540					1545			
Lys	Thr	Ile	Lys	Leu	Asn	Ser	Val	His	Leu	Asp	Glu	Ser	Gly	Val
1550						1555					1560			
Ala	Glu	Ile	Leu	Lys	Phe	Met	Asn	Arg	Lys	Gly	Ser	Thr	Asn	Thr
1565						1570					1575			
Ser	Asp	Ser	Leu	Met	Ser	Phe	Leu	Glu	Ser	Met	Asn	Ile	Lys	Ser
1580						1585					1590			
Ile	Phe	Val	Asn	Phe	Leu	Gln	Ser	Asn	Ile	Lys	Phe	Ile	Leu	Asp
1595						1600					1605			
Ala	Asn	Phe	Ile	Ile	Ser	Gly	Thr	Thr	Ser	Ile	Gly	Gln	Phe	Glu
1610						1615					1620			
Phe	Ile	Cys	Asp	Glu	Asn	Asn	Asn	Ile	Gln	Pro	Tyr	Phe	Ile	Lys
1625						1630					1635			
Phe	Asn	Thr	Leu	Glu	Thr	Asn	Tyr	Thr	Leu	Tyr	Val	Gly	Asn	Arg
1640						1645					1650			
Gln	Asn	Met	Ile	Val	Glu	Pro	Asn	Tyr	Asp	Leu	Asp	Asp	Ser	Gly
1655						1660					1665			
Asp	Ile	Ser	Ser	Thr	Val	Ile	Asn	Phe	Ser	Gln	Lys	Tyr	Leu	Tyr
1670						1675					1680			
Gly	Ile	Asp	Ser	Cys	Val	Asn	Lys	Val	Val	Ile	Ser	Pro	Asn	Ile
1685						1690					1695			
Tyr	Thr	Asp	Glu	Ile	Asn	Ile	Thr	Pro	Val	Tyr	Glu	Thr	Asn	Asn
1700						1705					1710			
Thr	Tyr	Pro	Glu	Val	Ile	Val	Leu	Asp	Ala	Asn	Tyr	Ile	Asn	Glu
1715						1720					1725			
Lys	Ile	Asn	Val	Asn	Ile	Asn	Asp	Leu	Ser	Ile	Arg	Tyr	Val	Trp

-continued

1730	1735	1740
Ser Asn Asp Gly Asn Asp Phe	Ile Leu Met Ser Thr	Ser Glu Glu
1745	1750	1755
Asn Lys Val Ser Gln Val Lys	Ile Arg Phe Val Asn	Val Phe Lys
1760	1765	1770
Asp Lys Thr Leu Ala Asn Lys	Leu Ser Phe Asn Phe	Ser Asp Lys
1775	1780	1785
Gln Asp Val Pro Val Ser Glu	Ile Ile Leu Ser Phe	Thr Pro Ser
1790	1795	1800
Tyr Tyr Glu Asp Gly Leu Ile	Gly Tyr Asp Leu Gly	Leu Val Ser
1805	1810	1815
Leu Tyr Asn Glu Lys Phe Tyr	Ile Asn Asn Phe Gly	Met Met Val
1820	1825	1830
Ser Gly Leu Ile Tyr Ile Asn	Asp Ser Leu Tyr Tyr	Phe Lys Pro
1835	1840	1845
Pro Val Asn Asn Leu Ile Thr	Gly Phe Val Thr Val	Gly Asp Asp
1850	1855	1860
Lys Tyr Tyr Phe Asn Pro Ile	Asn Gly Gly Ala Ala	Ser Ile Gly
1865	1870	1875
Glu Thr Ile Ile Asp Asp Lys	Asn Tyr Tyr Phe Asn	Gln Ser Gly
1880	1885	1890
Val Leu Gln Thr Gly Val Phe	Ser Thr Glu Asp Gly	Phe Lys Tyr
1895	1900	1905
Phe Ala Pro Ala Asn Thr Leu	Asp Glu Asn Leu Glu	Gly Glu Ala
1910	1915	1920
Ile Asp Phe Thr Gly Lys Leu	Ile Ile Asp Glu Asn	Ile Tyr Tyr
1925	1930	1935
Phe Glu Asp Asn Tyr Arg Gly	Ala Val Glu Trp Lys	Glu Leu Asp
1940	1945	1950
Gly Glu Met His Tyr Phe Ser	Pro Glu Thr Gly Lys	Ala Phe Lys
1955	1960	1965
Gly Leu Asn Gln Ile Gly Asp	Asp Lys Tyr Tyr Phe	Asn Ser Asp
1970	1975	1980
Gly Val Met Gln Lys Gly Phe	Val Ser Ile Asn Asp	Asn Lys His
1985	1990	1995
Tyr Phe Asp Asp Ser Gly Val	Met Lys Val Gly Tyr	Thr Glu Ile
2000	2005	2010
Asp Gly Lys His Phe Tyr Phe	Ala Glu Asn Gly Glu	Met Gln Ile
2015	2020	2025
Gly Val Phe Asn Thr Glu Asp	Gly Phe Lys Tyr Phe	Ala His His
2030	2035	2040
Asn Glu Asp Leu Gly Asn Glu	Glu Gly Glu Glu Ile	Ser Tyr Ser
2045	2050	2055
Gly Ile Leu Asn Phe Asn Asn	Lys Ile Tyr Tyr Phe	Asp Asp Ser
2060	2065	2070
Phe Thr Ala Val Val Gly Trp	Lys Asp Leu Glu Asp	Gly Ser Lys
2075	2080	2085
Tyr Tyr Phe Asp Glu Asp Thr	Ala Glu Ala Tyr Ile	Gly Leu Ser
2090	2095	2100
Leu Ile Asn Asp Gly Gln Tyr	Tyr Phe Asn Asp Asp	Gly Ile Met
2105	2110	2115

-continued

Gln Val Gly Phe Val Thr Ile Asn Asp Lys Val Phe Tyr Phe Ser
 2120 2125 2130
 Asp Ser Gly Ile Ile Glu Ser Gly Val Gln Asn Ile Asp Asp Asn
 2135 2140 2145
 Tyr Phe Tyr Ile Asp Asp Asn Gly Ile Val Gln Ile Gly Val Phe
 2150 2155 2160
 Asp Thr Ser Asp Gly Tyr Lys Tyr Phe Ala Pro Ala Asn Thr Val
 2165 2170 2175
 Asn Asp Asn Ile Tyr Gly Gln Ala Val Glu Tyr Ser Gly Leu Val
 2180 2185 2190
 Arg Val Gly Glu Asp Val Tyr Tyr Phe Gly Glu Thr Tyr Thr Ile
 2195 2200 2205
 Glu Thr Gly Trp Ile Tyr Asp Met Glu Asn Glu Ser Asp Lys Tyr
 2210 2215 2220
 Tyr Phe Val Pro Glu Thr Lys Lys Ala Cys Lys Gly Ile Asn Leu
 2225 2230 2235
 Ile Asp Asp Ile Lys Tyr Tyr Phe Asp Glu Lys Gly Ile Met Arg
 2240 2245 2250
 Thr Gly Leu Ile Ser Phe Glu Asn Asn Asn Tyr Tyr Phe Asn Glu
 2255 2260 2265
 Asn Gly Glu Ile Gln Phe Gly Tyr Ile Asn Ile Glu Asp Lys Met
 2270 2275 2280
 Phe Tyr Phe Gly Glu Asp Gly Val Met Gln Ile Gly Val Phe Asn
 2285 2290 2295
 Thr Pro Asp Gly Phe Lys Tyr Phe Ala His Gln Asn Thr Leu Asp
 2300 2305 2310
 Glu Asn Phe Glu Gly Glu Ser Ile Asn Tyr Thr Gly Trp Leu Gly
 2315 2320 2325
 Leu Asp Glu Lys Arg Tyr Tyr Phe Thr Asp Glu Tyr Ile Ala Ala
 2330 2335 2340
 Thr Gly Ser Val Ile Ile Asp Gly Glu Glu Tyr Tyr Phe Asp Pro
 2345 2350 2355
 Asp Thr Ala Gln Leu Val Ile Ser Glu
 2360 2365

<210> SEQ ID NO 43
 <211> LENGTH: 129
 <212> TYPE: PRT
 <213> ORGANISM: Homo sapiens

<400> SEQUENCE: 43

Met Asp Met Met Val Pro Ala Gln Leu Leu Gly Leu Leu Leu Trp
 1 5 10 15
 Phe Pro Gly Ser Arg Cys Asp Ile Gln Met Thr Gln Ser Pro Ser Ser
 20 25 30
 Val Ser Ala Ser Val Gly Asp Arg Val Thr Ile Thr Cys Arg Ala Ser
 35 40 45
 Gln Gly Ile Ser Ser Trp Leu Ala Trp Tyr Gln His Lys Pro Gly Lys
 50 55 60
 Ala Pro Lys Leu Leu Ile Tyr Ala Ala Ser Ser Leu Gln Ser Gly Val
 65 70 75 80
 Pro Ser Arg Phe Ser Gly Ser Gly Ser Gly Thr Asp Phe Thr Leu Thr

-continued

```

      85              90              95
Ile Ser Ser Leu Gln Pro Glu Asp Phe Ala Thr Tyr Tyr Cys Gln Gln
      100              105              110
Ala Asn Ser Phe Pro Trp Thr Phe Gly Gln Gly Thr Lys Val Glu Ile
      115              120              125

```

Lys

```

<210> SEQ ID NO 44
<211> LENGTH: 129
<212> TYPE: PRT
<213> ORGANISM: Homo sapiens

```

<400> SEQUENCE: 44

```

Met Asp Met Arg Val Leu Ala Gln Leu Leu Gly Leu Leu Leu Leu Cys
 1      5      10      15
Phe Pro Gly Ala Arg Cys Asp Ile Gln Met Thr Gln Ser Pro Ser Ser
 20      25      30
Leu Ser Ala Ser Val Gly Asp Arg Val Thr Ile Thr Cys Arg Ala Ser
 35      40      45
Gln Gly Ile Ser Ser Trp Leu Ala Trp Tyr Gln Gln Lys Pro Glu Lys
 50      55      60
Ala Pro Lys Ser Leu Ile Tyr Ala Ala Ser Ser Leu Gln Ser Gly Val
 65      70      75      80
Pro Ser Arg Phe Ser Gly Ser Gly Ser Gly Thr Asp Phe Thr Leu Thr
 85      90      95
Ile Ser Ser Leu Gln Pro Glu Asp Phe Ala Thr Tyr Tyr Cys Gln Gln
 100      105      110
Tyr Asn Ser Tyr Pro Trp Thr Phe Gly Gln Gly Thr Lys Val Glu Ile
 115      120      125

```

Lys

```

<210> SEQ ID NO 45
<211> LENGTH: 129
<212> TYPE: PRT
<213> ORGANISM: Homo sapiens

```

<400> SEQUENCE: 45

```

Met Asp Met Arg Val Pro Ala Gln Leu Leu Gly Leu Leu Leu Leu Trp
 1      5      10      15
Leu Pro Gly Ala Arg Cys Val Ile Trp Met Thr Gln Ser Pro Ser Leu
 20      25      30
Leu Ser Ala Ser Thr Gly Asp Arg Val Thr Ile Ser Cys Arg Met Ser
 35      40      45
Gln Gly Ile Ser Ser Tyr Leu Ala Trp Tyr Gln Gln Lys Pro Gly Lys
 50      55      60
Ala Pro Glu Leu Leu Ile Tyr Ala Ala Ser Thr Leu Gln Ser Gly Val
 65      70      75      80
Pro Ser Arg Phe Ser Gly Ser Gly Ser Gly Thr Asp Phe Thr Leu Thr
 85      90      95
Ile Ser Ser Leu Gln Pro Glu Asp Phe Ala Thr Tyr Tyr Cys Gln Gln
 100      105      110
Tyr Asn Ser Tyr Pro Trp Thr Phe Gly Gln Gly Thr Lys Val Glu Ile
 115      120      125

```

-continued

Lys

<210> SEQ ID NO 46

<211> LENGTH: 129

<212> TYPE: PRT

<213> ORGANISM: Homo sapiens

<400> SEQUENCE: 46

```

Met Asp Met Met Val Pro Ala Gln Leu Leu Gly Leu Leu Leu Leu Trp
 1          5          10          15
Phe Pro Gly Ser Arg Cys Asp Ile Gln Met Thr Gln Ser Pro Ser Ser
 20          25          30
Val Ser Ala Ser Val Gly Asp Arg Val Thr Ile Thr Cys Arg Ala Ser
 35          40          45
Gln Gly Ile Ser Ser Trp Leu Ala Trp Tyr Gln His Lys Pro Gly Lys
 50          55          60
Ala Pro Lys Leu Leu Ile Tyr Ala Ala Ser Ser Leu Gln Ser Gly Val
 65          70          75          80
Pro Ser Arg Phe Ser Gly Ser Gly Ser Gly Thr Asp Phe Thr Leu Thr
 85          90          95
Ile Ser Ser Leu Gln Pro Glu Asp Phe Ala Thr Tyr Tyr Cys Gln Gln
 100         105         110
Tyr Asn Ser Tyr Pro Trp Thr Phe Gly Gln Gly Thr Lys Val Glu Ile
 115         120         125

```

Lys

<210> SEQ ID NO 47

<211> LENGTH: 129

<212> TYPE: PRT

<213> ORGANISM: Homo sapiens

<400> SEQUENCE: 47

```

Met Asp Met Arg Val Pro Ala Gln Leu Leu Gly Leu Leu Leu Leu Cys
 1          5          10          15
Phe Pro Gly Ala Arg Cys Asp Ile Gln Met Thr Gln Ser Pro Ser Ser
 20          25          30
Val Ser Ala Ser Val Gly Asp Arg Val Thr Ile Thr Cys Arg Ala Ser
 35          40          45
Gln Gly Ile Ser Ser Trp Leu Ala Trp Tyr Gln Gln Lys Pro Glu Lys
 50          55          60
Ala Pro Lys Ser Leu Ile Tyr Ala Ala Ser Ser Leu Gln Ser Gly Val
 65          70          75          80
Pro Ser Arg Phe Ser Gly Ser Gly Ser Gly Thr Asp Phe Thr Leu Thr
 85          90          95
Ile Ser Ser Leu Gln Pro Glu Asp Phe Ala Thr Tyr Tyr Cys Gln Gln
 100         105         110
Tyr Asn Ser Tyr Pro Trp Thr Phe Gly Gln Gly Thr Lys Val Glu Ile
 115         120         125

```

Lys

<210> SEQ ID NO 48

<211> LENGTH: 129

<212> TYPE: PRT

<213> ORGANISM: Homo sapiens

-continued

<400> SEQUENCE: 48

Met Asp Met Arg Val Leu Ala Gln Leu Leu Gly Leu Leu Leu Leu Cys
 1 5 10 15
 Phe Pro Gly Ala Arg Cys Asp Ile Gln Met Thr Gln Ser Leu Ser Ser
 20 25 30
 Leu Ser Ala Ser Val Gly Asp Arg Val Thr Ile Thr Cys Arg Ala Ser
 35 40 45
 Gln Gly Ile Ser Ser Trp Leu Ala Trp Tyr Gln Gln Lys Pro Glu Lys
 50 55 60
 Ala Pro Lys Ser Leu Ile Tyr Ala Ala Ser Ser Leu Gln Ser Gly Val
 65 70 75 80
 Pro Ser Arg Phe Ser Gly Ser Gly Ser Gly Thr Asp Phe Thr Leu Thr
 85 90 95
 Ile Ser Ser Leu Gln Pro Glu Asp Phe Ala Thr Tyr Tyr Cys Gln Gln
 100 105 110
 Ala Asn Ser Phe Pro Trp Thr Phe Gly Gln Gly Thr Lys Val Glu Ile
 115 120 125

Lys

<210> SEQ ID NO 49

<211> LENGTH: 141

<212> TYPE: PRT

<213> ORGANISM: Homo sapiens

<400> SEQUENCE: 49

Met Glu Phe Gly Leu Ser Trp Val Phe Leu Val Ala Leu Leu Arg Gly
 1 5 10 15
 Val Gln Cys Gln Val Gln Leu Val Glu Ser Gly Gly Gly Val Val Gln
 20 25 30
 Pro Gly Arg Ser Leu Arg Leu Ser Cys Ala Ala Ser Gly Phe Ser Phe
 35 40 45
 Ser Asn Tyr Gly Met His Trp Val Arg Gln Ala Pro Gly Lys Gly Leu
 50 55 60
 Glu Trp Val Ala Leu Ile Trp Tyr Asp Gly Ser Asn Glu Asp Tyr Thr
 65 70 75 80
 Asp Ser Val Lys Gly Arg Phe Thr Ile Ser Arg Asp Asn Ser Lys Asn
 85 90 95
 Thr Leu Tyr Leu Gln Met Asn Ser Leu Arg Ala Glu Asp Thr Ala Val
 100 105 110
 Tyr Tyr Cys Ala Arg Trp Gly Met Val Arg Gly Val Ile Asp Val Phe
 115 120 125
 Asp Ile Trp Gly Gln Gly Thr Val Val Thr Val Ser Ser
 130 135 140

<210> SEQ ID NO 50

<211> LENGTH: 128

<212> TYPE: PRT

<213> ORGANISM: Homo sapiens

<400> SEQUENCE: 50

Met Glu Ala Pro Ala Gln Leu Leu Phe Leu Leu Leu Leu Trp Leu Pro
 1 5 10 15
 Asp Thr Thr Gly Glu Ile Val Leu Thr Gln Ser Pro Ala Thr Leu Ser
 20 25 30

-continued

Leu Ser Pro Gly Glu Arg Ala Thr Leu Ser Cys Arg Ala Ser Gln Ser
 35 40 45
 Val Ser Ser Tyr Leu Ala Trp Tyr Gln Gln Lys Pro Gly Gln Ala Pro
 50 55 60
 Arg Leu Leu Ile Tyr Asp Ala Ser Asn Arg Ala Thr Gly Ile Pro Ala
 65 70 75 80
 Arg Phe Ser Gly Ser Gly Ser Gly Thr Asp Phe Thr Leu Thr Ile Ser
 85 90 95
 Ser Leu Glu Pro Glu Asp Phe Ala Val Tyr Tyr Cys Gln Gln Arg Ser
 100 105 110
 Asn Trp Ser Gln Phe Thr Phe Gly Pro Gly Thr Lys Val Asp Ile Lys
 115 120 125

<210> SEQ ID NO 51
 <211> LENGTH: 133
 <212> TYPE: PRT
 <213> ORGANISM: Homo sapiens

<400> SEQUENCE: 51

Met Glu Phe Gly Leu Ser Trp Val Phe Leu Val Ala Leu Leu Arg Gly
 1 5 10 15
 Val Gln Cys Gln Met Gln Leu Val Glu Ser Gly Gly Gly Val Val Gln
 20 25 30
 Pro Gly Arg Ser Leu Arg Leu Ser Cys Glu Ala Ser Gly Phe Ser Phe
 35 40 45
 Asn Ser Tyr Gly Met His Trp Val Arg Gln Ala Pro Gly Lys Gly Leu
 50 55 60
 Glu Trp Val Ser Val Ile Trp Ala Ser Gly Asn Lys Lys Tyr Tyr Ile
 65 70 75 80
 Glu Ser Val Glu Gly Arg Phe Thr Ile Ser Arg Asp Asn Ser Lys Asn
 85 90 95
 Thr Leu Tyr Leu Gln Met Asn Ser Leu Arg Ala Glu Asp Thr Ala Val
 100 105 110
 Tyr Tyr Cys Ala Arg Ala Asn Phe Asp Tyr Trp Gly Gln Gly Thr Leu
 115 120 125
 Val Thr Val Ser Ser
 130

<210> SEQ ID NO 52
 <211> LENGTH: 129
 <212> TYPE: PRT
 <213> ORGANISM: Homo sapiens

<400> SEQUENCE: 52

Met Asp Met Arg Val Leu Ala Gln Leu Leu Gly Leu Leu Leu Cys
 1 5 10 15
 Phe Pro Gly Ala Arg Cys Asp Ile Gln Met Thr Gln Ser Pro Ser Ser
 20 25 30
 Leu Ser Ala Ser Val Gly Asp Arg Val Thr Ile Thr Cys Arg Ala Ser
 35 40 45
 Gln Gly Ile Ser Ser Trp Leu Ala Trp Tyr Gln Gln Lys Pro Glu Lys
 50 55 60
 Ala Pro Lys Ser Leu Ile Tyr Ala Ala Ser Ser Leu Gln Ser Gly Val
 65 70 75 80

-continued

Pro Ser Arg Phe Ser Gly Ser Gly Ser Gly Thr Asp Phe Thr Leu Thr
85 90 95
Ile Ser Ser Leu Gln Pro Glu Asp Phe Ala Thr Tyr Tyr Cys Gln Gln
100 105 110
Tyr Lys Ser Tyr Pro Val Thr Phe Gly Gly Gly Thr Lys Val Glu Ile
115 120 125

Lys

<210> SEQ ID NO 53
<211> LENGTH: 135
<212> TYPE: PRT
<213> ORGANISM: Homo sapiens

<400> SEQUENCE: 53

Met Glu Phe Gly Leu Ser Trp Val Phe Leu Val Ala Leu Leu Arg Gly
1 5 10 15
Val Gln Cys Gln Val Gln Leu Val Glu Ser Gly Gly Gly Val Val Gln
20 25 30
Pro Gly Arg Ser Leu Arg Leu Ser Cys Ala Ala Ser Gly Phe Thr Phe
35 40 45
Asn Lys Tyr Gly Met His Trp Val Arg Gln Ala Pro Gly Lys Gly Leu
50 55 60
Glu Trp Val Ala Val Ile Trp Tyr Asp Gly Thr Asn Lys Tyr Tyr Ala
65 70 75 80
Asp Ser Met Lys Gly Arg Phe Thr Ile Ser Arg Asp Asn Ser Lys Asn
85 90 95
Met Leu Tyr Leu Gln Met Asn Ser Leu Arg Ala Glu Asp Thr Ala Val
100 105 110
Tyr Tyr Cys Ala Arg Asp Pro Pro Thr Ala Asn Tyr Trp Gly Gln Gly
115 120 125
Thr Leu Val Thr Val Ser Ser
130 135

<210> SEQ ID NO 54
<211> LENGTH: 119
<212> TYPE: PRT
<213> ORGANISM: Homo sapiens

<400> SEQUENCE: 54

Glu Val Gln Leu Val Gln Ser Gly Ala Glu Val Lys Lys Ser Gly Glu
1 5 10 15
Ser Leu Lys Ile Ser Cys Lys Gly Ser Gly Tyr Ser Phe Thr Ser Tyr
20 25 30
Trp Ile Gly Trp Val Arg Gln Met Pro Gly Lys Gly Leu Glu Trp Met
35 40 45
Gly Ile Phe Tyr Pro Gly Asp Ser Ser Thr Arg Tyr Ser Pro Ser Phe
50 55 60
Gln Gly Gln Val Thr Ile Ser Ala Asp Lys Ser Val Asn Thr Ala Tyr
65 70 75 80
Leu Gln Trp Ser Ser Leu Lys Ala Ser Asp Thr Ala Met Tyr Tyr Cys
85 90 95
Ala Arg Arg Arg Asn Trp Gly Asn Ala Phe Asp Ile Trp Gly Gln Gly
100 105 110

-continued

Thr Met Val Thr Val Ser Ser
115

<210> SEQ ID NO 55
 <211> LENGTH: 357
 <212> TYPE: DNA
 <213> ORGANISM: Homo sapiens
 <220> FEATURE:
 <221> NAME/KEY: CDS
 <222> LOCATION: (1)..(357)

<400> SEQUENCE: 55

gag gtg cag ctg gtg cag tct gga gca gag gtg aaa aag tcc ggg gag 48
 Glu Val Gln Leu Val Gln Ser Gly Ala Glu Val Lys Lys Ser Gly Glu
 1 5 10 15

tct ctg aag atc tcc tgt aag ggt tct gga tac agc ttt acc agc tac 96
 Ser Leu Lys Ile Ser Cys Lys Gly Ser Gly Tyr Ser Phe Thr Ser Tyr
 20 25 30

tgg atc ggc tgg gtg cgc cag atg ccc ggg aag ggc ctg gag tgg atg 144
 Trp Ile Gly Trp Val Arg Gln Met Pro Gly Lys Gly Leu Glu Trp Met
 35 40 45

ggg atc ttc tat cct ggt gac tct agt acc aga tac agc ccg tcc ttc 192
 Gly Ile Phe Tyr Pro Gly Asp Ser Ser Thr Arg Tyr Ser Pro Ser Phe
 50 55 60

caa ggc cag gtc acc atc tca gcc gac aag tcc gtc aac acc gcc tac 240
 Gln Gly Gln Val Thr Ile Ser Ala Asp Lys Ser Val Asn Thr Ala Tyr
 65 70 75 80

ctg cag tgg agc agc ctg aag gcc tcg gac acc gcc atg tat tac tgt 288
 Leu Gln Trp Ser Ser Leu Lys Ala Ser Asp Thr Ala Met Tyr Tyr Cys
 85 90 95

gcg aga cgt cga aac tgg gga aat gct ttt gat atc tgg ggc caa ggg 336
 Ala Arg Arg Arg Asn Trp Gly Asn Ala Phe Asp Ile Trp Gly Gln Gly
 100 105 110

aca atg gtc acc gtc tct tca 357
 Thr Met Val Thr Val Ser Ser
 115

<210> SEQ ID NO 56
 <211> LENGTH: 138
 <212> TYPE: PRT
 <213> ORGANISM: Homo sapiens

<400> SEQUENCE: 56

Met Gly Ser Thr Ala Ile Leu Ala Leu Leu Leu Ala Val Leu Gln Gly
 1 5 10 15

Val Cys Ala Glu Val Gln Leu Val Gln Ser Gly Ala Glu Val Lys Lys
 20 25 30

Ser Gly Glu Ser Leu Lys Ile Ser Cys Lys Gly Ser Gly Tyr Ser Phe
 35 40 45

Thr Ser Tyr Trp Ile Gly Trp Val Arg Gln Met Pro Gly Lys Gly Leu
 50 55 60

Glu Trp Met Gly Ile Phe Tyr Pro Gly Asp Ser Ser Thr Arg Tyr Ser
 65 70 75 80

Pro Ser Phe Gln Gly Gln Val Thr Ile Ser Ala Asp Lys Ser Val Asn
 85 90 95

Thr Ala Tyr Leu Gln Trp Ser Ser Leu Lys Ala Ser Asp Thr Ala Met
 100 105 110

Tyr Tyr Cys Ala Arg Arg Arg Asn Trp Gly Asn Ala Phe Asp Ile Trp

-continued

Tyr Leu Ala Trp Tyr Gln Gln Lys Pro Gly Gln Ala Pro Arg Leu Leu
 35 40 45

atc tat ggt gca tcc agc agg gcc act ggc atc cca gac agg ttc agt 192
 Ile Tyr Gly Ala Ser Ser Arg Ala Thr Gly Ile Pro Asp Arg Phe Ser
 50 55 60

ggc agt ggg tct ggg aca gac ttc act ctc acc atc agc aga ctg gag 240
 Gly Ser Gly Ser Gly Thr Asp Phe Thr Leu Thr Ile Ser Arg Leu Glu
 65 70 75 80

cct gaa gat ttt gca gtg tat tac tgt cag cag tat ggt agc tca acg 288
 Pro Glu Asp Phe Ala Val Tyr Tyr Cys Gln Gln Tyr Gly Ser Ser Thr
 85 90 95

tgg acg ttc ggc caa ggg acc aag gtg gaa atc aaa 324
 Trp Thr Phe Gly Gln Gly Thr Lys Val Glu Ile Lys
 100 105

<210> SEQ ID NO 60
 <211> LENGTH: 128
 <212> TYPE: PRT
 <213> ORGANISM: Homo sapiens

<400> SEQUENCE: 60

Met Glu Thr Pro Ala Gln Leu Leu Phe Leu Leu Leu Leu Trp Leu Pro
 1 5 10 15

Asp Thr Thr Gly Glu Ile Val Leu Thr Gln Ser Pro Gly Thr Leu Ser
 20 25 30

Leu Ser Pro Gly Glu Arg Ala Thr Leu Ser Cys Arg Ala Ser Gln Ser
 35 40 45

Val Ser Ser Ser Tyr Leu Ala Trp Tyr Gln Gln Lys Pro Gly Gln Ala
 50 55 60

Pro Arg Leu Leu Ile Tyr Gly Ala Ser Ser Arg Ala Thr Gly Ile Pro
 65 70 75 80

Asp Arg Phe Ser Gly Ser Gly Ser Gly Thr Asp Phe Thr Leu Thr Ile
 85 90 95

Ser Arg Leu Glu Pro Glu Asp Phe Ala Val Tyr Tyr Cys Gln Gln Tyr
 100 105 110

Gly Ser Ser Thr Trp Thr Phe Gly Gln Gly Thr Lys Val Glu Ile Lys
 115 120 125

<210> SEQ ID NO 61
 <211> LENGTH: 384
 <212> TYPE: DNA
 <213> ORGANISM: Homo sapiens

<400> SEQUENCE: 61

atggaaaccc cagcgcagct tctcttctc ctgctactct ggctcccaga taccaccgga 60
 gaaattgtgt tgacgcagtc tccaggcacc ctgtctttgt ctccagggga aagagccacc 120
 ctctcctgca gggccagtca gactgttagc agcagctact tagcctggta ccagcagaaa 180
 cctggccagg ctcccaggct cctcatctat ggtgcatcca gcagggccac tgcatocca 240
 gacaggttca gtggcagtg gtctgggaca gacttcactc tcaccatcag cagactggag 300
 cctgaagatt ttgagtgta ttactgtcag cagtatgta gctcaactg gacgttcggc 360
 caagggacca aggtggaat caaa 384

<210> SEQ ID NO 62
 <211> LENGTH: 5

-continued

<212> TYPE: PRT
<213> ORGANISM: Homo sapiens

<400> SEQUENCE: 62

Ser Tyr Trp Ile Gly
1 5

<210> SEQ ID NO 63
<211> LENGTH: 15
<212> TYPE: DNA
<213> ORGANISM: Homo sapiens
<220> FEATURE:
<221> NAME/KEY: CDS
<222> LOCATION: (1)..(15)

<400> SEQUENCE: 63

agc tac tgg atc ggc 15
Ser Tyr Trp Ile Gly
1 5

<210> SEQ ID NO 64
<211> LENGTH: 17
<212> TYPE: PRT
<213> ORGANISM: Homo sapiens

<400> SEQUENCE: 64

Ile Phe Tyr Pro Gly Asp Ser Ser Thr Arg Tyr Ser Pro Ser Phe Gln
1 5 10 15

Gly

<210> SEQ ID NO 65
<211> LENGTH: 51
<212> TYPE: DNA
<213> ORGANISM: Homo sapiens
<220> FEATURE:
<221> NAME/KEY: CDS
<222> LOCATION: (1)..(51)

<400> SEQUENCE: 65

atc ttc tat cct ggt gac tct agt acc aga tac agc ccg tcc ttc caa 48
Ile Phe Tyr Pro Gly Asp Ser Ser Thr Arg Tyr Ser Pro Ser Phe Gln
1 5 10 15

ggc 51
Gly

<210> SEQ ID NO 66
<211> LENGTH: 10
<212> TYPE: PRT
<213> ORGANISM: Homo sapiens

<400> SEQUENCE: 66

Arg Arg Asn Trp Gly Asn Ala Phe Asp Ile
1 5 10

<210> SEQ ID NO 67
<211> LENGTH: 30
<212> TYPE: DNA
<213> ORGANISM: Homo sapiens
<220> FEATURE:
<221> NAME/KEY: CDS
<222> LOCATION: (1)..(30)

<400> SEQUENCE: 67

-continued

```

cgt cga aac tgg gga aat gct ttt gat atc          30
Arg Arg Asn Trp Gly Asn Ala Phe Asp Ile
1           5           10

```

```

<210> SEQ ID NO 68
<211> LENGTH: 12
<212> TYPE: PRT
<213> ORGANISM: Homo sapiens

```

```

<400> SEQUENCE: 68

```

```

Arg Ala Ser Gln Ser Val Ser Ser Ser Tyr Leu Ala
1           5           10

```

```

<210> SEQ ID NO 69
<211> LENGTH: 36
<212> TYPE: DNA
<213> ORGANISM: Homo sapiens
<220> FEATURE:
<221> NAME/KEY: CDS
<222> LOCATION: (1)..(36)

```

```

<400> SEQUENCE: 69

```

```

agg gcc agt cag agt gtt agc agc agc tac tta gcc          36
Arg Ala Ser Gln Ser Val Ser Ser Ser Tyr Leu Ala
1           5           10

```

```

<210> SEQ ID NO 70
<211> LENGTH: 7
<212> TYPE: PRT
<213> ORGANISM: Homo sapiens

```

```

<400> SEQUENCE: 70

```

```

Gly Ala Ser Ser Arg Ala Thr
1           5

```

```

<210> SEQ ID NO 71
<211> LENGTH: 21
<212> TYPE: DNA
<213> ORGANISM: Homo sapiens
<220> FEATURE:
<221> NAME/KEY: CDS
<222> LOCATION: (1)..(21)

```

```

<400> SEQUENCE: 71

```

```

ggt gca tcc agc agg gcc act          21
Gly Ala Ser Ser Arg Ala Thr
1           5

```

```

<210> SEQ ID NO 72
<211> LENGTH: 9
<212> TYPE: PRT
<213> ORGANISM: Homo sapiens

```

```

<400> SEQUENCE: 72

```

```

Gln Gln Tyr Gly Ser Ser Thr Trp Thr
1           5

```

```

<210> SEQ ID NO 73
<211> LENGTH: 27
<212> TYPE: DNA
<213> ORGANISM: Homo sapiens
<220> FEATURE:
<221> NAME/KEY: CDS
<222> LOCATION: (1)..(27)

```

-continued

<400> SEQUENCE: 73

cag cag tat ggt agc tca acg tgg acg
 Gln Gln Tyr Gly Ser Ser Thr Trp Thr
 1 5

27

<210> SEQ ID NO 74

<211> LENGTH: 15

<212> TYPE: PRT

<213> ORGANISM: Homo sapiens

<400> SEQUENCE: 74

Ala Phe Asp Ile Trp Gly Gln Gly Thr Met Val Thr Val Ser Ser
 1 5 10 15

<210> SEQ ID NO 75

<211> LENGTH: 5

<212> TYPE: PRT

<213> ORGANISM: Homo sapiens

<400> SEQUENCE: 75

Ser Tyr Trp Ile Gly
 1 5

<210> SEQ ID NO 76

<211> LENGTH: 17

<212> TYPE: PRT

<213> ORGANISM: Homo sapiens

<400> SEQUENCE: 76

Ile Ile Tyr Pro Gly Asp Ser Asp Thr Arg Tyr Ser Pro Ser Phe Gln
 1 5 10 15

Gly

<210> SEQ ID NO 77

<211> LENGTH: 10

<212> TYPE: PRT

<213> ORGANISM: Homo sapiens

<400> SEQUENCE: 77

Ala Arg Arg Arg Asn Trp Gly Asn Ala Phe
 1 5 10

<210> SEQ ID NO 78

<211> LENGTH: 12

<212> TYPE: PRT

<213> ORGANISM: Homo sapiens

<400> SEQUENCE: 78

Arg Ala Ser Gln Ser Val Ser Ser Ser Tyr Leu Ala
 1 5 10

<210> SEQ ID NO 79

<211> LENGTH: 12

<212> TYPE: PRT

<213> ORGANISM: Homo sapiens

<400> SEQUENCE: 79

Trp Thr Phe Gly Gln Gly Thr Lys Val Glu Ile Lys
 1 5 10

<210> SEQ ID NO 80

-continued

<211> LENGTH: 7
 <212> TYPE: PRT
 <213> ORGANISM: Homo sapiens

<400> SEQUENCE: 80

Gln Gln Tyr Gly Ser Ser Pro
 1 5

<210> SEQ ID NO 81
 <211> LENGTH: 98
 <212> TYPE: PRT
 <213> ORGANISM: Homo sapiens

<400> SEQUENCE: 81

Glu Val Gln Leu Val Gln Ser Gly Ala Glu Val Lys Lys Pro Gly Glu
 1 5 10 15

Ser Leu Lys Ile Ser Cys Lys Gly Ser Gly Tyr Ser Phe Thr Ser Tyr
 20 25 30

Trp Ile Gly Trp Val Arg Gln Met Pro Gly Lys Gly Leu Glu Trp Met
 35 40 45

Gly Ile Ile Tyr Pro Gly Asp Ser Asp Thr Arg Tyr Ser Pro Ser Phe
 50 55 60

Gln Gly Gln Val Thr Ile Ser Ala Asp Lys Ser Ile Ser Thr Ala Tyr
 65 70 75 80

Leu Gln Trp Ser Ser Leu Lys Ala Ser Asp Thr Ala Met Tyr Tyr Cys
 85 90 95

Ala Arg

<210> SEQ ID NO 82
 <211> LENGTH: 96
 <212> TYPE: PRT
 <213> ORGANISM: Homo sapiens

<400> SEQUENCE: 82

Glu Ile Val Leu Thr Gln Ser Pro Gly Thr Leu Ser Leu Ser Pro Gly
 1 5 10 15

Glu Arg Ala Thr Leu Ser Cys Arg Ala Ser Gln Ser Val Ser Ser Ser
 20 25 30

Tyr Leu Ala Trp Tyr Gln Gln Lys Pro Gly Gln Ala Pro Arg Leu Leu
 35 40 45

Ile Tyr Gly Ala Ser Ser Arg Ala Thr Gly Ile Pro Asp Arg Phe Ser
 50 55 60

Gly Ser Gly Ser Gly Thr Asp Phe Thr Leu Thr Ile Ser Arg Leu Glu
 65 70 75 80

Pro Glu Asp Phe Ala Val Tyr Tyr Cys Gln Gln Tyr Gly Ser Ser Pro
 85 90 95

<210> SEQ ID NO 83
 <211> LENGTH: 6
 <212> TYPE: PRT
 <213> ORGANISM: Artificial Sequence

-continued

<220> FEATURE:

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

6xHis tag

<400> SEQUENCE: 83

His His His His His His

1

5

What is claimed is:

1. An isolated monoclonal antibody that binds to *Clostridium difficile* (*C. difficile*) toxin A, or an antigen binding portion thereof, wherein the antibody, or antigen binding portion thereof, comprises:

(i) a heavy chain variable region CDR1 comprising SEQ ID NO: 7;

a heavy chain variable region CDR2 comprising SEQ ID NO: 8;

a heavy chain variable region CDR3 comprising SEQ ID NO: 9;

a light chain variable region CDR1 comprising SEQ ID NO: 16;

a light chain variable region CDR2 comprising SEQ ID NO: 17; and

a light chain variable region CDR3 comprising SEQ ID NO: 18;

(ii) a heavy chain variable region CDR1 comprising SEQ ID NO: 10;

a heavy chain variable region CDR2 comprising SEQ ID NO: 11;

a heavy chain variable region CDR3 comprising SEQ ID NO: 12;

a light chain variable region CDR1 comprising SEQ ID NO: 19;

a light chain variable region CDR2 comprising SEQ ID NO: 20; and

a light chain variable region CDR3 comprising SEQ ID NO: 21; or

(iii) a heavy chain variable region CDR1 comprising SEQ ID NO: 13;

a heavy chain variable region CDR2 comprising SEQ ID NO: 14;

a heavy chain variable region CDR3 comprising SEQ ID NO: 15;

a light chain variable region CDR1 comprising SEQ ID NO: 22;

a light chain variable region CDR2 comprising SEQ ID NO: 23; and

a light chain variable region CDR3 comprising SEQ ID NO: 24.

2. The isolated monoclonal antibody, or an antigen binding portion thereof, of claim **1**, wherein the antibody, or antigen binding portion thereof, comprises a heavy chain variable region CDR1 comprising SEQ ID NO: 7, a heavy chain variable region CDR2 comprising SEQ ID NO: 8, a heavy chain variable region CDR3 comprising SEQ ID NO: 9, a light chain variable region CDR1 comprising SEQ ID NO: 16, a light chain variable region CDR2 comprising SEQ ID NO: 17, and a light chain variable region CDR3 comprising SEQ ID NO: 18.

3. The isolated monoclonal antibody, or an antigen binding portion thereof, of claim **1**, wherein the antibody, or antigen

binding portion thereof, comprises a heavy chain variable region CDR1 comprising SEQ ID NO: 10, a heavy chain variable region CDR2 comprising SEQ ID NO: 11, a heavy chain variable region CDR3 comprising SEQ ID NO: 12, a light chain variable region CDR1 comprising SEQ ID NO: 19, a light chain variable region CDR2 comprising SEQ ID NO: 20, and a light chain variable region CDR3 comprising SEQ ID NO: 21.

4. The isolated monoclonal antibody, or an antigen binding portion thereof, of claim **1**, wherein the antibody, or antigen binding portion thereof, comprises a heavy chain variable region CDR1 comprising SEQ ID NO: 13, a heavy chain variable region CDR2 comprising SEQ ID NO: 14, a heavy chain variable region CDR3 comprising SEQ ID NO: 15, a light chain variable region CDR1 comprising SEQ ID NO: 22, a light chain variable region CDR2 comprising SEQ ID NO: 23, and a light chain variable region CDR3 comprising SEQ ID NO: 24.

5. An isolated monoclonal antibody that binds to *Clostridium difficile* (*C. difficile*) toxin A, or an antigen binding portion thereof, wherein the antibody, or antigen binding portion thereof, comprises a heavy chain variable region having an amino acid sequence at least 95% identical to the amino acid sequence set forth in SEQ ID NO: 1, SEQ ID NO: 2, or SEQ ID NO: 3 and/or a light chain variable region having an amino acid sequence at least 95% identical to the amino acid sequence set forth in SEQ ID NO: 4, SEQ ID NO: 5, or SEQ ID NO: 6.

6. The isolated monoclonal antibody, or an antigen binding portion thereof, of claim **5**, wherein the antibody, or antigen binding portion thereof, comprises a heavy chain variable region having an amino acid sequence at least 95% identical to the amino acid sequence set forth in SEQ ID NO: 1.

7. The isolated monoclonal antibody, or an antigen binding portion thereof, of claim **5**, wherein the antibody, or antigen binding portion thereof, comprises a heavy chain variable region having an amino acid sequence at least 95% identical to the amino acid sequence set forth in SEQ ID NO: 2.

8. The isolated monoclonal antibody, or an antigen binding portion thereof, of claim **5**, wherein the antibody, or antigen binding portion thereof, comprises a heavy chain variable region having an amino acid sequence at least 95% identical to the amino acid sequence set forth in SEQ ID NO: 3.

9. The isolated monoclonal antibody, or an antigen binding portion thereof, of claim **5**, wherein the antibody, or antigen binding portion thereof, comprises a light chain variable region having an amino acid sequence at least 95% identical to the amino acid sequence set forth in SEQ ID NO: 4.

10. The isolated monoclonal antibody, or an antigen binding portion thereof, of claim **5**, wherein the antibody, or antigen binding portion thereof, comprises a light chain vari-

able region having an amino acid sequence at least 95% identical to the amino acid sequence set forth in SEQ ID NO: 5.

11. The isolated monoclonal antibody, or an antigen binding portion thereof, of claim **5**, wherein the antibody, or antigen binding portion thereof, comprises a light chain variable region having an amino acid sequence at least 95% identical to the amino acid sequence set forth in SEQ ID NO: 6.

12. The isolated monoclonal antibody, or an antigen binding portion thereof, of claim **5**, wherein the antibody, or antigen binding portion thereof, comprises heavy and light chain variable regions comprising amino acid sequences at least 95% identical to the amino acid sequences set forth in SEQ ID NOs: 1 and 4, respectively.

13. The isolated monoclonal antibody, or an antigen binding portion thereof, of claim **5**, wherein the antibody, or antigen binding portion thereof, comprises heavy and light chain variable regions comprising amino acid sequences at least 95% identical to the amino acid sequences set forth in SEQ ID NOs: 2 and 5, respectively.

14. The isolated monoclonal antibody, or an antigen binding portion thereof, of claim **5**, wherein the antibody, or antigen binding portion thereof, comprises heavy and light chain variable regions comprising amino acid sequences at least 95% identical to the amino acid sequences set forth in SEQ ID NOs: 3 and 6, respectively.

15. The isolated monoclonal antibody, or antigen binding portion thereof, of claim **1**, wherein the antibody is a human antibody, a humanized antibody or a chimeric antibody.

16. The antigen binding portion of claim **1**, wherein the antigen binding portion is a Fab, Fab'2, ScFv, Fd, Fv or dAb.

17. The isolated monoclonal antibody of claim **1**, wherein the antibody is an IgG1 or IgG3 isotype.

18. The isolated monoclonal antibody, or antigen binding portion thereof, of claim **1**, wherein the K_D of the antibody, or antigen binding portion thereof, is less than 20×10^{-6} M.

19. The isolated monoclonal antibody, or antigen binding portion thereof, of claim **1**, wherein the antibody, or antigen binding portion thereof, neutralizes toxin A in vitro or in vivo.

* * * * *