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(54) Title: CHLAMYDIA ANTIGEN COMPOSITIONS AND USES THEREOF

(57) Abstract: The present invention provides in part fusion proteins derived from Chlamydia spp. The present invention also provides in part methods for treating or preventing Chlamydia infection using the fusion proteins.



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CHLAMYDIA ANTIGEN COMPOSITIONS AND USES THEREOF

FIELD OF INVENTION

[0001] The present invention relates to bacterial infections. More specifically, the invention provides in part fusion proteins for use against *Chlamydia* infection.

BACKGROUND OF THE INVENTION

[0002] *Chlamydia trachomatis* is an intracellular pathogen responsible for over 92 million sexually transmitted infections and 85 million ocular infections per year worldwide (Starnbach, M. N., and N. R. Roan. 2008. Conquering sexually transmitted diseases. *Nat Rev Immunol* 8:313-317.). Sexually transmitted *C. trachomatis* is a major cause of long-term disease sequelae in women such as infertility and ectopic pregnancy (Brunham, R. C., D. J. Zhang, X. Yang, and G. M. McClarty. 2000. The potential for vaccine development against chlamydial infection and disease. *J Infect Dis* 181 Suppl 3:S538-543; Igiertseme, J. U., C. M. Black, and H. D. Caldwell. 2002. Chlamydia vaccines: strategies and status. *BioDrugs* 16:19-35). *C. trachomatis* infection in women often goes unnoticed until severe reproductive damage (infertility, pelvic inflammatory disease, ectopic pregnancy) is already underway. In addition, women infected with *C. trachomatis* are at increased risk of contracting HIV following exposure.

[0003] The “seek and treat” programs to prevent and control *C. trachomatis* sexually transmitted infections appear to be failing as case rates and reinfection rates continue to rise (Brunham, R. C., B. Pourbohloul, S. Mak, R. White, and M. L. Rekart. 2005. The unexpected impact of a *Chlamydia trachomatis* infection control program on susceptibility to reinfection. *J Infect Dis* 192:1836-1844), possibly due to early treatment interfering with the development of protective immune responses (Su, H., R. Morrison, R. Messer, W. Whitmire, S. Hughes, and H. D. Caldwell. 1999. The effect of doxycycline treatment on the development of protective immunity in a murine model of chlamydial genital infection. *J Infect Dis* 180:1252-1258).

[0004] Previous attempts to vaccinate against *C. trachomatis* and *C. muridarum* infection in both human and murine models using dead elementary bodies (EBs), which are non-replicating infectious particles released when infected cells rupture, provided limited protection (Grayston,

J. T., and S. P. Wang. 1978. The potential for vaccine against infection of the genital tract with *Chlamydia trachomatis*. *Sex Transm Dis* 5:73-77; Grayston, J. T., S. P. Wang, L. J. Yeh, and C. C. Kuo. 1985. Importance of reinfection in the pathogenesis of trachoma. *Rev Infect Dis* 7:717-725; Lu, H., Z. Xing, and R. C. Brunham. 2002. GM-CSF transgene-based adjuvant allows the establishment of protective mucosal immunity following vaccination with inactivated *Chlamydia trachomatis*. *J Immunol* 169:6324-6331; Schachter, J., and H. D. Caldwell. 1980. Chlamydiae. *Annu Rev Microbiol* 34:285-309). Mice immunized with live *C. muridarum* EBs have however been shown to generate better protection (Lu, H., Z. Xing, and R. C. Brunham. 2002. GM-CSF transgene-based adjuvant allows the establishment of protective mucosal immunity following vaccination with inactivated *Chlamydia trachomatis*. *J Immunol* 169:6324-6331; Su, H., R. Messer, W. Whitmire, E. Fischer, J. C. Portis, and H. D. Caldwell. 1998. Vaccination against chlamydial genital tract infection after immunization with dendritic cells pulsed ex vivo with nonviable Chlamydiae. *J Exp Med* 188:809-818).

[0005] Investigation into the mechanism underlying the efficient induction of immunity provided by live *C. muridarum* in comparison to dead organisms suggests that dendritic cells (DCs) exposed to live or dead *C. muridarum* develop into distinct phenotypes. In particular DCs exposed to live *C. muridarum* become mature and stimulated antigen-specific CD4 T cells, while DCs exposed to dead *C. muridarum* are inhibited in acquiring a mature phenotype. Co-stimulation of DCs with dead EB and CpG oligodeoxynucleotide has been show to partially overcome dead EB inhibition of DC maturation (Rey-Ladino, J., K. M. Koochesfahani, M. L. Zaharik, C. Shen, and R. C. Brunham. 2005. A live and inactivated *Chlamydia trachomatis* mouse pneumonitis strain induces the maturation of dendritic cells that are phenotypically and immunologically distinct. *Infect Immun* 73:1568-1577). Investigation into the transcriptional responses of bone marrow derived DCs following exposure to live and dead *C. muridarum* using GeneChip microarrays revealed marked differences in CXC chemokine profiles in DCs exposed to live or dead organism (Zaharik, M. L., T. Nayar, R. White, C. Ma, B. A. Vallance, N. Straka, X. Jiang, J. Rey-Ladino, C. Shen, and R. C. Brunham. 2007. Genetic profiling of dendritic cells exposed to live- or ultraviolet-irradiated *Chlamydia muridarum* reveals marked differences in CXC chemokine profiles. *Immunology* 120:160-172). In aggregate, the data suggest that DCs exposed to live EBs are phenotypically and functionally distinct from DCs generated by exposure to dead EBs.

[0006] Immunity to *C. muridarum* infection is thought to be largely cell-mediated and therefore dependent on *Chlamydia*-derived peptides presented to CD4 T cells via MHC molecules on antigen presenting cells (Brunham, R. C., and J. Rey-Ladino. 2005. Immunology of *Chlamydia* infection: implications for a *Chlamydia trachomatis* vaccine. *Nat Rev Immunol* 5:149-161; Steinman, R. M., and M. Pope. 2002. Exploiting dendritic cells to improve vaccine efficacy. *J Clin Invest* 109:1519-1526; Su, H., and H. D. Caldwell. 1995. CD4+ T cells play a significant role in adoptive immunity to *Chlamydia trachomatis* infection of the mouse genital tract. *Infect Immun* 63:3302-3308; Morrison, S. G., H. Su, H. D. Caldwell, and R. P. Morrison. 2000. Immunity to murine *Chlamydia trachomatis* genital tract reinfection involves B cells and CD4(+) T cells but not CD8(+) T cells. *Infect Immun* 68:6979-6987; Morrison, R. P., and H. D. Caldwell. 2002. Immunity to murine chlamydial genital infection. *Infect Immun* 70:2741-2751; Igietseme, J. U., K. H. Ramsey, D. M. Magee, D. M. Williams, T. J. Kincy, and R. G. Rank. 1993. Resolution of murine chlamydial genital infection by the adoptive transfer of a biovar-specific, Th1 lymphocyte clone. *Reg Immunol* 5:317-324).

[0007] Immunoproteomic approaches (Hunt, D. F., R. A. Henderson, J. Shabanowitz, K. Sakaguchi, H. Michel, N. Sevilir, A. L. Cox, E. Appella, and V. H. Engelhard. 1992. Characterization of peptides bound to the class I MHC molecule HLA-A2.1 by mass spectrometry. *Science* 255:1261-1263; de Jong, A. 1998. Contribution of mass spectrometry to contemporary immunology. *Mass Spectrom Rev* 17:311-335; Olsen, J. V., L. M. de Godoy, G. Li, B. Macek, P. Mortensen, R. Pesch, A. Makarov, O. Lange, S. Horning, and M. Mann. 2005. Parts per million mass accuracy on an Orbitrap mass spectrometer via lock mass injection into a C-trap. *Mol Cell Proteomics* 4:2010-2021) to identify *C. muridarum* T cell antigens, based on isolating and sequencing of pathogen-derived peptides binding to MHC class II molecules presented on the surface of DCs after they were pulsed with live EBs, resulted in the identification of a number of *C. muridarum* peptides derived from 8 novel epitopes (Karunakaran, K. P., J. Rey-Ladino, N. Stoykov, K. Berg, C. Shen, X. Jiang, B. R. Gabel, H. Yu, L. J. Foster, and R. C. Brunham. 2008. Immunoproteomic discovery of novel T cell antigens from the obligate intracellular pathogen *Chlamydia*. *J Immunol* 180:2459-2465). These peptides were recognized by antigen-specific CD4 T cells *in vitro* and recombinant proteins containing the MHC binding peptides were able to induce partial protection via immunization against *C. muridarum* infection *in vivo* (Yu, H., X. Jiang, C. Shen, K. P. Karunakaran, and R. C. Brunham.

2009. Novel *Chlamydia muridarum* T cell antigens induce protective immunity against lung and genital tract infection in murine models. *J Immunol* 182:1602-1608).

[0008] *Chlamydia* sequences (nucleic acid and polypeptide) are described in, for example, US 6030799, US 6696421, US 6676949, US 6464979, US 6653461, US 6642023, US 6887843 and US 7459524; or in US Patent Publications 2005/0232941, 2009/0022755, and 2008/0102112. Specific *Chlamydia* antigens are described in, for example, PCT Publication No. WO 2010/085896 and WO2013/044398.

SUMMARY OF THE INVENTION

[0009] The present disclosure provides in part fusion proteins derived from *Chlamydia* spp. The present invention also provides in part methods for treating or preventing *Chlamydia* infection using the fusion proteins.

[0010] In one aspect, there is provided an immunogenic composition including a fusion protein which includes at least two *Chlamydia* proteins selected from: Polymorphic membrane protein G (PmpG), Polymorphic membrane protein F (PmpF), Polymorphic membrane protein E (PmpE), Polymorphic membrane protein H (PmpH), Ribosomal protein L6 (RplF), Anti-anti-sigma factor (Aasf), Translocated actin-recruiting phosphoprotein (Tarp), hypothetical protein corresponding to locus tag CT143/TC0420, metalloprotease, insulinase family (CT806/TC0190), hypothetical protein corresponding to locus tag CT538/TC0825, hypothetical protein corresponding to locus tag CT017/TC0285, hypothetical protein corresponding to locus tag CT619, or MOMP, or an immunogenic fragment thereof, together with a physiologically acceptable carrier.

[0011] In alternative embodiments, the fusion protein includes combinations of: PmpG and MOMP, PmpG and PmpF, PmpG and PmpH or PmpE and PmpF.

[0012] In alternative embodiments, the composition further includes an adjuvant, such as DDA/TDB, DDA/MMG or DDA/MPL.

[0013] In alternative aspects, there is provided a method for eliciting an immune response against a *Chlamydia* spp., or component thereof, in an animal by administering to the animal an effective amount of the composition as described herein, thereby eliciting an immune response in the animal. The immune response may be a cellular immune response.

[0014] In alternative aspects, there is provided a method for treating or preventing infection by a *Chlamydia* spp. in an animal by administering to the animal an effective amount of the composition as described herein, thereby treating or preventing infection by the *Chlamydia* spp. in the animal.

[0015] In alternative embodiments, the *Chlamydia* spp. may be a *Chlamydia trachomatis* or a *Chlamydia muridarum*.

[0016] In alternative embodiments, the animal may be a human.

[0017] In alternative aspects, there is provided the use of the composition as described herein, for eliciting an immune response against a *Chlamydia* spp., or component thereof, in an animal. The immune response may be a cellular immune response.

[0018] In alternative aspects, there is provided the use of the composition as described herein, for treating or preventing infection by a *Chlamydia* spp. or component thereof, in an animal. The *Chlamydia* spp. may be a *Chlamydia trachomatis* or a *Chlamydia muridarum*. The animal may be a human.

[0019] This summary does not necessarily describe all features of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[0020] These and other features of the disclosure will become more apparent from the following description in which reference is made to the appended drawings wherein:

[0021] **FIGURES 1A-II** show amino acid sequences for *Chlamydia muridarum* and *Chlamydia trachomatis* proteins, together with the corresponding nucleic acid sequences (SEQ ID Nos: 1-35).

[0022] **FIGURES 2A-F** show amino acid and nucleic acid sequences for PmpE-PmpF & PmpG-PmpH fusion proteins (italized sequences indicating the second protein; underlined sequences representing alpha helix linkers connecting two protein domains; SEQ ID NOs: 36-41).

[0023] **FIGURES 3A-B** are graphs showing fusion protein-elicited protection at day 6 (**A**) and day 12 (**B**) against *Chlamydia* genital tract infection.

[0024] FIGURES 4A-C are graphs showing *C. muridarum*-specific cytokine responses after immunization with PmpE, F, G, H plus MOMP either as individual (mixed) or as fusion formats in C57 (A), Balb/c (B), or C3H (C) mice.

[0025] FIGURES 5A-C are graphs showing *C. muridarum* individual antigen-specific IFN- γ responses in C57 (A), Balb/c (B), or C3H (C) mice after immunization with PmpE, F, G, H plus MOMP either as individual (mixed) or as fusion formats.

[0026] FIGURES 6A-C are graphs showing vaccine-elicited protection against *C. muridarum* genital tract infection in C57 (A), Balb/c (B), or C3H (C) mice after immunization with PmpE, F, G, H plus MOMP, either as individual(mixed) or as fusion formats.

[0027] FIGURES 7A-C are graphs showing vaccine-elicited protection against *C. muridarum* genital tract infection in C57 (A), Balb/c (B), or C3H (C) mice after immunization with with PmpE, F, G, H plus MOMP, either as individual(mixed) or as fusion formats.

DETAILED DESCRIPTION

[0028] The present disclosure provides, in part, fusion proteins derived from *Chlamydia* spp. proteins. The present disclosure also provides, in part, methods for treating or preventing *Chlamydia* infection using the fusion proteins.

[0029] In some embodiments, these fusion proteins may be useful as vaccines for use in the prevention or treatment of *Chlamydia* spp. infection.

[0030] *Chlamydia* spp.

[0031] By “*Chlamydia* spp.” is meant a genus of bacteria that are obligate intracellular parasites. *Chlamydia* spp. include *C. trachomatis* (a human pathogen) and *C. muridarum* (pathogenic to mice and hamsters). As *C. muridarum* and *C. trachomatis* are highly orthologous pathogenic microbes that have co-evolved with their host species, *C. muridarum* has been used as a robust animal model for studying cellular immunity and vaccine development.

[0032] In some embodiments, a *C. trachomatis* includes without limitation a *C. trachomatis* serovar D/UW-3/CX, as well as serovars A, B, Ba, C (implicated in trachoma), serovars D, E, F,

G, H, I, J K (implicated in urogenital tract infections) and L1, L2, L3 (lymphogranuloma venereum serovars).

[0033] In some embodiments, a *C. muridarum* includes a *C. muridarum* mouse pneumonitis (MoPn) strain Nigg.

[0034] The genome sequences of various *Chlamydia* spp. have been determined. The genome sequence of *C. trachomatis* strain D/UW-3/CX is described for example in Stephens, R.S. *et al.*, 1998 (Genome sequence of an obligate intracellular pathogen of humans: *Chlamydia trachomatis*. Science 282 (5389): 754-759) and provided in GenBank Accession No. NC_000117.1, GI:15604717; referred to herein as the “*C. trachomatis* genome sequence”).

[0035] The genome sequence of *C. muridarum* is described in for example Read, T., *et al.*, 2000 (Genome sequences of *Chlamydia trachomatis* MoPn and *Chlamydia pneumoniae* AR39 Nucleic Acids Res. 28 (6): 1397-1406) and provided in GenBank Accession No. NC_002620.2, GI:29337300; referred to herein as the “*C. muridarum* genome sequence”).

[0036] *Chlamydia* spp. Fusion Polypeptides and Nucleic Acid Molecules

[0037] Compounds for use in the compositions and methods according to the disclosure include, without limitation, a fusion protein including the sequence of two or more of the *Chlamydia* polypeptides described herein, for example, the proteins or polypeptides listed in Tables 1 or 2, or in Figures 1A-II, or an immunogenic fragment thereof, as well as a nucleic acid molecule encoding such a fusion protein.

Table 1: Homology of *C. muridarum*-derived source proteins to *C. trachomatis*, other bacteria and human

Peptide Sequence	<i>Chlamydia muridarum</i> Locus#	Source Proteins	Protein Abbr.	<i>C. trachomatis</i> Identity and Locus #	Other Bacteria (30% cut off)	Human (25% cut off)
AFHLFASPAANYIHTG (SEQ ID NO: 42)	TC0262	Polymorphic membrane protein F	PmpF	61% - CT870	N	N
NAKTVFLSNVASPIYVDPA (SEQ ID NO: 43) ASPIYVDPAAGGQPPA (SEQ ID NO: 44)	TC0263	Polymorphic membrane protein G	PmpG	71% - CT871	N	N
VKGNEVFVSPAHHIDRPG (SEQ ID NO: 45)	TC0801	Ribosomal protein L6	RplF	96% - CT514	Y	N

Peptide Sequence	<i>Chlamydia muridarum</i> Locus#	Source Proteins	Protein Abbr.	<i>C.trachomatis</i> Identity and Locus #	Other Bacteria (30% cut off)	Human (25% cut off)
SPGQNTNYAAAKAGIIGFS (SEQ ID NO: 46)	TC0508	3-oxoacyl-(acyl carrier protein) reductase	FabG	90% - CT237	Y	Y (44%)
KLDGVSSPAVQESISE (SEQ ID NO: 47)	TC0707	Anti-anti-sigma factor	Aasf	96% - CT424	Y	N
IGQEITEPLANTVIA (SEQ ID NO: 48)	TC0079	ATP dependent Clp protease, proteolytic subunit	ClpP	92% - CT706	Y	Y (56%)
MTTVHAATATQSVVD (SEQ ID NO: 49)	TC0792	Glyceraldehyde 3-phosphate dehydrogenase	Gap	95% - CT505	Y	Y (56%)
DLNVTGPKIQTDVD (SEQ ID NO: 50)	TC0420	Hypothetical protein		75% - CT143	N	N
EGTKPIGTPIAVFSTEQN (SEQ ID NO: 51)	TC0518	Pyruvate dehydrogenase	PdhC	87% - CT247	Y	Y (38%)
SVPSYVYYPSPGNRAPVV (SEQ ID NO: 52)	TC0884	Thiol disulfide interchange protein	DsbD	73% - CT595	Y	N
YDHIIVTPGANADIL (SEQ ID NO: 53)	TC0654	Oxidoreductase, DadA family		85% - CT375	Y	N
LPLMIVSSPKASESGAA (SEQ ID NO: 54)	TC0190	Metalloprotease , insulinase family		80% - CT806	N	N
GANAI PVHCPIGAESQ (SEQ ID NO: 55) VFWLGSKINIIDTPG (SEQ ID NO: 56)	TC0721	Translation elongation factor G	FusA	97% - CT437	Y	Y (43%)
ISRALYTPVNSNQSVG (SEQ ID NO: 57)	TC0050	Translation elongation factor Ts	Tsf	89% - CT679	Y	Y (31%)
FEVQLISPVAAEEGMR (SEQ ID NO: 58) GDAAYIEKVRLEMQ (SEQ ID NO: 59)	TC0596	Translation elongation factor Tu	Tuf	95% - CT322	Y	Y (55%)
SRALYAQPMLAISEA (SEQ ID NO: 60)	TC0261	Polymorphic membrane protein E	PmpE	69% - CT869	N	N
KPAEEEEAGSIVHNAREQ (SEQ ID NO: 61)	TC0584	V-type, ATP synthase subunit E	AtpE	91% - CT310	N	N
SPQVLTNPVPIPKGDD (SEQ ID NO: 62)	TC0264	Polymorphic membrane protein H	PmpH	76% - CT872	N	N
SMLIIPALGG (SEQ ID NO: 63)	TC0895	Nucleoside triphosphatase	YggV	81% - CT606	Y	Y (33%)
LAAAVMHADSGAILKEK (SEQ ID NO: 64)	TC0839	D-analyl-D-alanine carboxypeptidase	DacC	76% - CT551	Y	N
DDPEVIRAYIVPPKEP (SEQ ID NO: 65)	TC0825	Hypothetical protein		91% - CT538	N	N

Peptide Sequence	<i>Chlamydia muridarum</i> Locus#	Source Proteins	Protein Abbr.	<i>C.trachomatis</i> Identity and Locus #	Other Bacteria (30% cut off)	Human (25% cut off)
KIFSPAGLLSAFAKNGA (SEQ ID NO: 66)	TC0755	DNA repair protein	RecO	85% - CT470	N	N
DPVDMFQMTKIVSKH (SEQ ID NO: 67)	TC0745	SWIB (YM74) complex protein		86% - CT460	Y	Y (33%)
KLEGIINNNNTPS (SEQ ID NO: 68)	TC0741	Translocated actin-recruiting phosphoprotein	Tarp	45% - CT456	N	N
AVPRTSLIF (SEQ ID NO: 69)	TC0021	Exodeoxyribonuclease V, alpha subunit	RecD_2	81% - CT652	Y	Y
GGAEVILSRSHPEFVKQ (SEQ ID NO: 70)	TC0372	N utilization substance protein A	NusA	97% - CT097	Y	Y
APILARLS (SEQ ID NO: 71)	TC0285	Hypothetical protein		82% - CT017	N	N

Table 2 *Chlamydia trachomatis* Source Proteins

<i>Chlamydia trachomatis</i> Locus#	Source Proteins	Protein Abbreviation
CT559	Yop proteins translocation lipoprotein	CdsJ
CT837	Hypothetical protein CT837	
CT110	Chaperonin GroEL1	GroEL1
CT144	Hypothetical protein CT144	
CT289	Hypothetical protein CT289	
CT619	Hypothetical protein CT619	
CT561	Type III secretion translocase	CdsL
CT681	Major Outer Membrane Protein	MOMP
CT664	FHA domain; homology to adenylate cyclase	
CT113	Clp Protease ATPase	ClpB
CT759	Muramidase (invasin repeat family)	NlpD
CT045	Leucyl aminopeptidase	PepA
CT420	50S ribosomal protein L21	Rl21
CT622	CHLPN 76kDa Homolog	
CT472	Hypothetical protein CT472	
CT842	Polyribonucleotide Nucleotidyltransferase	Pnp
CT778	Primosome assembly protein	PriA

[0038] In some embodiments, a compound for use in the compositions and methods according to the disclosure includes, without limitation, a *C. muridarum*- or *C. trachomatis*-derived amino acid sequence, such as a fusion protein including an amino acid sequence substantially identical to the sequence of two or more of the polypeptides described herein, for example, those listed in Tables 1 or 2, or in Figures 1A-II, or an immunogenic fragment thereof.

[0039] In some embodiments, a compound for use in the compositions and methods according to the disclosure includes, without limitation, a *C. muridarum*- or *C. trachomatis*-derived nucleic acid molecule, such as a nucleic acid sequence that encodes a fusion protein including an amino acid sequence substantially identical to the sequence of two or more of the polypeptides described herein, for example, those listed in Tables 1 or 2, or in Figures 1A-II, or an immunogenic fragment thereof.

[0040] In some embodiments, a compound for use in the compositions and methods according to the disclosure includes, without limitation, a *C. muridarum*- or *C. trachomatis*-derived nucleic acid molecule, such as a nucleic acid sequence substantially identical to the nucleic acid sequence of two or more of the polypeptides described herein, for example, those listed in Tables 1 or 2, or in Figures 1A-II, or an immunogenic fragment thereof.

[0041] In alternative embodiments, a compound for use in the compositions and methods according to the disclosure includes, without limitation, a fusion protein including two or more of a *Chlamydia* polypeptide, such as Polymorphic membrane protein G (PmpG), Polymorphic membrane protein F (PmpF), Polymorphic membrane protein E (PmpE), Polymorphic membrane protein H (PmpH), Ribosomal protein L6 (RplF), Anti-anti-sigma factor (Aasf), Translocated actin-recruiting phosphoprotein (Tarp), hypothetical protein corresponding to locus tag CT143/TC0420, metalloprotease, insulinase family (CT806/TC0190), hypothetical protein corresponding to locus tag CT538/TC0825, hypothetical protein corresponding to locus tag CT017/TC0285, hypothetical protein corresponding to locus tag CT619, or MOMP, or an immunogenic fragment thereof.

[0042] In alternative embodiments, a compound for use in the compositions and methods according to the disclosure includes, without limitation, a fusion protein including two or more

of a *Chlamydia*-derived amino acid sequence, such as a fusion protein including an amino acid sequence substantially identical to the sequence of two or more of the following polypeptides: Polymorphic membrane protein G (PmpG), Polymorphic membrane protein F (PmpF), Polymorphic membrane protein E (PmpE), Polymorphic membrane protein H (PmpH), Ribosomal protein L6 (RplF), Anti-anti-sigma factor (Aasf), Translocated actin-recruiting phosphoprotein (Tarp), hypothetical protein corresponding to locus tag CT143/TC0420, metalloprotease, insulinase family (CT806/TC0190), hypothetical protein corresponding to locus tag CT538/TC0825, hypothetical protein corresponding to locus tag CT017/TC0285, hypothetical protein corresponding to locus tag CT619, or MOMP, or an immunogenic fragment thereof.

[0043] In alternative embodiments, a compound for use in the compositions and methods according to the disclosure includes, without limitation, a fusion protein encoded by two or more of a *Chlamydia*-derived nucleic acid sequence, such as a nucleic acid sequence that encodes a fusion protein including an amino acid sequence substantially identical to the sequence of two or more of the following polypeptides: Polymorphic membrane protein G (PmpG), Polymorphic membrane protein F (PmpF), Polymorphic membrane protein E (PmpE), Polymorphic membrane protein H (PmpH), Ribosomal protein L6 (RplF), Anti-anti-sigma factor (Aasf), Translocated actin-recruiting phosphoprotein (Tarp), hypothetical protein corresponding to locus tag CT143/TC0420, metalloprotease, insulinase family (CT806/TC0190), hypothetical protein corresponding to locus tag CT538/TC0825, hypothetical protein corresponding to locus tag CT017/TC0285, hypothetical protein corresponding to locus tag CT619, or MOMP, or an immunogenic fragment thereof.

[0044] In alternative embodiments, a compound for use in the compositions and methods according to the disclosure includes, without limitation, a fusion protein encoded by two or more of a *Chlamydia*-derived nucleic acid sequence, such as a nucleic acid sequence substantially identical to the nucleic acid sequence encoding two or more of the following polypeptides: Polymorphic membrane protein G (PmpG), Polymorphic membrane protein F (PmpF), Polymorphic membrane protein E (PmpE), Polymorphic membrane protein H (PmpH), Ribosomal protein L6 (RplF), Anti-anti-sigma factor (Aasf), Translocated actin-recruiting phosphoprotein (Tarp), hypothetical protein corresponding to locus tag CT143/TC0420,

metalloprotease, insulinase family (CT806/TC0190), hypothetical protein corresponding to locus tag CT538/TC0825, hypothetical protein corresponding to locus tag CT017/TC0285, hypothetical protein corresponding to locus tag CT619, or MOMP, or an immunogenic fragment thereof.

[0045] In some embodiments, a compound for use in the compositions and methods according to the disclosure includes, without limitation, a fusion protein including two or more of PmpG, PmpF, PmpE, PmpH, RplF, Aasf, Tarp, TC0420, TC0190, TC0825, TC0285, CT619, MOMP, or an immunogenic fragment thereof, or a nucleic acid molecule encoding such a fusion protein.

[0046] In some embodiments, a compound for use in the compositions and methods according to the disclosure includes, without limitation, a fusion protein including three or more of PmpG, PmpF, PmpE, PmpH, RplF, Aasf, Tarp, TC0420, TC0190, TC0825, TC0285, CT619, MOMP, or an immunogenic fragment thereof, or a nucleic acid molecule encoding such a fusion protein.

[0047] In some embodiments, a compound for use in the compositions and methods according to the disclosure includes, without limitation, a fusion protein including four or more of PmpG, PmpF, PmpE, PmpH, RplF, Aasf, Tarp, TC0420, TC0190, TC0825, TC0285, CT619, MOMP, or an immunogenic fragment thereof, or a nucleic acid molecule encoding such a fusion protein.

[0048] In some embodiments, a compound for use in the compositions and methods according to the disclosure includes, without limitation, a fusion protein including two or more of the following *Chlamydia* proteins/antigens: PmpG, PmpE, PmpF, PmpH and, optionally, MOMP, or an immunogenic fragment thereof, or a nucleic acid molecule encoding such a fusion protein.

[0049] In some embodiments, a compound for use in the compositions and methods according to the disclosure includes, without limitation, a fusion protein including two or more of the following *Chlamydia* proteins/antigens: PmpG, PmpE, PmpF and TC0420 and, optionally, MOMP, or an immunogenic fragment thereof, or a nucleic acid molecule encoding such a fusion protein.

[0050] In some embodiments, a compound for use in the compositions and methods according to the disclosure includes, without limitation, a fusion protein including the following *Chlamydia* proteins/antigens: PmpG and MOMP, or an immunogenic fragment thereof, or a nucleic acid

molecule encoding such a fusion protein. In alternative embodiments a fusion protein including only the following *Chlamydia* proteins/antigens: PmpG and MOMP, or an immunogenic fragment thereof, or a nucleic acid molecule encoding such a fusion protein.

[0051] In some embodiments, a compound for use in the compositions and methods according to the disclosure includes, without limitation, a fusion protein including the following *Chlamydia* proteins/antigens: PmpG and PmpF, or an immunogenic fragment thereof, or a nucleic acid molecule encoding such a fusion protein. In alternative embodiments, a compound for use in the compositions and methods according to the disclosure includes a fusion protein including only the following *Chlamydia* proteins/antigens: PmpG and PmpF, or an immunogenic fragment thereof, or a nucleic acid molecule encoding such a fusion protein.

[0052] In some embodiments, a compound for use in the compositions and methods according to the disclosure includes, without limitation, a fusion protein including the following *Chlamydia* proteins/antigens: PmpG and PmpH, or an immunogenic fragment thereof, or a nucleic acid molecule encoding such a fusion protein. In alternative embodiments, a compound for use in the compositions and methods according to the disclosure includes a fusion protein including only the following *Chlamydia* proteins/antigens: PmpG and PmpH, or an immunogenic fragment thereof, or a nucleic acid molecule encoding such a fusion protein.

[0053] In some embodiments, a compound for use in the compositions and methods according to the disclosure includes, without limitation, a fusion protein including the following *Chlamydia* proteins/antigens: PmpE and PmpF, or an immunogenic fragment thereof, or a nucleic acid molecule encoding such a fusion protein. In alternative embodiments, a compound for use in the compositions and methods according to the disclosure includes a fusion protein including only the following *Chlamydia* proteins/antigens: PmpE and PmpF, or an immunogenic fragment thereof, or a nucleic acid molecule encoding such a fusion protein.

[0054] In some embodiments, a compound for use in the compositions and methods according to the disclosure includes, without limitation, a fusion protein including the following *Chlamydia* proteins/antigens: PmpG and TC0420, or an immunogenic fragment thereof, or a nucleic acid molecule encoding such a fusion protein. In alternative embodiments, a compound for use in the compositions and methods according to the disclosure includes a fusion protein including only

the following *Chlamydia* proteins/antigens: PmpG and TC0420, or an immunogenic fragment thereof, or a nucleic acid molecule encoding such a fusion protein.

[0055] In alternative embodiments, a compound for use in the compositions and methods according to the disclosure includes, without limitation, one or more of the fusion proteins described in Figures 2A-F.

[0056] It is to be understood that compositions according to the disclosure can include mixtures of fusion proteins and individual (non-fusion) proteins, or immunogenic fragments thereof, as long as at least one polypeptide in the mixture is a fusion protein.

[0057] In some embodiments, a composition according to the disclosure includes, without limitation, a mixture of two or more fusion proteins, and optionally individual antigens, such as a mixture of PmpG/PmpH and PmpE/PmpF and optionally, MOMP; and/or PmpG/ TC0420 and PmpE/PmpF and optionally, MOMP, or an immunogenic fragment thereof.

[0058] In alternative embodiments, compositions according to the disclosure further include, without limitation, mixtures of fusion proteins, where MOMP, or an immunogenic fragment thereof, is part of a fusion protein.

[0059] In alternative embodiments, compounds for use in the compositions and methods according to the disclosure include, without limitation, a fusion protein including two or more of a *C. trachomatis* polypeptide, such as Ribosomal protein L6 (RpIF, gi:3328951), Anti anti sigma factor (Aasf, gi: 15605151), Polymorphic membrane protein G (PmpG, gi:3329346), Hypothetical protein (TC0420, gi: 15604862), Polymorphic membrane protein F (PmpF, gi:3329345), or major outer membrane protein 1 (MOMP) (gi:3329133), or an immunogenic fragment or portion thereof. Examples of fragments or portions of such *C. trachomatis* polypeptides include, without limitation, amino acids 25 - 512 of PmpG (PmpG₂₅₋₅₁₂), amino acids 26-585 of PmpF (PmpF₂₆₋₅₈₅), or amino acids 22-393 of MOMP.

[0060] In alternative embodiments, compounds for use in the compositions and methods according to the disclosure further include, without limitation, a fusion protein including two or more of a *C. muridarum* polypeptide, such as Ribosomal protein L6 (RpIF, gi: 15835415), Anti anti sigma factor (Aasf, gi: 15835322), Polymorphic membrane protein G (PmpG or PmpG-1, gi:

15834883), Hypothetical protein TC0420(gi: 15835038), Polymorphic membrane protein F (PmpF or PmpE/F, gi: 15834882), or major outer membrane protein 1 (MOMP, gi7190091), or an immunogenic fragment or portion thereof. Examples of such fragments or portions of *C. muridarum* polypeptides include, without limitation, amino acids 25 - 500 of PmpG- 1 (PmpG-1₂₅₋₅₀₀), amino acids 25-575 of PmpE/F-2 (PmpE/F-2₂₅₋₅₇₅), or amino acids 23 -387 of MOMP.

[0061] In alternative embodiments, an immunogenic fragment or portion of a *Chlamydia* polypeptide includes the region of the polypeptide that is generally exposed on the surface of the polypeptide. In alternative embodiments, such a fragment or portion of a *Chlamydia* polypeptide includes the passenger domain of a Pmp polypeptide *e.g.*, the domain located between the signal sequence and the translocation unit.

[0062] In alternative embodiments, an immunogenic fragment or portion of a *C. muridarum* polypeptide includes the passenger domain, or a portion thereof, of a *C. muridarum* Pmp polypeptide, for example, amino acids 18 to 667 of PmpE; amino acids 18 to 575 of PmpE; amino acids 20 to 722 of PmpF; amino acids 20 to 575 of PmpF; amino acids 25 to 675 of PmpG; amino acids 25 to 555 of PmpG; amino acids 27 to 653 of PmpH; or amino acids 27 to 575 of PmpH. In alternative embodiments, an immunogenic fragment or portion of a *C. trachomatis* polypeptide includes the passenger domain, or a portion thereof, of a *C. trachomatis* Pmp polypeptide. In alternative embodiments, an immunogenic fragment or portion of a *Chlamydia* polypeptide includes a peptide sequence as described in Table 1. In alternative embodiments, passenger domain fragments can be about 550 amino acids in length, or about 600 amino acids from the N-terminus of the Pmp polypeptide, or less. In alternative embodiments, an immunogenic fragment can be about 25 to about 600 amino acids in length, for example, about 25, 50, 75, 100, 125, 150, 175, 200, 225, 250, 275, 300, 325, 350, 375, 400, 425, 450, 475, 500, 525, 550, 575, 600, or any integer within these values.

[0063] In general, it is to be understood that the sequences of polypeptides and amino acids referenced herein correspond to those indicated in the locus tags referenced in the *C. trachomatis* genome sequence and/or the *C. muridarum* genome sequence. It is also to be understood that the nucleic acid sequences corresponding to the locus tags can be obtained from the *C. trachomatis* genome sequence and/or the *C. muridarum* genome sequence.

[0064] In some embodiments, fusion proteins for use according to the disclosure consist essentially of two *Chlamydia* polypeptides, or an immunogenic fragment thereof, as described herein.

[0065] In some embodiments, fusion proteins for use according to the disclosure consist essentially of three *Chlamydia* polypeptides, or an immunogenic fragment thereof, as described herein.

[0066] In some embodiments, fusion proteins for use according to the disclosure consist essentially of four *Chlamydia* polypeptides, or an immunogenic fragment thereof, as described herein.

[0067] In some embodiments, fusion proteins for use according to the disclosure include at least two *Chlamydia* polypeptides, or an immunogenic fragment thereof, for example, at least 2, 3, 4, 5, or more.

[0068] By “fusion protein” or “chimeric protein” is meant a recombinant protein or polypeptide in which at least two *Chlamydia* proteins or antigens, as for example, described herein or set forth in Tables 1 or 2, or Figures 1A-II, are present in a single, recombinant polypeptide. It is to be understood that the individual *Chlamydia* proteins or antigens that make up the fusion protein can be present in the fusion protein in any order or orientation. For example, in some embodiments, the individual *Chlamydia* proteins or antigens can be present in the fusion protein in the opposite direction relative to the naturally occurring (i.e. N-terminal to C-terminal reversed) direction. In some embodiments, the fusion protein can include full-length *Chlamydia* proteins or antigens. In alternative embodiments, the fusion protein can include portions or fragments of *Chlamydia* proteins or antigens, such as regions of the *Chlamydia* proteins or antigens exposed to the surface (“passenger domains”) or including immunodominant epitopes.

[0069] In some embodiments, a fusion protein may be provided in combination with a heterologous peptide or polypeptide, such as an epitope tag.

[0070] In some embodiments, the individual *Chlamydia* protein or antigen sequences may be joined directly to each other.

[0071] In some embodiments, a fusion protein may be provided in combination with a heterologous peptide or polypeptide, such as a linker or spacer that, for example, enables correct folding and/or presentation and/or expression of the fusion protein. The linker or spacer may be placed between each individual *Chlamydia* protein or antigen sequence, or may be placed between only some of the individual *Chlamydia* protein or antigen sequences present in the fusion protein.

[0072] In alternative embodiments, the linker may be a heterologous linker, such as a sequence (*e.g.*, an alpha helical sequence) from another *Chlamydia* protein or antigen or from a non-adjacent location of the *Chlamydia* proteins or antigens forming the fusion protein, or may be a homologous linker, such as a sequence (*e.g.*, an alpha helical sequence) from one of the *Chlamydia* proteins or antigens forming the fusion protein and adjacent to the sequence used in the fusion protein. For example, the passenger domains of the Pmp fusion partners can be connected via an alpha-helical linker (shown in underline in Figures 2E-F) polypeptide. The linker polypeptides can be derived from polypeptide sequences of one of the fusion protein partners. For example, the linker for the PmpE-PmpF fusion protein includes a sequence from PmpE and the linker for the PmpG-PmpH fusion protein includes a sequence from PmpG (Figures 2E-F).

[0073] It is well known in the art that some modifications and changes can be made in the structure of a polypeptide without substantially altering the biological function of that polypeptide *e.g.*, its ability to be cleaved into smaller peptides that are capable of binding to MHC proteins, to obtain a biologically equivalent polypeptide. Accordingly, it will be appreciated by a person of skill in the art that the numerical designations of the positions of amino acids within a sequence are relative to the specific sequence. Also the same positions may be assigned different numerical designations depending on the way in which the sequence is numbered and the sequence chosen. Furthermore, sequence variations such as insertions or deletions, may change the relative position and subsequently the numerical designations of particular amino acids at and around a site.

[0074] A “protein,” “peptide,” or “polypeptide” is any chain of two or more amino acids, including naturally occurring or non-naturally occurring amino acids or amino acid analogues,

regardless of post-translational modification (*e.g.*, glycosylation or phosphorylation). An “amino acid sequence,” “polypeptide,” “peptide,” or “protein” of the invention may include peptides or proteins that have abnormal linkages, cross links and end caps, non-peptidyl bonds or alternative modifying groups. Such modified peptides are also within the scope of the invention. The term “modifying group” is intended to include structures that are directly attached to the peptidic structure (*e.g.*, by covalent coupling), as well as those that are indirectly attached to the peptidic structure (*e.g.*, by a stable non-covalent association or by covalent coupling to additional amino acid residues, or mimetics, analogues or derivatives thereof, which may flank the core peptidic structure). For example, the modifying group can be coupled to the amino-terminus or carboxy-terminus of a peptidic structure, or to a peptidic or peptidomimetic region flanking the core domain.

[0075] Alternatively, the modifying group can be coupled to a side chain of at least one amino acid residue of a peptidic structure, or to a peptidic or peptido- mimetic region flanking the core domain (*e.g.*, through the epsilon amino group of a lysyl residue(s), through the carboxyl group of an aspartic acid residue(s) or a glutamic acid residue(s), through a hydroxy group of a tyrosyl residue(s), a serine residue(s) or a threonine residue(s) or other suitable reactive group on an amino acid side chain). Modifying groups covalently coupled to the peptidic structure can be attached by means and using methods well known in the art for linking chemical structures, including, for example, amide, alkylamino, carbamate or urea bonds.

[0076] In one aspect of the invention, polypeptides of the present invention also extend to biologically equivalent peptides or “variants” that differ from a portion of the sequence of the polypeptides of the present invention by conservative amino acid substitutions, or differ by non-conservative substitutions that do not affect biological function *e.g.*, immunogenicity. As used herein, the term “conserved amino acid substitutions” refers to the substitution of one amino acid for another at a given location in the peptide, where the substitution can be made without substantial loss of the relevant function. In making such changes, substitutions of like amino acid residues can be made on the basis of relative similarity of side-chain substituents, for example, their size, charge, hydrophobicity, hydrophilicity, and the like, and such substitutions may be assayed for their effect on the function of the peptide by routine testing.

[0077] As used herein, the term “amino acids” means those L-amino acids commonly found in naturally occurring proteins, D-amino acids and such amino acids when they have been modified. Accordingly, amino acids of the invention may include, for example: 2-Aminoadipic acid; 3-Aminoadipic acid; beta-Alanine; beta-Aminopropionic acid; 2-Aminobutyric acid; 4-Aminobutyric acid; piperidinic acid; 6-Aminocaproic acid; 2-Aminoheptanoic acid; 2-Aminoisobutyric acid; 3-Aminoisobutyric acid; 2-Aminopimelic acid; 2,4 Diaminobutyric acid; Desmosine; 2,2'-Diaminopimelic acid; 2,3-Diaminopropionic acid; N-Ethylglycine; N-Ethylasparagine; Hydroxylysine; allo-Hydroxylysine; 3-Hydroxyproline; 4-Hydroxyproline; Isodesmosine; allo-Isoleucine; N-Methylglycine; sarcosine; N-Methylisoleucine; 6-N-methyllysine; N-Methylvaline; Norvaline; Norleucine; and Ornithine.

[0078] In some embodiments, conserved amino acid substitutions may be made where an amino acid residue is substituted for another having a similar hydrophilicity value (e.g., within a value of plus or minus 2.0, or plus or minus 1.5, or plus or minus 1.0, or plus or minus 0.5), where the following may be an amino acid having a hydropathic index of about -1.6 such as Tyr (-1.3) or Pro (-1.6) are assigned to amino acid residues (as detailed in United States Patent No. 4,554,101, incorporated herein by reference): Arg (+3.0); Lys (+3.0); Asp (+3.0); Glu (+3.0); Ser (+0.3); Asn (+0.2); Gln (+0.2); Gly (0); Pro (-0.5); Thr (-0.4); Ala (-0.5); His (-0.5); Cys (-1.0); Met (-1.3); Val (-1.5); Leu (-1.8); Ile (-1.8); Tyr (-2.3); Phe (-2.5); and Trp (-3.4).

[0079] In alternative embodiments, conservative amino acid substitutions may be made where an amino acid residue is substituted for another having a similar hydropathic index (e.g., within a value of plus or minus 2.0, or plus or minus 1.5, or plus or minus 1.0, or plus or minus 0.5). In such embodiments, each amino acid residue may be assigned a hydropathic index on the basis of its hydrophobicity and charge characteristics, as follows: He (+4.5); Val (+4.2); Leu (+3.8); Phe (+2.8); Cys (+2.5); Met (+1.9); Ala (+1.8); Gly (-0.4); Thr (-0.7); Ser (-0.8); Trp (-0.9); Tyr (-1.3); Pro (-1.6); His (-3.2); Glu (-3.5); Gln (-3.5); Asp (-3.5); Asn (-3.5); Lys (-3.9); and Arg (-4.5).

[0080] In alternative embodiments, conservative amino acid substitutions may be made using publicly available families of similarity matrices (60, 70, 102, 103, 94, 104, 86) The PAM matrix is based upon counts derived from an evolutionary model, while the Blosum matrix uses counts

derived from highly conserved blocks within an alignment. A similarity score of above zero in either of the PAM or Blosum matrices may be used to make conservative amino acid substitutions.

[0081] In alternative embodiments, conservative amino acid substitutions may be made where an amino acid residue is substituted for another in the same class, where the amino acids are divided into non-polar, acidic, basic and neutral classes, as follows: non-polar: Ala, Val, Leu, Ile, Phe, Trp, Pro, Met; acidic: Asp, Glu; basic: Lys, Arg, His; neutral: Gly, Ser, Thr, Cys, Asn, Gln, Tyr.

[0082] Conservative amino acid changes can include the substitution of an L-amino acid by the corresponding D-amino acid, by a conservative D-amino acid, or by a naturally-occurring, non-genetically encoded form of amino acid, as well as a conservative substitution of an L-amino acid. Naturally-occurring non-genetically encoded amino acids include beta-alanine, 3-amino-propionic acid, 2,3-diamino propionic acid, alpha-aminoisobutyric acid, 4-amino-butyric acid, N-methylglycine (sarcosine), hydroxyproline, ornithine, citrulline, t-butylalanine, t-butylglycine, N-methylisoleucine, phenylglycine, cyclohexylalanine, norleucine, norvaline, 2-naphthylalanine, pyridylalanine, 3-benzothienyl alanine, 4-chlorophenylalanine, 2-fluorophenylalanine, 3-fluorophenylalanine, 4-fluorophenylalanine, penicillamine, 1,2,3,4-tetrahydro-isoquinoline-3-carboxylic acid, beta-2-thienylalanine, methionine sulfoxide, homoarginine, N-acetyl lysine, 2-amino butyric acid, 2-amino butyric acid, 2,4,-diamino butyric acid, p-aminophenylalanine, N-methylvaline, homocysteine, homoserine, cysteic acid, epsilon-amino hexanoic acid, delta-amino valeric acid, or 2,3-diaminobutyric acid.

[0083] In alternative embodiments, conservative amino acid changes include changes based on considerations of hydrophilicity or hydrophobicity, size or volume, or charge. Amino acids can be generally characterized as hydrophobic or hydrophilic, depending primarily on the properties of the amino acid side chain. A hydrophobic amino acid exhibits a hydrophobicity of greater than zero, and a hydrophilic amino acid exhibits a hydrophilicity of less than zero, based on the normalized consensus hydrophobicity scale of Eisenberg *et al.* (*Ann. Rev. Biochem.* **53**: 595–623, 1984). Genetically encoded hydrophobic amino acids include Gly, Ala, Phe, Val, Leu, Ile, Pro, Met and Trp, and genetically encoded hydrophilic amino acids include Thr, His, Glu, Gln, Asp,

Arg, Ser, and Lys. Non-genetically encoded hydrophobic amino acids include t-butylalanine, while non-genetically encoded hydrophilic amino acids include citrulline and homocysteine.

[0084] Hydrophobic or hydrophilic amino acids can be further subdivided based on the characteristics of their side chains. For example, an aromatic amino acid is a hydrophobic amino acid with a side chain containing at least one aromatic or heteroaromatic ring, which may contain one or more substituents such as -OH, -SH, -CN, -F, -Cl, -Br, -I, -NO₂, -NO, -NH₂, -NHR, -NRR, -C(O)R, -C(O)OH, -C(O)OR, -C(O)NH₂, -C(O)NHR, -C(O)NRR, etc., where R is independently (-C₆) alkyl, substituted (C₁-C₆) alkyl, (C₆) alkenyl, substituted (-C₆) alkenyl, (C_j-C₆) alkynyl, substituted (C₁-C₆) alkynyl, (C₅-C₂₀) aryl, substituted (C₅-C₂₀) aryl, (C₆-C₂₆) alkaryl, substituted (C₆-C₂₆) alkaryl, 5-20 membered heteroaryl, substituted 5-20 membered heteroaryl, 6-26 membered alkheteroaryl or substituted 6-26 membered alkheteroaryl.

Genetically encoded aromatic amino acids include Phe, Tyr, and Trp, while non-genetically encoded aromatic amino acids include phenylglycine, 2-naphthylalanine, beta-2-thienylalanine, 1,2,3,4-tetrahydro-isoquinoline-3-carboxylic acid, 4-chlorophenylalanine, 2-fluorophenylalanine, 3-fluorophenylalanine, and 4-fluorophenylalanine.

[0085] An apolar amino acid is a hydrophobic amino acid with a side chain that is uncharged at physiological pH and which has bonds in which a pair of electrons shared in common by two atoms is generally held equally by each of the two atoms (i.e., the side chain is not polar).

Genetically encoded apolar amino acids include Gly, Leu, Val, He, Ala, and Met, while non-genetically encoded apolar amino acids include cyclohexylalanine. Apolar amino acids can be further subdivided to include aliphatic amino acids, which is a hydrophobic amino acid having an aliphatic hydrocarbon side chain. Genetically encoded aliphatic amino acids include Ala, Leu, Val, and He, while non-genetically encoded aliphatic amino acids include norleucine.

[0086] A polar amino acid is a hydrophilic amino acid with a side chain that is uncharged at physiological pH, but which has one bond in which the pair of electrons shared in common by two atoms is held more closely by one of the atoms.

Genetically encoded polar amino acids include Ser, Thr, Asn, and Gin, while non-genetically encoded polar amino acids include citrulline, N-acetyl lysine, and methionine sulfoxide.

[0087] An acidic amino acid is a hydrophilic amino acid with a side chain pKa value of less than 7. Acidic amino acids typically have negatively charged side chains at physiological pH due to loss of a hydrogen ion. Genetically encoded acidic amino acids include Asp and Glu. A basic amino acid is a hydrophilic amino acid with a side chain pKa value of greater than 7. Basic amino acids typically have positively charged side chains at physiological pH due to association with hydronium ion.

Genetically encoded basic amino acids include Arg, Lys, and His, while non-genetically encoded basic amino acids include the non-cyclic amino acids ornithine, 2,3,-diaminopropionic acid, 2,4-diaminobutyric acid, and homoarginine.

It will be appreciated by one skilled in the art that the above classifications are not absolute and that an amino acid may be classified in more than one category. In addition, amino acids can be classified based on known behaviour and or characteristic chemical, physical, or biological properties based on specified assays or as compared with previously identified amino acids. Amino acids can also include bifunctional moieties having amino acid-like side chains.

[0088] Conservative changes can also include the substitution of a chemically derivatised moiety for a non-derivatised residue, by for example, reaction of a functional side group of an amino acid. Thus, these substitutions can include compounds whose free amino groups have been derivatised to amine hydrochlorides, p-toluene sulfonyl groups, carbobenzoxy groups, t-butyloxycarbonyl groups, chloroacetyl groups or formyl groups. Similarly, free carboxyl groups can be derivatized to form salts, methyl and ethyl esters or other types of esters or hydrazides, and side chains can be derivatized to form O-acyl or O-alkyl derivatives for free hydroxyl groups or N-im-benzylhistidine for the imidazole nitrogen of histidine.

[0089] Peptides or peptide analogues can be synthesised by standard chemical techniques, for example, by automated synthesis using solution or solid phase synthesis methodology. Automated peptide synthesisers are commercially available and use techniques well known in the art. Peptides and peptide analogues can also be prepared using recombinant DNA technology using standard methods such as those described in, for example, Sambrook, *et al.* (Molecular Cloning: A Laboratory Manual. 3rd ed., Cold Spring Harbor Laboratory, Cold Spring Harbor

Laboratory Press, Cold Spring Harbor, N.Y., 2000) or Ausubel *et al.* (Current Protocols in Molecular Biology, John Wiley & Sons, New York, N.Y., 1987-2012).

[0090] Accordingly, and as discussed herein, compounds for use according to the disclosure include nucleic acid molecules encoding the fusion proteins described herein.

[0091] The terms “nucleic acid” or “nucleic acid molecule” encompass both RNA (plus and minus strands) and DNA, including cDNA, genomic DNA, and synthetic (e.g., chemically synthesized) DNA. The nucleic acid may be double-stranded or single-stranded. Where single-stranded, the nucleic acid may be the sense strand or the antisense strand. A nucleic acid molecule may be any chain of two or more covalently bonded nucleotides, including naturally occurring or non-naturally occurring nucleotides, or nucleotide analogs or derivatives. By “RNA” is meant a sequence of two or more covalently bonded, naturally occurring or modified ribonucleotides. One example of a modified RNA included within this term is phosphorothioate RNA. By “DNA” is meant a sequence of two or more covalently bonded, naturally occurring or modified deoxyribonucleotides. By “cDNA” is meant complementary or copy DNA produced from an RNA template by the action of RNA-dependent DNA polymerase (reverse transcriptase). Thus a “cDNA clone” means a duplex DNA sequence complementary to an RNA molecule of interest, carried in a cloning vector. By “complementary” is meant that two nucleic acids, e.g., DNA or RNA, contain a sufficient number of nucleotides which are capable of forming Watson-Crick base pairs to produce a region of double-strandedness between the two nucleic acids. Thus, adenine in one strand of DNA or RNA pairs with thymine in an opposing complementary DNA strand or with uracil in an opposing complementary RNA strand. It will be understood that each nucleotide in a nucleic acid molecule need not form a matched Watson-Crick base pair with a nucleotide in an opposing complementary strand to form a duplex. A nucleic acid molecule is “complementary” to another nucleic acid molecule if it hybridizes, under conditions of high stringency, with the second nucleic acid molecule.

[0092] A compound is “isolated” when it is separated from the components that naturally accompany it. Typically, a compound is isolated when it is at least 50%, or 60%, or more generally at least 70%, 75%, 80%, 85%, 90%, 95%, or 99% by weight, of the total material in a sample. Thus, for example, a polypeptide that is chemically synthesized or produced by

recombinant technology will be generally be substantially free from its naturally associated components. A nucleic acid molecule will generally be substantially pure or “isolated” when it is not immediately contiguous with (i.e., covalently linked to) the coding sequences with which it is normally contiguous in the naturally occurring genome of the organism from which the DNA of the invention is derived. Therefore, an “isolated” gene or nucleic acid molecule is intended to mean a gene or nucleic acid molecule which is not flanked by nucleic acid molecules which normally (in nature) flank the gene or nucleic acid molecule (such as in genomic sequences) and/or has been completely or partially purified from other transcribed sequences (as in a cDNA or RNA library). For example, an isolated nucleic acid of the invention may be substantially isolated with respect to the complex cellular milieu in which it naturally occurs. The term therefore includes, *e.g.*, a recombinant nucleic acid incorporated into a vector, such as an autonomously replicating plasmid or virus; or into the genomic DNA of a prokaryote or eukaryote, or which exists as a separate molecule (*e.g.*, a cDNA or a genomic DNA fragment produced by PCR or restriction endonuclease treatment) independent of other sequences. It also includes a recombinant nucleic acid which is part of a hybrid gene encoding additional polypeptide sequences. Preferably, an isolated nucleic acid comprises at least about 50, 80 or 90 percent (on a molar basis) of all macromolecular species present. Thus, an isolated gene or nucleic acid molecule can include a gene or nucleic acid molecule which is synthesized chemically or by recombinant means. Recombinant DNA contained in a vector are included in the definition of “isolated” as used herein. Also, isolated nucleic acid molecules include recombinant DNA molecules in heterologous host cells, as well as partially or substantially purified DNA molecules in solution. In vivo and in vitro RNA transcripts of the DNA molecules of the present invention are also encompassed by “isolated” nucleic acid molecules.

[0093] Various genes and nucleic acid sequences of the invention may be recombinant sequences. The term “recombinant” means that something has been recombined, so that when made in reference to a nucleic acid construct the term refers to a molecule that is comprised of nucleic acid sequences that are joined together or produced by means of molecular biological techniques. The term “recombinant” when made in reference to a protein or a polypeptide refers to a protein or polypeptide molecule which is expressed using a recombinant nucleic acid construct created by means of molecular biological techniques. Recombinant nucleic acid constructs may include a nucleotide sequence which is ligated to, or is manipulated to

become ligated to, a nucleic acid sequence to which it is not ligated in nature, or to which it is ligated at a different location in nature. Referring to a nucleic acid construct as “recombinant” therefore indicates that the nucleic acid molecule has been manipulated using genetic engineering, *i.e.* by human intervention.

[0094] Recombinant nucleic acid constructs may for example be introduced into a host cell by transformation. Such recombinant nucleic acid constructs may include sequences derived from the same host cell species or from different host cell species, which have been isolated and reintroduced into cells of the host species. Recombinant nucleic acid construct sequences may become integrated into a host cell genome, either as a result of the original transformation of the host cells, or as the result of subsequent recombination and/or repair events.

[0095] As used herein, “heterologous” in reference to a nucleic acid or protein is a molecule that has been manipulated by human intervention so that it is located in a place other than the place in which it is naturally found. For example, a nucleic acid sequence from one species may be introduced into the genome of another species, or a nucleic acid sequence from one genomic locus may be moved to another genomic or extrachromosomal locus in the same species. A heterologous protein includes, for example, a protein expressed from a heterologous coding sequence or a protein expressed from a recombinant gene in a cell that would not naturally express the protein. A heterologous fusion protein may include a protein in a non-natural orientation (*i.e.*, N to C) or may include a fragment or portion of a protein located in a place, within the protein, other than the place in which it is naturally found.

[0096] A “substantially identical” sequence is an amino acid or nucleotide sequence that differs from a reference sequence only by one or more conservative substitutions, as discussed herein, or by one or more non-conservative substitutions, deletions, or insertions located at positions of the sequence that do not destroy the biological function of the amino acid or nucleic acid molecule. Such a sequence can be any integer from 45% to 99%, or more generally at least 45%, 50, 55% or 60%, or at least 65%, 75%, 80%, 85%, 90%, or 95%, or as much as 96%, 97%, 98%, or 99% identical at the amino acid or nucleotide level to the sequence used for comparison using, for example, the Align Program or FASTA. For polypeptides, the length of comparison sequences may be at least 2, 5, 10, or 15 amino acids, or at least 20, 25, or 30 amino acids. In alternate

embodiments, the length of comparison sequences may be at least 35, 40, or 50 amino acids, or over 60, 80, or 100 amino acids. For nucleic acid molecules, the length of comparison sequences may be at least 5, 10, 15, 20, or 25 nucleotides, or at least 30, 40, or 50 nucleotides. In alternate embodiments, the length of comparison sequences may be at least 60, 70, 80, or 90 nucleotides, or over 100, 200, or 500 nucleotides. Sequence identity can be readily measured using publicly available sequence analysis software (e.g., Sequence Analysis Software Package of the Genetics Computer Group, University of Wisconsin Biotechnology Center, 1710 University Avenue, Madison, Wis. 53705, or BLAST software available from the National Library of Medicine, or as described herein). Examples of useful software include the programs Pile-up and PrettyBox. Such software matches similar sequences by assigning degrees of homology to various substitutions, deletions, substitutions, and other modifications.

[0097] Alternatively, or additionally, two nucleic acid sequences may be “substantially identical” if they hybridize under high stringency conditions. In some embodiments, high stringency conditions are, for example, conditions that allow hybridization comparable with the hybridization that occurs using a DNA probe of at least 500 nucleotides in length, in a buffer containing 0.5 M NaHPO₄, pH 7.2, 7% SDS, 1 mM EDTA, and 1% BSA (fraction V), at a temperature of 65°C, or a buffer containing 48% formamide, 4.8x SSC, 0.2 M Tris-Cl, pH 7.6, 1x Denhardt’s solution, 10% dextran sulfate, and 0.1% SDS, at a temperature of 42°C. (These are typical conditions for high stringency northern or Southern hybridizations.) Hybridizations may be carried out over a period of about 20 to 30 minutes, or about 2 to 6 hours, or about 10 to 15 hours, or over 24 hours or more. High stringency hybridization is also relied upon for the success of numerous techniques routinely performed by molecular biologists, such as high stringency PCR, DNA sequencing, single strand conformational polymorphism analysis, and *in situ* hybridization. In contrast to northern and Southern hybridizations, these techniques are usually performed with relatively short probes (e.g., usually about 16 nucleotides or longer for PCR or sequencing and about 40 nucleotides or longer for *in situ* hybridization). The high stringency conditions used in these techniques are well known to those skilled in the art of molecular biology (Ausubel *et al*, Current Protocols in Molecular Biology, John Wiley & Sons, New York, N.Y., 1998).

[0098] Substantially identical sequences may for example be sequences that are substantially identical to the *Chlamydia* spp. sequences described or referenced herein. A substantially identical sequence may for example be a sequence that is substantially identical to the sequence of any one of SEQ ID NOs: 1-71, or to any one of the sequences indicated by the locus tags referenced in the *C. trachomatis* genome sequence and/or the *C. muridarum* genome sequence as indicated herein, or a fragment or variant thereof. In some embodiments, a substantially identical sequence may for example be a nucleotide sequence that is complementary to or hybridizes with the sequence of any one of the nucleic acid sequences described herein, or with the sequence encoding any one of the amino acid sequences described herein, or to any one of the sequences indicated by the locus tags referenced in the *C. trachomatis* genome sequence and/or the *C. muridarum* genome sequence as indicated herein, or a fragment or variant thereof. In some embodiments, a substantially identical sequence may be derived from a *Chlamydia* spp., such as a *C. trachomatis* or a *C. muridarum*.

[0099] Pharmaceutical & Veterinary Compositions, Dosages, And Administration

[00100] The compounds and compositions as described herein may be used to prepare vaccine or other formulations and/or used in the induction of an immune response to a *Chlamydia* antigen or epitope. In some embodiments, the compositions may be formulated as admixtures of fusion proteins consisting of two or more *Chlamydia* proteins or immunogenic fragments thereof, as described herein. In alternative embodiments, the compositions may be formulated using a single fusion protein. In alternative embodiments, the compositions may include MOMP, either as part of a fusion protein or as an individual protein in admixture with a fusion protein as described herein.

[00101] The compounds and compositions can be provided alone or in combination with other compounds (for example, nucleic acid molecules, small molecules, polypeptides, peptides, or peptide analogues), in the presence of a liposome, an adjuvant, or any pharmaceutically acceptable carrier, in a form suitable for administration to an animal subject, for example, mice, humans, pigs, *etc.* If desired, treatment with a compound according to the invention may be combined with more traditional and existing therapies for *Chlamydia* infection.

[00102] Conventional pharmaceutical practice may be employed to provide suitable formulations to administer the compounds or compositions to subjects infected by a *Chlamydia* pathogen. Any appropriate route of administration may be employed, for example, parenteral, intravenous, subcutaneous, intramuscular, intracranial, intrathecal, intraorbital, ophthalmic, intraventricular, intracapsular, intraspinal, intracisternal, intraperitoneal, intranasal, epidermal, transdermal, mucosal membrane aerosol, nasal, rectal, vaginal, topical or oral administration. In some embodiments, the compounds or compositions described herein may be applied to epithelial surfaces. Some epithelial surfaces may comprise a mucosal membrane, for example buccal, gingival, nasal, tracheal, bronchial, gastrointestinal, genital, rectal, urethral, vaginal, cervical, uterine and the like. Some epithelial surfaces may comprise keratinized cells, for example, skin, tongue, gingival, palate or the like. In some embodiments, the *Chlamydia* infection may be in the lung, genital tract or eye and the compounds or compositions described herein may be administered intranasally or by injection.

[00103] Formulations may be in the form of liquid solutions or suspensions; tablets or capsules; powders, nasal drops, or aerosols. Methods are well known in the art for making formulations (Berge et al. 1977. J. Pharm Sci. 66: 1 - 19); Remington-The Science and Practice of Pharmacy, 21st edition. Gennaro et al editors. Lippincott Williams & Wilkins Philadelphia.). Such excipients may include, for example, salts, buffers, antioxidants, complexing agents, tonicity agents, cryoprotectants, lyoprotectants, suspending agents, emulsifying agents, antimicrobial agents, preservatives, chelating agents, binding agents, surfactants, wetting agents, anti-adherents agents, disintegrants, coatings, glidants, deflocculating agents, anti-nucleating agents, surfactants, stabilizing agents, non-aqueous vehicles such as fixed oils, polymers or encapsulants for sustained or controlled release, ointment bases, fatty acids, cream bases, emollients, emulsifiers, thickeners, preservatives, solubilizing agents, humectants, water, alcohols or the like.

[00104] Formulations for parenteral administration may, for example, contain excipients, sterile water, or saline, polyalkylene glycols such as polyethylene glycol, oils of vegetable origin, or hydrogenated naphthalenes. Biocompatible, biodegradable lactide polymer, lactide/glycolide copolymer, or polyoxyethylene-polyoxypropylene copolymers may be used to control the release of the compounds or compositions. Other potentially useful parenteral delivery systems for

modulatory compounds include ethylene-vinyl acetate copolymer particles, osmotic pumps, implantable infusion systems, and liposomes. Formulations for inhalation may contain excipients, for example, lactose, or may be aqueous solutions containing, for example, polyoxyethylene-9-lauryl ether, glycocholate and deoxycholate, or may be oily solutions for administration in the form of nasal drops, or as a gel.

[00105] For therapeutic or prophylactic compositions, the compounds or compositions are administered to an animal in an amount effective to stop or slow a *Chlamydia* infection.

[00106] An “effective amount” of a compound according to the invention includes a therapeutically effective amount or a prophylactically effective amount. A “therapeutically effective amount” refers to an amount effective, at dosages and for periods of time necessary, to achieve the desired therapeutic result, such as reduction of a *Chlamydia* infection or induction of an immune response to a *Chlamydia* antigen or epitope. A therapeutically effective amount of a compound may vary according to factors such as the disease state, age, sex, and weight of the subject, and the ability of the compound to elicit a desired response in the subject. Dosage regimens may be adjusted to provide the optimum therapeutic response. A therapeutically effective amount is also one in which any toxic or detrimental effects of the compound are outweighed by the therapeutically beneficial effects. A “prophylactically effective amount” refers to an amount effective, at dosages and for periods of time necessary, to achieve the desired prophylactic result, such as prevention of a *Chlamydia* infection or induction of an immune response to a *Chlamydia* antigen or epitope. Typically, a prophylactic dose is used in subjects prior to or at an earlier stage of disease, so that a prophylactically effective amount may be less than a therapeutically effective amount. A suitable range for therapeutically or prophylactically effective amounts of a compound maybe any integer from 0.1 nM-0.1M, 0.1 nM-0.05M, 0.05 nM-15 μ M or 0.01 nM-10 μ M.

[00107] In some embodiments, an effective amount may be calculated on a mass/mass basis (*e.g.* micrograms or milligrams per kilogram of subject), or may be calculated on a mass/volume basis (*e.g.* concentration, micrograms or milligrams per milliliter). Using a mass/volume unit, one or more peptides or polypeptides may be present at an amount from about 0.1 μ g/ml to about 20 mg/ml, or any amount therebetween, for example 0.1, 0.5, 1, 2, 5, 10, 15,

20, 25, 30, 35, 40, 50, 60, 70, 80, 90, 100, 120, 140, 160 180, 200, 250, 500, 750, 1000, 1500, 2000, 5000, 10000, 20000 ug/ml, or any amount therebetween; or from about 1 ug/ml to about 2000 ug/ml, or any amount therebetween, for example 1.0, 2.0, 5.0, 10.0, 15.0, 20.0, 25.0, 30.0, 35.0, 40.0, 50.0 60.0, 70.0, 80.0, 90.0, 100, 120, 140, 160 180, 200, 250, 500, 750, 1000, 1500, 2000, ug/ml or any amount therebetween; or from about 10 ug/ml to about 1000 ug/ml or any amount therebetween, for example 10.0, 15.0, 20.0, 25.0, 30.0, 35.0, 40.0, 50.0 60.0, 70.0, 80.0, 90.0, 100, 120, 140, 160 180, 200, 250, 500, 750, 1000 ug/ml, or any amount therebetween; or from about 30ug/ml to about 1000ug/ml or any amount therebetween, for example 30.0, 35.0, 40.0, 50.0 60.0, 70.0, 80.0, 90.0, 100, 120, 140, 160 180, 200, 250, 500, 750, 1000 ug/ml.

[00108] Quantities and/or concentrations may be calculated on a mass/mass basis (e.g. micrograms or milligrams per kilogram of subject), or may be calculated on a mass/volume basis (e.g. concentration, micrograms or milligrams per milliliter). Using a mass/volume unit, one or more peptides or polypeptides may be present at an amount from about 0.1 ug/ml to about 20 mg/ml, or any amount therebetween, for example 0.1, 0.5, 1, 2, 5, 10, 15, 20, 25, 30, 35, 40, 50, 60, 70, 80, 90, 100, 120, 140, 160 180, 200, 250, 500, 750, 1000, 1500, 2000, 5000, 10000, 20000 ug/ml, or any amount therebetween; or from about 1 ug/ml to about 2000 ug/ml, or any amount therebetween, for example 1.0, 2.0, 5.0, 10.0, 15.0, 20.0, 25.0, 30.0, 35.0, 40.0, 50.0 60.0, 70.0, 80.0, 90.0, 100, 120, 140, 160 180, 200, 250, 500, 750, 1000, 1500, 2000, ug/ml or any amount therebetween; or from about 10ug/ml to about 1000ug/ml or any amount therebetween, for example 10.0, 15.0, 20.0, 25.0, 30.0, 35.0, 40.0, 50.0 60.0, 70.0, 80.0, 90.0, 100, 120, 140, 160 180, 200, 250, 500, 750, 1000 ug/ml, or any amount therebetween; or from about 30ug/ml to about 1000ug/ml or any amount therebetween, for example 30.0, 35.0, 40.0, 50.0 60.0, 70.0, 80.0, 90.0, 100, 120, 140, 160 180, 200, 250, 500, 750, 1000 ug/ml.

[00109] Compositions according to various embodiments of the invention, including therapeutic compositions, may be administered as a dose comprising an effective amount of one or more peptides or polypeptides. The dose may comprise from about 0.1 ug/kg to about 20mg/kg (based on the mass of the subject), for example 0.1, 0.5, 1, 2, 5, 10, 15, 20, 25, 30, 35, 40, 50, 60, 70, 80, 90, 100, 120, 140, 160 180, 200, 250, 500, 750, 1000, 1500, 2000, 5000, 10000, 20000 ug/kg, or any amount therebetween; or from about 1ug/kg to about 2000ug/kg or any amount therebetween, for example 1.0, 2.0, 5.0, 10.0, 15.0, 20.0, 25.0, 30.0, 35.0, 40.0, 50.0

60.0, 70.0, 80.0, 90.0, 100, 120, 140, 160 180, 200, 250, 500, 750, 1000, 1500, 2000 ug/kg, or any amount therebetween; or from about 10 ug/kg to about 1000 ug/kg or any amount therebetween, for example 10.0, 15.0, 20.0, 25.0, 30.0, 35.0, 40.0, 50.0 60.0, 70.0, 80.0, 90.0, 100, 120, 140, 160 180, 200, 250, 500, 750, 1000 ug/kg, or any amount therebetween; or from about 30ug/kg to about 1000ug/kg or any amount therebetween, for example 30.0, 35.0, 40.0, 50.0 60.0, 70.0, 80.0, 90.0, 100, 120, 140, 160 180, 200, 250, 500, 750, 1000 ug/kg.

[00110] One of skill in the art will be readily able to interconvert the units as necessary, given the mass of the subject, the concentration of the composition, individual components or combinations thereof, or volume of the composition, individual components or combinations thereof, into a format suitable for the desired application.

[00111] It is to be noted that dosage values may vary with the severity of the condition to be alleviated. For any particular subject, specific dosage regimens may be adjusted over time according to the individual need and the professional judgment of the person administering or supervising the administration of the compositions. Dosage ranges set forth herein are exemplary only and do not limit the dosage ranges that may be selected by medical practitioners. The amount of active compound in the composition may vary according to factors such as the disease state, age, sex, and weight of the individual. Dosage regimens may be adjusted to provide the optimum 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 may be advantageous to formulate parenteral compositions in dosage unit form for ease of administration and uniformity of dosage.

[00112] The amount of a composition administered, where it is administered, the method of administration and the timeframe over which it is administered may all contribute to the observed effect. As an example, a composition may be administered systemically *e.g.* by intravenous administration and have a toxic or undesirable effect, while the same composition administered subcutaneously or intranasally may not yield the same undesirable effect. In some embodiments, localized stimulation of immune cells in the lymph nodes close to the site of subcutaneous injection may be advantageous, while a systemic immune stimulation may not.

[00113] In general, compounds or compositions should be used without causing substantial toxicity. Toxicity of the compounds of the invention can be determined using standard techniques, for example, by testing in cell cultures or experimental animals and determining the therapeutic index, i.e., the ratio between the LD50 (the dose lethal to 50% of the population) and the LD100 (the dose lethal to 100% of the population). In some circumstances however, such as in severe disease conditions, it may be necessary to administer substantial excesses of the compositions.

[00114] Compositions according to various embodiments of the invention may be provided in a unit dosage form, or in a bulk form suitable for formulation or dilution at the point of use. Compositions according to various embodiments of the invention may be administered to a subject in a single-dose, or in several doses administered over time. Dosage schedules may be dependent on, for example, the subject's condition, age, gender, weight, route of administration, formulation, or general health. Dosage schedules may be calculated from measurements of adsorption, distribution, metabolism, excretion and toxicity in a subject, or may be extrapolated from measurements on an experimental animal, such as a rat or mouse, for use in a human subject. Optimization of dosage and treatment regimens are discussed in, for example, Goodman & Gilman's *The Pharmacological Basis of Therapeutics* 11th edition. 2006. LL Brunton, editor. McGraw-Hill, New York, or Remington- *The Science and Practice of Pharmacy*, 21st edition. Gennaro et al editors. Lippincott Williams & Wilkins Philadelphia.

[00115] A “vaccine” is a composition that includes materials that elicit a desired immune response. A desired immune response may include protection against infection by a *Chlamydia* spp. pathogen. For example, a desired immune response may include any value from between 10% to 100%, e.g., 10%, 20%, 30%, 40%, 50%, 60%, 70%, 80%, 90%, 100%, protection against infection by a *Chlamydia* spp. pathogen in a vaccinated animal when compared to a non-vaccinated animal.

[00116] An “immune response” may generally refer to a response of the adaptive immune system, such as a humoral response, and a cell-mediated response. The humoral response is the aspect of immunity that is mediated by secreted antibodies, produced in the cells of the B lymphocyte lineage (B cell). Secreted antibodies bind to antigens on the surfaces of invading

microbes (such as viruses or bacteria), which flags them for destruction. Humoral immunity is used generally to refer to antibody production and the processes that accompany it, as well as the effector functions of antibodies, including Th2 cell activation and cytokine production, memory cell generation, opsonin promotion of phagocytosis, pathogen elimination and the like. A cell-mediated response may refer to an immune response that does not involve antibodies but rather involves the activation of macrophages, natural killer cells (NK), antigen-specific cytotoxic T-lymphocytes, and the release of various cytokines in response to an antigen. Cell-mediated immunity may generally refer to some Th cell activation, Tc cell activation and T-cell mediated responses.

[00117] Antigen presenting cells (APCs) such as dendritic cells (DCs) take up polypeptides and present epitopes of such polypeptides within the context of the DC MHC I and II complexes to other immune cells including CD4⁺ and CD8⁺ cells. An “MHC complex” or “MHC receptor” is a cell-surface receptor encoded by the major histocompatibility complex of a subject, with a role in antigen presentation for the immune system. MHC proteins may be found on several cell types, including antigen presenting cells (APCs) such as macrophages or dendritic cells (DCs), or other cells found in a mammal. Epitopes associated with MHC Class I may range from about 8- 11 amino acids in length, while epitopes associated MHC Class II may be longer, ranging from about 9-25 amino acids in length.

[00118] Accordingly, an “immune response” includes, but is not limited to, one or more of the following responses in a mammal: induction of antibodies, B cells, T cells (including helper T cells, suppressor T cells, cytotoxic T cells, $\gamma\delta$ T cells) directed specifically to the antigen(s) in a composition or vaccine, following administration of the composition or vaccine. An immune response to a composition or vaccine thus generally includes the development in the host mammal of a cellular and/or antibody-mediated response to the composition or vaccine of interest. In general, the immune response will result in prevention or reduction of infection by a *Chlamydia* spp. pathogen. In some embodiments, an immune response refers specifically to a cell-mediated response. In some embodiments, an immune response refers specifically to a cell-mediated response against a *Chlamydia* spp. pathogen. In some embodiments, the compounds and compositions described herein may be used in the induction of a cell-mediated immune response against a *Chlamydia* spp. pathogen.

[00119] Vaccines according to the disclosure may include the polypeptides and nucleic acid molecules described herein, or immunogenic fragments thereof, and may be administered using any form of administration known in the art or described herein.

[00120] An “immunogenic fragment” of a polypeptide or nucleic acid molecule refers to an epitope or amino acid or nucleotide sequence that elicits an immune response. The term “epitope” refers to an arrangement of amino acids in a protein or modifications thereon (for example glycosylation). The amino acids may be arranged in a linear fashion, such as a primary sequence of a protein, or may be a secondary or tertiary arrangement of amino acids in close proximity once a protein is partially or fully configured. Epitopes may be specifically bound by an antibody, antibody fragment, peptide, peptidomimetic or the like, or may be specifically bound by a ligand or held within an MHC I or MHC II complex. Epitopes may be present in a larger fragment or sequence of a *Chlamydia* protein as described herein.

[00121] Thus, an immunogenic fragment may include, without limitation, any portion of any of the sequences described herein, or a sequence substantially identical thereto, that includes one or more epitopes (the site recognized by a specific immune system cell, such as a T cell). For example, an immunogenic fragment may include, without limitation, peptides of any value between 6 and 60, or over 60, amino acids in length, e.g., peptides of any value between 10 and 20 amino acids in length, or between 20 and 40 amino acids in length, derived from any one or more of the sequences described herein. Such fragments may be identified using standard methods known to those of skill in the art, such as epitope mapping techniques or antigenicity or hydropathy plots using, for example, the Omega version 1.0 program from Oxford Molecular Group (see, for example, U. S. Patent No. 4,708,871)(76, 77, 81, 92, 73,). An epitope may have a range of sizes - for example a linear epitope may be as small as two amino acids, or may be larger, from about 3 amino acids to about 20 amino acids. In some embodiments, an epitope may be from about 5 amino acids to about 10 or about 15 amino acids in length. An epitope of secondary or tertiary arrangements of amino acids may encompass as few as two amino acids, or may be larger, from about 3 amino acids to about 20 amino acids. In some embodiments, a secondary or tertiary epitope may be from about 5 amino acids to about 10 or about 15 amino acids in proximity to some or others within the epitope. In some embodiments, a fusion protein as described herein will contain multiple epitopes; in such cases, an immunogenic fragment may

include a significant portion of a whole protein that is present in a fusion protein, as described herein.

[00122] In some embodiments, a vaccine includes a suitable carrier, such as an adjuvant, which is an agent that acts in a non-specific manner to increase the immune response to a specific antigen, or to a group of antigens, enabling the reduction of the quantity of antigen in any given vaccine dose, or the reduction of the frequency of dosage required to generate the desired immune response.

[00123] Exemplary adjuvants include, without limitation, aluminum hydroxide, alum, Alhydrogel™ (aluminum trihydrate) or other aluminum-comprising salts, virosomes, nucleic acids comprising CpG motifs such as CpG oligodeoxynucleotides (CpG-ODN), squalene, oils, MF59 (Novartis), LTK63 (Novartis), QS21, various saponins, virus-like particles, monomycolyl glycerol (MMG), monophosphoryl-lipid A (MPL)/trehalose dicorynomycolate, toll-like receptor agonists, copolymers such as polyoxypropylene and polyoxyethylene, AbISCO, ISCOM (AbISCO-100), montanide ISA 51, Montanide ISA 720 + CpG, *etc.* or any combination thereof. In some embodiments, exemplary adjuvants include a cationic lipid delivery agent such as dimethyldioctadecylammonium Bromide (DDA) together with a modified mycobacterial cord factor trehalose 6,6'-dibehenate (TDB) (DDA/TDB), DDA/MMG or DDA/MPL or any combination thereof. Liposomes with or without incorporated MPL further been adsorbed to alum hydroxide may also be useful, see, for example US Patent Nos. 6,093,406 and 6,793,923 B2. In some embodiments, exemplary adjuvants include prokaryotic RNA. In some embodiments, exemplary adjuvants include those described in for example US Patent Publication 2006/0286128 In some embodiments, exemplary adjuvants include DDA/TDB, DDA/MMG or DDA/MPL and prokaryotic RNA.

[00124] In some embodiments, vaccine compositions include, without limitation, fusion proteins as described herein in combination with DDA/TDB, DDA/MMG or DDA/MPL and, optionally, prokaryotic RNA.

[00125] In alternative embodiments, vaccine compositions include, without limitation, fusion proteins as described herein, in admixture with MOMP, in combination with DDA/TDB, DDA/MMG or DDA/MPL and, optionally, prokaryotic RNA.

[00126] In alternative embodiments, vaccine compositions include, without limitation, fusion proteins as described herein, in admixture with MOMP, in combination with DDA/TDB, DDA/MMG or DDA/MPL and, optionally, prokaryotic RNA.

[00127] In alternative embodiments, vaccine compositions include a) a recombinant fusion protein including the polypeptide sequences of the *Chlamydia* proteins PmpG, PmpE, PmpF and PmpH or immunogenic fragment thereof, b) the adjuvant DDA/MPL and c) prokaryotic RNA.

[00128] In alternative embodiments, vaccine compositions include a) a recombinant fusion protein including the polypeptide sequences of the *Chlamydia* proteins PmpG, PmpE, PmpF and PmpH or immunogenic fragment thereof, b) the adjuvant DDA/TDB and c) prokaryotic RNA.

[00129] In alternative embodiments, vaccine compositions include a) a recombinant fusion protein including the polypeptide sequences of the *Chlamydia* proteins PmpG, PmpE, PmpF and PmpH or immunogenic fragment thereof and b) the adjuvant DDA/MPL.

[00130] In alternative embodiments, vaccine compositions include a) a recombinant fusion protein including the polypeptide sequences of the *Chlamydia* proteins PmpG, PmpE, PmpF and PmpH and b) the adjuvant DDA/TDB.

[00131] In alternative embodiments, vaccine compositions include a formulation comprising a) a combination (admixture) of two separate fusion proteins, such as PmpG/PmpH and PmpE/PmpF respectively, or immunogenic fragments thereof; b) the adjuvant DDA/MPL and c) prokaryotic RNA.

[00132] In alternative embodiments, vaccine compositions include a formulation comprising a) a combination (admixture) of two separate fusion proteins, between PmpG/PmpH and PmpE/PmpF respectively, or immunogenic fragments thereof; b) the adjuvant DDA/TDB and c) prokaryotic RNA.

[00133] In alternative embodiments, vaccine compositions include a formulation comprising a) a combination (admixture) of two separate fusion proteins, between PmpG/PmpH and PmpE/PmpF respectively or immunogenic fragments thereof; and b) the adjuvant DDA/MPL.

[00134] In alternative embodiments, vaccine compositions include a formulation comprising a) a combination (admixture) of two separate fusion proteins, between PmpG/PmpH and PmpE/PmpF respectively or immunogenic fragments thereof; and b) the adjuvant DDA/TDB.

[00135] In some embodiments, a composition as described herein may be used to inoculate a test subject, for example, an animal model of *Chlamydia* infection, such as a mouse. Methods of experimentally inoculating experimental animals are known in the art. For example, testing a *Chlamydia* spp. vaccine may involve infecting previously inoculated mice intranasally with an inoculum comprising an infectious *Chlamydia* strain, and assessing for development of pneumonia. An exemplary assay is described in, for example Tammiruusu et al 2007. Vaccine 25(2):283-290, or in Rey-Ladino et al 2005. Infection and Immunity 73:1568-1577. It is within the ability of one of skill in the art to make any minor modifications to adapt such an assay to a particular pathogen model.

[00136] In another example, testing a *Chlamydia* vaccine may involve serially inoculating female mice with a candidate T-cell antigen cloned and expressed as described above. A series of inoculations may comprise two, three or more serial inoculations. The candidate T-cell antigens may be combined with an adjuvant. About three weeks following the last inoculation in the series, mice may be treated subcutaneously with 2.5 mg Depo-Provera and one week later both naïve and immunized mice may be infected intravaginally with *Chlamydia*. The course of infection may be followed by monitoring the number of organisms shed at 2 to 7 day intervals for 6 weeks. The amount of organism shed may be determined by counting *Chlamydia* inclusion formation in HeLa cells using appropriately diluted vaginal wash samples. Immunity may be measured by the reduction in the amount of organism shed in immunized mice compared to naïve mice.

[00137] In some embodiments, the present disclosure also provides for a composition for inducing an immune response in a subject. Compositions according to various embodiments of the invention may be used as a vaccine, or in the preparation of a vaccine.

[00138] In another embodiment, a fusion protein as described herein may be used in the preparation of a medicament such as a vaccine composition, for the prevention or treatment of a

Chlamydia infection. Treatment or treating includes prevention unless prevention is specifically excluded, as in alternative embodiments of the disclosure. Treatment or treating refers to fully or partially reducing severity of a *Chlamydia* infection and/or delaying onset of a *Chlamydia* infection, and/or reducing incidence of one or more symptoms or features of a *Chlamydia* infection, including reducing survival, growth, and/or spread of a *Chlamydia* spp., such as *C. muridarum* or *C. trachomatis*. In some embodiments, treatment includes inducing immunity in an animal subject. In alternative embodiments, treatment includes inducing cellular immunity in an animal subject. Treatment may be administered to a subject who does not exhibit signs of a disease, disorder, and/or condition (an asymptomatic subject), and/or to a subject who exhibits only early signs of a disease, disorder, and/or condition for the purpose of decreasing the risk of developing pathology associated with the disease, disorder, and/or condition. In some embodiments, treatment includes delivery of an immunogenic composition (*e.g.*, a vaccine) to a subject.

[00139] The composition or medicament may be used for the prevention or treatment of a *Chlamydia* infection in a subject having, or suspected of having such an infection. In some embodiments, the composition or medicament may be used for the prevention or treatment of urogenital or ocular conditions. Urogenital conditions include without limitation urethritis, cervicitis, pharyngitis, proctitis, epididymitis, and prostatitis. Ocular conditions include without limitation trachoma and conjunctivitis.

[00140] In some embodiments, a fusion protein described herein, alone or in combination, may be used to diagnose the presence of a *Chlamydia* infection in a subject for example even in an asymptomatic subject. Diagnosis may be determine T cell responses and may be performed using any technique described herein or known to the skilled person.

[00141] Articles of Manufacture

[00142] Also provided is an article of manufacture, comprising packaging material and a composition comprising one or more fusion proteins as provided herein. The composition includes a physiologically or pharmaceutically acceptable excipient, and may further include an adjuvant, a delivery agent, or an adjuvant and a delivery agent, and the packaging material may include a label which indicates the active ingredients of the composition (*e.g.* the fusion protein,

adjuvant or delivery agent as present). The label may further include an intended use of the composition, for example as a therapeutic or prophylactic composition to be used in the manner described herein.

[00143] Kits

[00144] In another embodiment, a kit for the preparation of a medicament, comprising a composition comprising one or more fusion proteins as provided herein, along with instructions for its use is provided. The instructions may comprise a series of steps for the preparation of the medicament, the medicament being useful for inducing a therapeutic or prophylactic immune response in a subject to whom it is administered. The kit may further comprise instructions for use of the medicament in treatment for treatment, prevention or amelioration of one or more symptoms of a Chlamydia infection, and include, for example, dose concentrations, dose intervals, preferred administration methods or the like.

[00145] The present invention will be further illustrated in the following examples.

EXAMPLES

[00146] EXAMPLE 1

[00147] Molecular cloning, expression and purification of recombinant fusion proteins

[00148] PmpE, pmpF, pmpG, and pmpH DNA fragments were generated by PCR using genomic DNA isolated from *C. muridarum*. The DNA fragments generated by PCR were cloned stepwise into pET32a expression vector (GE Healthcare) after restriction enzyme digestion using standard molecular biology techniques. For all four pmp genes, only the regions that encode passenger domain of the Pmp protein were cloned into the vector for expression. The amino acid sequences of *C. muridarum* PmpE, PmpF, PmpG and PmpH proteins are shown in Figure 1. Passenger domain portions of PmpE, PmpF, PmpG and PmpH, between amino acid 18 to 575, 20 to 575, 25 to 555, and 27 to 575, respectively, of the whole proteins were used. A C-terminal His-tag was introduced to all the fusion proteins. Plasmids containing the pmp genes were transformed into the *E. coli* strain BL21(DE3) (Stratagene) where protein expression was carried

out by inducing the lac promoter for expression of T7 RNA polymerase using isopropyl-b-D-thiogalactoside pyranoside.

[00149] The soluble expressed fusion proteins were purified from *E. coli* lysates by affinity chromatography using glutathione sepharose 4 fastflow purification system (GE Healthcare) using the N-terminal GST-tag. Insoluble fusion proteins were purified by nickel column using the His bind purification system (Qiagen) using the C-terminal His-tag and refolded by removing urea stepwise. LPS removal of these proteins was carried out by adding 0.1% Triton-114 in one of the wash buffers during purification. The amino acid sequences of recombinant fusion proteins between PmpE and PmpF (*i.e.* PmpE-PmpF) and PmpG and PmpH (*i.e.* PmpG-PmpH) are shown in Figure 2.

[00150] Protection against *Chlamydia* genital tract infection in mice immunized with both individual protein/antigens, as well as in combinations of proteins formulated with different adjuvants, was evaluated. More specifically, groups of eight C57BL/6 mice were immunized 3 times at 2-week interval with *Chlamydia* proteins PmpG (G), PmpF (F), MOMP (M), either mixed or fused formulated with DDA/TDB (D/T) adjuvant. A group of mice immunized with phosphatebuffered saline (PBS) was used as a negative control. Another group of mice infected once with 1,500 inclusion-forming units (IFU) of live *C. muridarum* elementary bodies (EB) intranasally (in) was used as a positive control. The experimental groups were as follows: 1) PBS (negative control), 2) PmpG + PmpF mixed proteins + DDA/TDB, 3) PmpG-PmpF fusion protein + DDA/TDB, 4) PmpG + MOMP mixed proteins + DDA/TDB, 5) PmpG-MOMP fusion protein + DDA/TDB and 6) Live EB (in) 1500 IFU (positive control). All groups were intravaginally challenged with 1,500 IFU of live *C. muridarum* EBs 4 weeks after the final immunization or 8 weeks after infection. Cervicovaginal washes were taken at day 6 and day 12, and bacterial titers were measured on HeLa 229 cells.

[00151] The results indicated that PmpG-PmpF and PmpG-MOMP fusion proteins formulated in the adjuvant DDA/TDB were protective against *Chlamydia* genital tract infection when evaluated at days 6 and 12 (**Figures 3A-B**).

[00152] EXAMPLE 2

[00153] To evaluate protective effect against *Chlamydia muridarum* genital tract infection, C57, Balb/c or C3H mice were immunized with PmpE, F, G, H plus MOMP (either individual proteins or fusion proteins), as in the following groups.

[00154] C57 mice: (1) PmpE+PmpF+PmpG+PmpH+MOMP (mixed); (2) PmpE-F fusion+PmpG-H fusion+MOMP (fusion); (3) PBS; (4) Live EB.

[00155] Balb/c mice: (5) PmpE+PmpF+PmpG+PmpH+MOMP (mixed); (6) PmpE-F fusion+PmpG-H fusion+MOMP (fusion); (7) PBS; (8) Live EB.

[00156] C3H mice: (9) PmpE+PmpF+PmpG+PmpH+MOMP (mixed); (10) PmpE-F fusion+PmpG-H fusion+MOMP (fusion); (11) PBS; (12) Live EB.

[00157] Mice were immunized 3 times at 2-week intervals with the fused proteins formulated with DDA/MPL. PBS was used as the negative control and mice infected once with 1,500 inclusion-forming units (IFU) of live *C. muridarum* elementary bodies (EB), administered intranasally, were used as positive controls. All groups were intravaginally challenged with 1,500 IFU of live *C. muridarum* elementary bodies 4 weeks after the final immunization or 8 weeks after live Chlamydia infection. Cervicovaginal washes were taken at day 12 and bacterial titers were measured on HeLa 229 cells to assess protection.

[00158] Two weeks after the final immunization, mouse splenocytes were harvested and stimulated with HK-EB (5×10^5 IFU/ml). IFN- γ - or TNF- α -producing CD4 T cells were analyzed by multiparameter flow cytometry. The results are expressed as means $\pm$ SEM for groups of four mice (Figure 4).

[00159] *C. muridarum* individual antigen-specific IFN- γ responses in C57, Balb/c, or C3H mice after immunization with PmpE, F, G, H plus MOMP either as individual (mixed) or as fusion formats were determined by ELISPOT assay. Two weeks after the final immunization, mouse splenocytes were harvested and stimulated *in vitro* for 20 h with 5×10^5 IFU/ml of HK-

EB, or 1 µg/ml of indicated *Chlamydia* recombinant protein respectively. The results are expressed as means ± SEM for groups of four mice (Figures 5A-C).

[00160] Vaccine-elicited protection against *Chlamydia muridarum* genital tract infection in C57, Balb/c, or C3H mice after immunization with PmpE, F, G, H plus MOMP, either as individual(mixed) or as fusion formats, was evaluated. Four weeks after the final immunization, mice were challenged intravaginally with 1,500 IFU of *C. muridarum*. Cervicovaginal washes were taken at day 3, day 6, day 13 and day 13 after infection, and bacterial shedding was measured on HeLa 229 cells. Mice immunized with PBS were used as a negative control, and mice infected with 1,500 IFU of live *C. muridarum* intravaginally were used as a positive control. *** *P* value <0.001 in comparison with the PBS group (Figures 6A-C).

[00161] Vaccine-elicited protection against *Chlamydia muridarum* genital tract infection in C57 (A), Balb/c (B), or C3H (C) mice after immunization with PmpE, F, G, H plus MOMP, either as individual(mixed) or as fusion formats, was evaluated. Four weeks after the final immunization, mice were challenged intravaginally with 1,500 IFU of *C. muridarum*. Cervicovaginal washes were taken at day 3, day 6, day 13 and day 13 after infection, and bacterial shedding was measured on HeLa 229 cells. Mice immunized with PBS were used as a negative control, and mice infected with 1,500 IFU of live *C. muridarum* intravaginally were used as a positive control. The mean Chlamydia IFU ± SD is indicated (Figures 7A-C).

[00162] Different mouse strains showed equal levels of protective effect against *Chlamydia muridarum* genital tract infection after immunization with PmpE, F, G, H plus MOMP either as individual or as fusion formats.

[00163] All citations are hereby incorporated by reference.

[00164] The present invention has been described with regard to one or more embodiments. However, it will be apparent to persons skilled in the art that a number of variations and modifications can be made without departing from the scope of the invention as defined in the claims.

WHAT IS CLAIMED IS:

1. An immunogenic composition comprising a fusion protein which comprises at least two *Chlamydia* proteins selected from: Polymorphic membrane protein G (PmpG), Polymorphic membrane protein F (PmpF), Polymorphic membrane protein E (PmpE), Polymorphic membrane protein H (PmpH), Ribosomal protein L6 (RplF), Anti-anti-sigma factor (Aasf), Translocated actin-recruiting phosphoprotein (Tarp), hypothetical protein corresponding to locus tag CT143/TC0420, metalloprotease, insulinase family (CT806/TC0190), hypothetical protein corresponding to locus tag CT538/TC0825, hypothetical protein corresponding to locus tag CT017/TC0285, hypothetical protein corresponding to locus tag CT619, or MOMP, or an immunogenic fragment thereof, together with a physiologically acceptable carrier.
2. The composition of claim 1 wherein the fusion protein comprises PmpG and MOMP.
3. The composition of claim 1 wherein the fusion protein comprises PmpG and PmpF.
4. The composition of claim 1 wherein the fusion protein comprises PmpG and PmpH.
5. The composition of claim 1 wherein the fusion protein comprises PmpE and PmpF.
6. The composition of any one of claims 1 to 5 further comprising an adjuvant.
7. The composition of claim 6 wherein the adjuvant is selected from DDA/TDB, DDA/MMG or DDA/MPL.
8. A method for eliciting an immune response against a *Chlamydia* spp., or component thereof, in an animal comprising administering to the animal an effective amount of the composition of any one of claims 1 to 7, thereby eliciting an immune response in the animal.
9. The method of claim 8 wherein the immune response is a cellular immune response.
10. A method for treating or preventing infection by a *Chlamydia* spp. in an animal comprising administering to the animal an effective amount of the composition of any one of claims 1 to 7, thereby treating or preventing infection by the *Chlamydia* spp. in the animal.
11. The method of any one of claims 8 to 10 wherein the *Chlamydia* spp. is a *Chlamydia trachomatis* or a *Chlamydia muridarum*.
12. The method of any one of claims 8 to 11 wherein the animal is a human.
13. Use of the composition of any one of claims 1 to 7 for eliciting an immune response against a *Chlamydia* spp., or component thereof, in an animal.

14. The use of claim 13 wherein the immune response is a cellular immune response.
15. Use of the composition of any one of claims 1 to 7 for treating or preventing infection by a *Chlamydia* spp. in an animal.
16. The use of any one of claims 13-15 wherein the *Chlamydia* spp. is a *Chlamydia trachomatis* or a *Chlamydia muridarum*.
17. The use of any one of claims 13-16 wherein the animal is a human.

A. *Chlamydia muridarum* PmpE (PmpE/F-1) TC0261

MKKLFFFVLIGSSILGFTREVPPSILLKPILNPHYMTGLFFPKVNLLGDTHNLTDYHLDN
 LKCILACLQRTPEGAFTVTDYLGFSDTQKDGI FCFKNLTPESGGVIGSPTQNTPTIKI
 HNTIGPVL FENNTCHRLWTQTDPENEGNKAREGGAIHAGDVYISNNQNLVGF IKNFAYVQ
 GGAI SANTFAYKENKSSFLCLNNSCIQTKTGKGGAIVYSTSCSFENNNKDLLFIQNSGC
 AGGAIFSP TCSLIGNQGDIVFYSNHGFKNV DNATNESGDGGAIKVTTRLDITNNGSQIFF
 SDNISRNFGGAIHAPCLHLVGN GPTYFTNNIANHTGGAIYITGTETSKISADHHAIIFDN
 NISANATNADGSSSNTNPPHRNAITMDNSAGGIELGAGKSQNLI FYDPIQVTNAGVTVD F
 NKDASQTGCVVFSGATVLSADISQANLQTKTPATLTLSHGLLCIEDRAQLTVNNFTQTGG
 IVALGN GAVLSSYQHSTTDATQTPPTTTT DASVTLNHIGLNLPSILKDGAE MPLLWVEP
 ISTTQGN TTTTYS DTAASFSLNGATLSLIDEDGNSPYENTDLSRALYAQPMLAISEASDN
 QLQSESMDFSKVNVPHYGWQGLWTGWAKTENPTTTPPATITDPKKANQFHRTLLLTWLP
 AGYIPSPKHKSPLIANTLWGNILFATENLKNSSGQELLDRPFWGITGGGLGMMVYQEP RK
 DHPGFHMTSGYSAGMITGNTHTFSLRFSQSYTKLNERYAKNYVSSKNYS CQGEMLLSLQ
 EGLMLTKLIGLYSYGNHNSHHFYTQGEDLSSQGEFHSQTFFGAVFFDLPLKPFGRTHILT
 APFLGAIGMYSKLSSFTVEVGAYPRFTFITETPLINVLPIGVKGSFMNATHRPQAWTVELA
 YQPVLYRQEPSISTQLLAGKGMWFGHGSPASRHALAYKISQKTQLLR FATLQLQYHGYYS
 SSTFCNYLNGEVSLRF (SEQ ID NO:1)

B. *Chlamydia trachomatis* PmpE CT869

MKKAFFFFLIGNSLSGLAREVPSRI FLMPNSVPDPTKESLSNKISLTGDTHNL TN CYLDN
 LRYILAILQKTPNEGA AVTITDYL SFFDTQKEGIYFAKNLTPESGGAI GYASPN SPTVEI
 RDTIGPVI FENNTCCRLFTWRNPYAADKIREGGAIHAQNLYINHNDVVGFMKNFSYVQG
 GAISTANTFV VSENQSCFLFMDNICIQTNTAGKGGAIYAGTSNSFESNNCDLFFINNACC
 AGGAIFSPICSLTGNRGNIVFYNNRCFKNVETASSEASDGAIKVTTRLDVTGNRGRIFF
 SDNITKNYGGAIYAPVVT LVDNGPTYFINNIANNKGGAIYIDGTSNSKISADRHAII FNE
 NIVTNVTNANGTSTSANPPRRNAITVASSSGEILLGAGSSQNLI FYDPIEVS NAGVSVSF
 NKEADQTGSVVFSGATVNSADFHQRNLQTKTPAPLTLSNGFLCIEDHAQLTVNRFTQTGG
 VVSLGN GAVLSCYKNGTGDSASNASITLKHIGLNLSSILKSGAEI PLLWVEPTNNSNNYT
 ADTAATFSLSDVKLSLIDDYGNSPYESTDLTHALSSQPMLSISEASDNQLQSENIDFSGL
 NVPHYGWQGLWTGWAKTQDPEPASSATITDPQKANRFHRTLLLTWLPAGYVPSPKHRSP
 LIANTLWGNMLLATESLKNSAELTPSGHPFWGITGGGLGMMVYQDPRENHPGFHMRSSGY
 SAGMIAGQTHTFSLKFSQTYTKLNERYAKNNVSSKNYS CQGEMLFSLQEGFLLTKLVGLY
 SYGDHNCHHFY TQGENLTSQGTFRSQTMGAVFFDLPMKPFGSTHILTAPFLGALGIYSS
 LSHFTEVGAYPRSFSTKTPLINVLVPIGVKGSFMNATHRPQAWTVELAYQPVLYRQEPGI
 AAQLLASKGIWFGSGSPSSRHAMS YKISQQTQPLSWLTLHFQYHGFYSSSTFCNYLNGEI
 ALRF (SEQ ID NO:2)

FIGURE 1-1

C. Chlamydia muridarum pmpE (pmpE/F-1) TC0261

ATGAAAAAACTGTTCTTTTTTGTCTTATTGGAAGCTCTATACTGGGATTTACTCGAGAA
 GTCCCTCCTTCGATTCTTTTAAAGCCTATACTAAATCCATACCATATGACCGGGTTATTT
 TTTCCCAAGGTTAATTTGCTTGGAGACACACATAATCTCACTGATTACCATTTGGATAAT
 CTAAAATGCATTCTGGCTTGCCTACAAAGAACTCCTTATGAAGGAGCTGCTTTCACAGTA
 ACCGATTACTTAGGTTTTTCAGATACACAAAAGGATGGTATTTTTTGTTTTAAAAATCTT
 ACTCCAGAGAGTGGAGGGGTTATTGGTTCCCCAACTCAAAACACTCCTACTATAAAAAATT
 CATAATACAATCGGCCCGTTCTTTTCGAAAATAATACCTGTCATAGACTGTGGACACAG
 ACCGATCCCGAAAATGAAGGAAACAAAGCACGCGAAGGCGGGGCAATTCATGCTGGGGAC
 GTTTACATAAGCAATAACCAGAACCTTGTGCGATTCTATAAAGAACTTTGCTTATGTTCAA
 GGTGGAGCTATTAGTGCTAATACTTTTGCCTATAAAGAAAATAAATCGAGCTTTCTTTGC
 CTAAATAACTCTTGTATACAACTAAGACGGGAGGGAAAGGTGGTGTCTATTTACGTTAGT
 ACGAGCTGCTCTTTCGAGAACAATAACAAGGATCTGCTTTTCATCCAAAACCTCCGGCTGT
 GCAGGAGGAGCTATCTTCTCTCAACCTGTTCTCTAATAGGAAACCAAGGAGATATTGTT
 TTTTACAGCAACCACGGTTTTTAAAAATGTTGATAATGCAACTAACGAATCTGGGGATGGA
 GGAGCTATTAAAGTAACTACCCGCTTGGACATCACCAATAATGGTAGTCAAATCTTTTTT
 TCTGATAATATCTCAAGAAATTTTGGAGGAGCTATTCATGCTCCTTGTCTTCATCTTGTT
 GGTAATGGGCCAACCTATTTTACAAACAATATAGCTAATCACACAGGTGGGGCTATTTAT
 ATAACAGGAACAGAAACCTCAAAGATTTCTGCAGATCACCATGCTATTATTTTTGATAAT
 AACATTTCTGCAACGCCACCAATGCGGACGGATCTAGCAGCAACACTAATCCTCCTCAC
 AGAAATGCGATCACTATGGACAATTCCGCTGGAGGAATAGAACTTGGTGCAGGGAAGAGC
 CAGAATCTTATTTCTATGATCCTATTCAAGTGACGAATGCTGGAGTTACCGTAGACTTC
 AATAAGGATGCCTCCCAACCGGATGTGTAGTTTTCTCTGGAGCGACTGTCTTTCTGCA
 GATATTTCTCAGGCTAATTTGCAAACTAAAACACCTGCAACGCTTACTCTCAGTCACGGT
 CTTCTGTGTATCGAAGATCGTGCTCAGCTCACAGTGAACAATTTTACACAAACAGGAGGG
 ATTGTAGCCTTAGGAAATGGAGCAGTTTTTAAGCAGCTACCAACACAGCACTACAGACGCC
 ACTCAAACCTCCCCCTACAACCACCACTACAGATGCTTCCGTAACCTCTAATCACATTGGA
 TTAAATCTCCCCTCTATTCTTAAGGATGGAGCAGAGATGCCTCTATTATGGGTAGAACCT
 ATAAGCACAACCTCAAGGTAACACTACAACATATACGTGAGATACCGCGGCTTCCTTCTCA
 TTAAATGGAGCCACACTCTCTCTCATTGATGAAGATGGAAATCTCCCTATGAAAACACG
 GACCTCTCTCGTGCATTGTACGCTCAACCTATGCTAGCAATTTCTGAGGCCAGTGATAAC
 CAATTGCAATCCGAAAGCATGGACTTTTCTAAAGTTAATGTTCCCTCACTATGGATGGCAA
 GGACTTTGGACCTGGGGGTGGGCAAAAACCTGAAAATCCAACAACAACCTCCTCCAGCAACA
 ATTACTGATCCGAAAAAAGCTAATCAGTTTCATAGAACCTTTATTATTAACGTGGCTCCCT
 GCTGGTTATATCCCCAGCCCTAAACATAAAAGCCCTTTAATAGCTAATACCTTGTGGGGG
 AATATACTTTTTGCAACGGAAAACCTAAAAAATAGCTCAGGGCAAGAACTTCTTGATCGT
 CTTTCTGGGGAATTACAGGAGGGGGCTTGGGGATGATGGTCTATCAAGAACCTAGAAAA
 GACCATCCTGGATTCCACATGCATACCTCCGGATATTACAGCAGGAATGATTACAGGAAAC
 ACACATACCTTCTCATTACGATTACGCCAGTCCTATACAAAACCTCAATGAACGTTATGCC
 AAGAAGTATGTGTCTTCTAAAAATTACTCTTGCCAAGGGGAAATGCTTTTGTCTTACAA
 GAAGGACTCATGCTGACTAAACTAATTGGTCTCTATAGTTATGGGAATCACAAACAGCCAC
 CATTTCTATACCCAAGGAGAAGACCTATCGTCTCAAGGGGAGTTCCATAGTCAGACTTTT
 GGAGGGGCTGTCTTTTTTGTCTACCTCTGAAACCTTTTGGGAAGAACACACATACTTACA
 GCTCCTTTCTTAGGTGCCATTGGTATGTATTCTAAGCTGTCTAGCTTTACAGAAGTAGGA
 GCCTATCCAAGAACCTTTATTACAGAAACGCCTTTAATCAATGTCCTGATTCTATCGGA
 GTAAAAGGTAGCTTCATGAATGCCACCCATAGACCTCAGGCCTGGACTGTAGAGCTTGCT
 TACCAACCTGTTCTTTACAGACAAGAACCTAGTATCTCTACCCAATTACTCGCTGGTAAA
 GGTATGTGGTTTGGGCATGGAAGTCCTGCATCTCGCCACGCTCTAGCTTATAAAATTTCA
 CAGAAAACACAGCTTTTGCATTTGCAACACTTCAACTCCAGTATCACGGATACTATTCTG
 TCTTCCACTTTCTGTAATTATCTGAATGGAGAGGTATCTTTACGTTTCTAA
 SEQ ID NO:3)

FIGURE 1-2

D. *Chlamydia trachomatis* *pmpE* CT869

ATGAAAAAAGCGTTTTTCTTTTCTTTATCGGAAACTCCCTATCAGGACTAGCTAGAGAG
 GTTCCTTCTAGAATCTTTCTTATGCCCCAACTCAGTTCCAGATCCTACGAAAGAGTCGCTA
 TCAAATAAAATTAGTTTGACAGGAGACACTCACAATCTCACTAACTGCTATCTCGATAAC
 CTACGCTACATACTGGCTATTCTACAAAAAACTCCCAATGAAGGAGCTGCTGTCACAATA
 ACAGATTACCTAAGCTTTTTTGATACACAAAAAGAAGGTATTTATTTTGCAAAAAATCTC
 ACCCCTGAAAGTGGTGGTGGCGATTGGTTATGCGAGTCCCAATTCTCCTACCGTGGAGATT
 CGTGATACAATAGGTCCTGTAATCTTTGAAAATAATACTTGTTCAGACTATTTACATGG
 AGAAATCCTTATGCTGCTGATAAAATAAGAGAAGGCGGAGCCATTCATGCTCAAAATCTT
 TACATAAATCATAATCATGATGTGGTCGGATTTATGAAGAACTTTTCTTATGTCCAAGGA
 GGAGCCATTAGTACCGCTAATACCTTTGTTGTGAGCGAGAATCAGTCTTGTTTTCTCTTT
 ATGGACAACATCTGTATTCAAACCTAATACAGCAGGAAAAGGTGGCGCTATCTATGCTGGA
 ACGAGCAATTCTTTGAGAGTAATAACTGCGATCTCTTCTTCATCAATAACGCCTGTTGT
 GCAGGAGGAGCGATCTTCTCCCCTATCTGTTCTCTAACAGGAAATCGTGGTAACATCGTT
 TTCTATAACAATCGCTGCTTTAAAAATGTAGAAACAGCTTCTTCAGAAGCTTCTGATGGA
 GGAGCAATTAAAGTAACTACTCGCCTAGATGTTACAGGCAATCGTGGTAGGATCTTTTTT
 AGTGACAATATCACAAAAAATTATGGCGGAGCTATTTACGCTCCTGTAGTTACCCTAGTG
 GATAATGGCCCTACCTACTTTATAAACAATATCGCCAATAATAAGGGGGGCGCTATCTAT
 ATAGACGGAACCACTAATCCAAAATTTCTGCCGACCGCCATGCTATTATTTTAAATGAA
 AATATTGTGACTAATGTAATAATGCAATGGTACCAGTACGTACGCTAGCTAATCCTCCTAGA
 AGAAATGCAATAACAGTAGCAAGCTCCTCTGGTGAAATTCTATTAGGAGCAGGGAGTAGC
 CAAAATTTAATTTTTTATGATCCTATTGAAGTTAGCAATGCAGGGGTCTCTGTGTCTTCT
 AATAAGGAAGCTGATCAACAGGCTCTGTAGTATTTTCAGGAGCTACTGTTAATTCTGCA
 GATTTTCATCAACGCAATTTACAAACAAAAACACCTGCACCCCTTACTCTCAGTAATGGT
 TTTCTATGTATCGAAGATCATGCTCAGCTTACAGTGAATCGATTACACAAAACCTGGGGGT
 GTTGTCTCTCTGGGAATGGAGCAGTTCTGAGTTGCTATAAAAAATGGTACAGGAGATTCT
 GCTAGCAATGCCTCTATAACACTGAAGCATATTGGATTGAATCTTTCTTCCATTCTGAAA
 AGTGGTGTGAGATTCCTTTATTGTGGGTAGAGCCTACAAATAACAGCAATAACTATACA
 GCAGACTCTCCTTATGAATCCACAGATCTGACCCATGCTCTGTCTATCACAGCCTATGCTA
 TCTATTTCTGAAGCTAGCGATAACCAGCTACAATCAGAAAATATAGATTTTTTCGGGACTA
 AATGTCCCTCATTATGGATGGCAAGGACTTTGGACTTGGGGCTGGGCAAAAACTCAAGAT
 CCAGAACCAGCATCTTCAGCAACAATCACTGATCCACAAAAAGCCAATAGATTTTCATAGA
 ACCTTACTACTAACATGGCTTCCTGCCGGGTATGTTCTAGCCCCAAAACACAGAAGTCCC
 CTCATAGCTAACACCTTATGGGGGAATATGCTGCTTGCAACAGAAAGCTTAAAAAATAGT
 GCAGAGCTGACACCTAGTGGTCATCCTTTCTGGGGAATTACAGGAGGAGGACTAGGCATG
 ATGGTTTACCAAGATCCTCGAGAAAATCATCCTGGATTCCATATGCGCTCTTCCGGATAC
 TCTGCGGGGATGATAGCAGGGCAGACACACACCTTCTCATTGAAATTCAGTCAGACCTAC
 ACCAAACTCAATGAGCGTTACGCAAAAAACAACGTATCTTCTAAAAATTACTCATGCCAA
 GGAGAAATGCTCTTCTCATTGCAAGAAGGTTTCTTGCTGACTAAATTAGTTGGGCTTTAC
 AGCTATGGAGACCATAACTGTCACCATTTCTATACTCAAGGAGAAAAATCTAACATCTCAA
 GGGACGTTCCGCGAGTCAAACGATGGGAGGTGCTGTCTTTTTTGATCTCCCTATGAAACCC
 TTTGGATCAACGCATATACTGACAGCTCCCTTTTTAGGTGCTCTTGGTATTTATTCTAGC
 CTGTCTCACTTTACTGAGGTGGGAGCCTATCCGCGAAGCTTTTCTACAAAGACTCCTTTG
 ATCAATGTCTAGTCCCTATTGGAGTTAAAGGTAGCTTTATGAATGCTACCCACAGACCT
 CAAGCCTGGACTGTAGAATTGGCATAACCAACCGTTCTGTATAGACAAGAACCAGGGATC
 GCAGCCCAGCTCTAGCCAGTAAGGGTATTTGGTTTCGGTAGTGGAAGCCCTCATCGCGT
 CATGCCATGTCTATAAAATCTCACAGCAAACACACCTTTGAGTTGGTTAACTCTCCAT
 TTCCAGTATCATGGATTCTACTCCTCTTCAACCTTCTGTAATTATCTCAATGGGGAAATT
 GCTCTGCGATTCTAG (SEQ ID NO:4)

FIGURE 1-3

E. *Chlamydia muridarum* PmpF (PmpE/F-2) TC0262

MTRRILPLSLVFIPLSCISASETDTLKLPLNLTFFGGREIEFIVTPPSSIAAQYITYANVSN
 YRGNFTISSCTQDQWFSRGLSTTNSSGAFVESMTSFTAIDNADLFFCNNYCTHQGGGGAI
 NATGLISFKNNQNILFYNNNTTIGTQFTGVALRTERNRGGALYGSSIELINNHSLNFINNT
 SGDMGGAVSTIQNLVIKNTSGIVAFENNHTTDHIPNTFATILARGGAVGCQGACEISHNT
 GPVVFNSNYGGYGGAI STGGQCI FRDNKDKLIFINNSALGWHNTSAQNGAVISAGGEFG
 LLNNKGPIYFENNNASYIAGAI SCNNLNFQENGPIYFLNNSALYGGAFHLFASPAANYIH
 TGSGDII FNNNTELSTTGMSAGLRKLFYIPGTTNNNPITLSLGAKKDTRIIFYDLFQWGG
 LKKANTPPENSPHTVTINPSDEFSGAVVFSYKNISSDLQAHMIASKTHNQIKDSPTTLKF
 GTMSIENGAEFEFFNGPLTQESTSLLALGQDSILTVGKDASLTITHLGIILPGLLNDQGT
 TAPRIRVNPQDMTQNTNSNQAPVSTENVATQKIFFSGLVSLVDENYESVYDSCDLSRGKA
 NQPIILHIETTNDQAQLSNDWKNTLNTSLYSLPHYGYQGLWTSNWMTTTTRTVSLTNSTETQT
 ANNSIQEQKNTSETFDSNSTTTAKIPSI RASTGGTTPLATTDVTVTRHSLVSVWTPIGYI
 ADPARRGDLIANNLVSSGRNTTLYLRSLLPDDSWFALQGSAA TLFTKQQRKLDYHGYSSA
 SKGYAISSQASGAHGKFLFSFSQSSDTMKEKRTNNKISSRYYLSALCFEQPMFDRIALI
 GAAAYNYGTHKTYNFYGTKKFSKGNFHS TT LGGSLRCEL RDSMPFQSIMLT PFIQALISR
 TEPASIQEQGLARLFLSKQPHTAVVSPIGIKGVYSSNKWPTVSCMEVAYQPTLYWKRP
 ILNTVLIKNNGSWETTNTPLAKHSFYGRGSSSLKFSYLKLFANYQAQVATSTVSHYMNAG
 GALVF (SEQ ID NO:5)

F. *Chlamydia trachomatis* PmpF CT870

MIKRTSLSFACLSFFYLSTISILQANETDTLQFRRTFSDREIQFVLDPASLITAQNIVL
 SNLQSNGTGACTISGNTQTQIFSNVNTTADSGGAFDMVTTSTASDNANLLFCNNYCTH
 NKGGAIRSGGPPIRFLNNQDVLFYNNISAGAKYVGTGDHNEKNRGGALYATTITLTGNRT
 LAFINNMSGDCGGAISADTQISITDTVKGILFENNHTLNHI PYTQ AENMARGGAICSR RD
 LCSISNNSGPVFNYNQGGKGAISATRCVIDNNKERIIFSNSSSLGWSQSSSASNGGAI
 QTTQGF TLRNNKGSIFYDSNTATHAGGAINCGYIDIRDNGPVYFLNNSAAWGAAFNLSKP
 RSATNYIHTGTGDIVFNNNVFTLDGNLLGKRKLFHINNNEITPYTSLGAKKDTRIIFY
 DLFQWERVKENTSNNPPSPTSRNTITVNPETEFSGAVVFSYNQMSSDIRTLMGKEHNYIK
 EAPTTLKFGTLAIEDDAELEIFNIPFTQNPTSLALGSGATLTVGKHGKLNITNLGVILP
 IILKEGKSPPCIRVNPQDMTQNTGTGQTPSSTSSISTPMIIFNGRLSIVDENYESVYDSM
 DLSRGKAEQLILSIETTNDGQLDSNWQSSLNTSLLSPPHYGYQGLWTPNWITTTYTITLN
 NNSSAPT SATSIAEQKKTSETFTPSNTTTASIPNIKASAGSGSGSASNSGEVTITKHTLV
 VNWAPVG YIVDP IRRGDLIANS LVHSGRNMTMGLRSLLPDNSWFALQGAATTLFTKQQR
 LSYHGYSSASKGYTVSSQASGAHGKFLLSFSQSSDKMKEKETNNRLSSRYYLSALCFEH
 PMFDRIALIGAAACNYGTHNMRSFYGTKKSSKGKFHSTTLGASLRCEL RDSMP LRSIMLT
 PFAQALFSRTEPASIRESGDLARLFTLEQAHTAVVSPIGIKGAYSSDTWPTLSWEMELAY
 QPTLYWKRP LLNTLLIQNNGSWVTTNTPLAKHSFYGRGSHSLKFSHLKLFANYQAQVATSTV
 TVSHYINAGGALVF (SEQ ID NO:6)

FIGURE 1-4

G. *Chlamydia muridarum* *pmpF* (*pmpE/F-2*) TC0262

ATGACTCGCAGAATTCTCCCTCTTTCACTTGTTTTTCATTCCTTTATCTTGATTTTCGGCC
 AGTGAAACCGATACACTCAAACCTCCGAACCTTGACTTTTTGGTGGTAGAGAGATTGAATTC
 ATAGTTACTCCGCCTAGCTCCATTGCTGCTCAATACATCACTTACGCAAATGTTTCTAAT
 TATAGAGGGAACCTTACTATTTCAAGTTGTACGCAGGATCAATGGTTTTCGAGAGGTTTA
 AGCACTACAACTCTAGTGGAGCTTTTGTGAGTCTATGACTTCTTTCACAGCCATTGAC
 AATGCAGACTTGTTTTTTGTAAACAATTATTGCACCCATCAGGGAGGAGGGGGAGCTATA
 AATGCTACAGGCCTTATTAGCTTTAAAAACAACCAAAACATATTGTTCTATAATAATACA
 ACTATTGGAACCTCAATTTACAGGAGTAGCATTAAAGAACCGAAAGGAATCGCGGAGGGGCT
 TTATACGGATCAAGCATCGAGCTAATTAATAATCATAGCTTAAATTTTATCAATAACACT
 TCTGGGGATATGGGAGGAGCCGTATCCACAATCCAAAACCTAGTTATCAAAAATACGTCC
 GGAATAGTTGCTTTTGAAAATAACCATACTACTGATCACATAACCAACACATTTGCTACA
 ATTCTTGCTCGAGGAGGAGCTGTTGGCTGCCAAGGTGCCTGCGAAATCTCACACAATACT
 GGTCCGGTAGTCTTCAATTCCAACTATGGAGGATACGGAGGAGCTATCAGCACCGGGGGA
 CAGTGTATTTTTAGAGATAATAAGGATAAGCTTATTTTTATAAATAATAGCGCTTTAGGA
 TGGCATAACACTAGTGTCAAGGAAATGGAGCAGTTATAAGCGCAGGAGGAGAGTTTGGT
 CTTCTAAATAATAAAGGCCCTATCTACTTTGAGAATAATAATGCCTCATACATAGCAGGA
 GCTATTTCTGCAACAACCTTAATTTTCAAGAAAATGGTCTTATCTATTTTCTTAATAAT
 TCGGCTCTGTATGGAGGAGCTTTTACCTATTTGCAAGCCCAGCTGCGAACTATATTTCAT
 ACTGGCTCTGGGGATATTATCTTCAACAATAATACAGAGCTTTCAACTACCGGAATGTCA
 GCAGGTTTGCGAAAACCTTTTTTATATTCTGGAACAACCAACAATAACCCCTATCACCCCTA
 TCTCTTGGTGCTAAGAAAGATACTCGCATCTATTTTTATGATCTTTTTCAATGGGGAGGC
 TTAaaaaaAGCTAATACACCCCTGAAAATAGCCCGCACACCGTTACCATCAATCCTTCG
 GATGAGTTCTCTGGCGCTGTTGTGTTTTCATACAAAACATATCCAGTGATCTACAAGCT
 CACATGATTGCCAGTAAACTCATAACCAATTAAAGACTCCCCACTACCTTGAAGTTT
 GGGCATAGTCCATAGAAAATGGCGCAGAGTTTGAATTTTTCAATGGCCCTCTTACTCAA
 GAAAGCAGTACCTTCTTGCTTTAGGACAAGATTCTATTCTTACTGTAGGGAAGACGCT
 TCTCTCACTATTACGCATCTTGAATCATTTTCCAGGTCTTCTCAATGACCAAGGTACT
 ACAGCTCCACGTATTCGTGTTAATCCCCAAGATATGACACAGAATACAACTCTAACCAA
 GCTCCAGTAAGCACAGAGAACGTGGCAACTCAAAAGATCTTTTTCTCCGGTCTTGCTCG
 TTAGTAGATGAAAATTACGAATCAGTTTATGACAGCTGCGACCTATCCCAGGAAAAGCA
 AATCAACCCATTTTACATATCGAAACGACTAATGATGCGCAGTTAAGCAATGATTGGAAA
 AACACTCTCAATACCTCGCTATATTCTTTACCACATTACGGATACCAAGGACTCTGGACA
 TCTAATTGGATGACAACCCCGTACGGTCTCTCTTACCAATAGTACAGAGACTCAAACA
 GCCAACAATTCTATTCAAGAACAaaaaaACACTAGCGAACTTTTGATTCCAACAGTACA
 ACTACAGCTAAGATTCTTCCATTAGAGCTTCTACAGGAGGAACAACCTCCTCTTGCTACA
 ACGGACGTAACAGTCACTAGACACTCCTTAGTAGTGAGCTGGACCCCAATCGGATATATA
 GCAGATCCTGCTCGTAGAGGGGATCTTATTGCGAATAATTTAGTGTCTTCTGGAAGAAAT
 ACAACCCTGTACTTACGTTCACTACTACCAGATGACTCTTGGTTTCGCTTTACAAGGATCT
 GCAGCTACGCTATTCACCAACAGCAGAAACGCTTAGATTATCACGGATATTCTTCTGCA
 TCGAAAGGATATGCTATATCTTCAAGCATCAGGAGCACACGGACATAAGTTTTTTATTT
 TCCTTTTCCCAATCCTCCGACACAATGAAAGAGAAACGTACCAATAATAAAATTTCTTCT
 CGTTATTATCTCTCCGCTCTGTGTTTTGAACAACCTATGTTTGATCGTATCGCTCTTATT
 GGAGCAGCTGCTTATAACTATGGTACTCATAAAACATATAACTTCTATGGAACGAAAAAG
 TTTTCTAAAGGGAACCTTCACTCTACGACTCTGGGGGCTCTCTACGTTGCGAACTGCGG
 GATAGTATGCCTTTCCAATCGATTATGTTGACACCATTCAAGCTCTCATCTCCCGA
 ACAGAGCCTGCATCTATCCAGGAGCAGGGAGACCTGGCTAGATTATTTTCGTTAAAACAA
 CCACATACAGCTGTTGTTTCTCCAATAGGAATTAAAGGTGTTTATTCTTCTGAATAAATGG
 CCAACTGTATCCTGCGAAATGGAGGTAGCATAACCAGCCTACTCTTTACTGGAAGCGCCCC
 ATTCTTAATACCGTTTTAATCAAAAACAATGGTTCTTGGGAAACAACAACACTCCTTTA
 GCTAAGCATTCTTTTATGGGAGAGGATCATCTTCTCTAAAATTCTCTTATCTTAACTA
 TTCGCTAATTATCAAGCGCAGGTGGCTACTTCTACAGTCTCACACTACATGAATGCAGGA
 GGGGCTCTGGTCTTTTAA (SEQ ID NO:7)

FIGURE 1-5

ATGATTAAAGGAAGAACTCTCTATCTCTTTGCTTGCTCAGTTTTTTTTTATCTTTTCAACTATA
TCCATTTTTGCAAGCTAATGAAACGGATACGCTACAGTTCCGGCGATTACTTTTTTCGGAT
AGAGAGATTTCAGTTCGTCTAGATCCCGCCTCTTTAATTACCGCCCAAAACATCGTTTTTA
TCTAATTTACAGTCAAACGGAACCGGAGCCTGTACCATTTCAGGCAATACGCAAACCTCAA
ATCTTTTTCTAATTCGGTTAACACCACCGCAGATTCTGGTGGAGCCTTTGATATGGTTACT
ACCTCATTCACGGCCTCTGATAATGCTAATCTACTCTTCTGCAACAACACTACTGCACACAT
AATAAAGGCGGAGGAGCTATTCGTTCCGGAGGACCTATTCGATTCTTAAATAATCAAGAC
GTGCTTTTTTTATAATAACATATCGGCAGGGGCTAAATATGTTGGAACAGGAGATCACAAC
GAAAAAATAGGGGCGGTGCGCTTTATGCAACTACTATCACTTTGACAGGGAATCGAAC
CTTGCTTTTATTAACAATATGTCTGGAGACTGCGGTGGAGCCATCTCTGCTGACACTCA
ATATCAATAACTGATACCGTTAAAGGAATTTTATTTGAAAACAATCACACGCTCAATCAT
ATACCGGTACACGCAAGCTGAAAATATGGCACGAGGAGGAGCAATCTGTAGTAGAAGAGAC
TTGTGCTCAATCAGCAATAATTTCTGGTCCCATAGTTTTTAACATAACCAAGGCGGGAAA
GGTGGAGCTATTAGCGCTACCCGATGTGTTATTGACAATAACAAAGAAAGATCATCTTT
TCAAACAATAGTTCCCTGGGATGGAGCCAATCTTCTTCTGCAAGTAACGGAGGAGCCATT
CAAACGACACAAGGATTTACTTTACGAAATAATAAAGGCTCTATCTACTTCGACAGCAAC
ACTGCTACACACGCGGGGGAGCCATTAAGTGTGGTTACATTGACATCCGAGATAACGGA
CCCGTCTATTTTTCTAAATAACTCTGCTGCCTGGGGAGCGGCCTTTAATTTATCGAAACCA
CGTTCAGCGACAAATTATATCCATACAGGGACAGGCGATATTGTTTTTAATAATAACGTT
GTCTTTACTCTTGACGGTAATTTATTAGGGAAACGGAACTTTTTCATATTAATAATAAT
GAGATAACACCATATACATTGTCTCTCGGCGCTAAAAAGATACTCGTATCTATTTTTTAT
GATCTTTTTCCAATGGGAGCGTGTTAAAGAAAATACTAGCAATAACCCACCATCTCCTACC
AGTAGAAACACCATTACCGTTAACCCGGAACAGAGTTTTCTGGAGCTGTTGTGTTCTCC
TACAATCAAATGTCTAGTGACATACGAACTCTGATGGGTAAAGAACACAATTACATTAAA
GAAGCCCCAACTACTTTTAAATTCGGAACGCTAGCCATAGAAGATGATGCAGAATTAGAA
ATCTTCAATATCCCGTTTTACCCAAAATCCGACTAGCCTTCTTGCTTTAGGAAGCGGCGCT
ACGCTGACTGTTGGAAAGCACGGTAAGCTCAATATTACAAATCTTGGTGTTATTTTACCC
ATTATTTCTCAAAGAGGGGAAGAGTCCGCCTTGATTTCGCGTCAACCCACAAGATATGACC
CAAATACTGGTACCGGCCAAACTCCATCAAGCACAAAGTAGTATAAGCACTCCAATGATT
ATCTTTAATGGGCGCCTCTCAATTGTAGACGAAAATTATGAATCAGTCTACGACAGTATG
GACCTCTCCAGAGGGAAGCAGAACAACCTAATTCTATCCATGAAACCACATAATGATGG
CAATTAGACTCCAATTGGCAAAGTCTCTGAATACTTCTCTACTCTCTCTCCACACTAT
CGGTATCAAGGTCTATGGACTCCTAATTGGATAACAACAACCTATACCATCACGCTTAAT
AATAATTCTTCAGCTCCAACATCTGCTACCTCCATCGCTGAGCAGAAAAAACTAGTGAA
ACTTTTACTCCTAGTAACACAACCTACAGCTAGTATCCCTAATATTAAAGCTTCGCGAGGA
TCAGGCTCTGGATCGGCTTCCAATTCAGGAGAAGTTACGATTACCAAACATACCCTTGTT
GTAAACTGGGCACCAGTCGGCTACATAGTAGATCCTATTCTGATAGGAGATCTGATAGCC
AATAGCTTAGTACATTACGGAAGAAACATGACCATGGGCTTACGATCATTACTCCCGGAT
AACTCTTGGTTTTGCTTTGCAAGGAGCTGCAACAACATTATTTACAAAACAACAAAACGT
TTGAGTTATCATGGCTACTCTTCTGCATCAAAGGGGTATACCGTCTCTTCTCAAGCATCA
GGAGCTCATGGTCATAAGTTTTCTTCTTCTCTCCAGTCATCTGATAAGATGAAAGAA
AAAGAAACAAATAACCGCCTTTCTTCTCGTTACTATCTTTCTGCTTTATGTTTCGAACAT
CCTATGTTTGATCGCATTGCTCTTATCGGAGCAGCAGCTTGCAATTATGGAACACATAAC
ATGCGGAGTTTCTATGGAATAAAAAATCTTCTAAAGGGAAATTTCACTCTACAACCTTA
GGAGCTTCTCTTCGCTGTGAACTACGCGATAGTATGCCTTTACGATCAATAATGCTCACC
CCATTTGCTCAGGCTTTATTTCTCTCGAACAGAACAGCTTCTATCCGAGAAAGCGGTGAT
CTAGCTAGATTATTTACATTAGAGCAAGCCCATACTGCCGTTGTCTCTCCAATAGGAATC
AAAGGAGCTTATCTTCTGATACATCGCCAACACTCTCTTGGGAAATGCAACTAGCTTAC
CAACCCACCTTCTACTTGGAAACGTCTCTACTCAACACACTATTAATGCAAAATCAACGGT
TCTTGGGTCAACACAAATACCCATTAGCTAAACATTCTTTTATGGGAGAGGTTCTCAC
TCCCTCAAATTTTTCTCATCTGAAACTATTTGCTAACTATCAAGCAGAAAGTGGCTACTTCC
ACTGTCTCACACTACATCAATGCAGGAGGAGCTCTGGTCTTTTTAA (SEQ ID NO:8)

6/29

I. *Chlamydia muridarum* PmpG (PmpG-1) TC0263

MMQTPFHKFFLLAMLSYSLQGGHAADISMPPIYDGTTLTAPFPYTVIGDPRGTVKVTSS
 GSLELKNLDNSIATLPLSCFGNLLGNFTIAGRHSVLFENIRTSTNGAALS NHAPSGLFV
 IEAFDELSLLNCNSLVSVVPQTGGTTTSVPSNGTIYSRTDLVLRDIKKVSFYSNLVSGDG
 GAIDAQSLMVNGIEKLCTFQENVAQSDGGACQVTKTFSAVGNKVPLSFLGNVAGNKGGGV
 AAVKDGQGAGGATDLNVNFANNTAVEFEFEGNSARIGGGIYSDGNISFLGNAKTVFLSNVAS
 PIYVDPAAAGGQPPADKDNYGDDGAI FCKNDTNIGEVSFKDEGVVFFSKNIAAGKGGAIY
 AKKLTISDCGPVQFLGNVANDGGAIYLVDDQELSL SADRGDII FDGNLKRMATQGAATVH
 DVMVASNAISMATGGQITTLRAKEGRRI LFNDPIEMANGQPVIQTLTVNEGEGYTGDIVF
 AKGDNVLYSSIELSQGRIILREQTKLLVNSLTQTGGSVHMEGGSTLDFAVTTPPAANSMA
 LTNVHFSLASLLKNNGVTPNPTNPVQVSSPAVIGNTAAGTVTISGPIFFEDLDETAYDN
 NQWLGAQDTIDVLQLHLGANPPANAPTDLTLGNESSKYGYQGSWTLQWEPDPANPPQNNNS
 YMLKASWTKTGYNPGPERVASLVNSLWGSILDVRSASAIQASIDGRAYCRGIWISGIS
 NFFYHDQDALGQGYRHISGGYSIGANSYFGSSMFLAFTETFGRSKDYVVCRSNDHTCVG
 SVYLSTRQALCGSCLFGDAFVRASYGFGNQHMKT SYTFAEESNVRWDNNCVVGEVAGLP
 IMLAASKLYLNLRPFVQAEFAYAEHESFTERGDQAREFKSGHLMNLSIPVGVKFDRCSS
 KHPNKYSFMGAYICDAYRSISGTETTTLLSHKETWTTDAFHLLARHGVMVRGSMYASLTGNI
 EVYGHGKYEYRDASRGYGLSIGSKIRF (SEQ ID NO:9)

J. *Chlamydia trachomatis* PmpG CT871

MQTSFHKFFLSMILAYSCCSLGGGYAAEIMIPQGIYDGETLTVSFPYTVIGDPSGTTVF
 SAGELTLKNLDNSIAALPLSCFGNLLGSFTVLGRGHS LTFENIRTSTNGAALSDSANSGL
 FTIEGFKELSFNSCNLLAVLPAATTNNGSQTPTTTSTPSNGTIYSKTDLLLLNNEKFSF
 YSNLVSGDGGIDAISLTVQGISKL CVFQENTAQADGGACQVVTSSFSAMANEAPIAFIAN
 VAGVRGGGIAAVQDGQGVSSSTSTEDPVVFSFRNTAVEFDGNVARVGGGIYSYGNVAF
 NNGKTLFLNNVASPVYIAAEQPTNGQASNTSDNYGDGGAI FCKNGAQAAGSNNSGSVSFD
 GEGVVFSSNVAAGKGGAIYAKKLSVANCGPVQFLGNIANDGGAIYLGESGELSLSADYG
 DII FDGNLKR TAKENAADVNGVTVSSQAI SMGSGGKITTLRAKAGHQILFNDPIEMANGN
 NQPAQSSEPLKINDGEGYTGDIVFANGNSTLYQNV TIEQGRIVLREKAKLSVNSLSQTGG
 SLYMEAGSTLDFVTPQPPQPPAANQLITLSNLHLSLSLLANNAVTPNPPTNPPAQDSHP
 AIIGSTTAGSVTISGPIFFEDLDDTAYDRYDWLGSNQKIDVLKLQLGTQPSANAPSDTL
 GNEMP KYGYQGSWKLA WDPNTANNGPYTLKATWTKTGYNPGPERVASLVPSNLWGSILDI
 RSAHSAIQASVDGRSYCRGLWVSGVSNFFYHDDR DALGQGYRIISGGYSLGANSYFGSSMF
 GLAFTEVFGRSKDYVVCRSNHHACIGSVYLSTKQALCGSYLFGDAFIRASYGFGNQHMKT
 SYTFAEESDVRWDNNCLVGEIGVGLPIVITPSKLYLNLRPFVQAEFSYADHESFTEEGD
 QARAFRSGHLMNLSVPVGKFDRCSSSTHPNKYSFMGAYICDAYRTISGTQTTLSSHQETW
 TTDAFHLLARHGVI VRGSMYASLT SNIEVYGHGRYEYRDTSRGYGLSAGSKVRF
 (SEQ ID NO:10)

FIGURE 1-7

K. *Chlamydia muridarum* *pmpG* (*pmpG-1*) TC0263

GTGATGCAAACGCCTTTTCATAAGTTCTTTCTTCTAGCAATGCTATCTTACTCTTTATTG
CAAGGAGGGCATGCGGCAGATATTTCCATGCCTCCGGGAATTTATGATGGGACAACATTG
ACGGCGCCATTTCCCTACACTGTGATCGGAGATCCCAGAGGGACAAAGGTTACTTCATCG
GGATCGCTAGAGTTGAAAAACCTGGACAATTCCATTGCGACTTTACCTCTAAGTTGTTTT
GGTAATTTGTTGGGAATTTCACTATTGCAGGAAGAGGGCATTTCGTTAGTATTTGAGAAT
ATACGAACATCTACAAATGGGGCGGCATTGAGTAATCATGCTCCTTCTGGACTGTTTGTA
ATTGAAGCTTTTGATGAACCTCTCTTTTGAATTGTAATTCATTGGTATCTGTAGTTCCT
CAAACAGGGGGTACGACTACTTCTGTTCCCTTCTAATGGGACGATCTATTCTAGAACAGAT
CTTGTTCTAAGAGATATCAAGAAGGTTTCTTTCTATAGTAACCTAGTTTCTGGAGATGGG
GGAGCTATAGATGCACAAAGTTTAATGGTTAACGGAATTGAAAACTTTGTACCTTCCAA
GAAAATGTAGCGCAGTCCGATGGGGGAGCGTGTGAGGTAACAAAGACCTTCTCTGCTGTG
GGCAATAAGGTTTCCTTTGTCTTTTTTAGGCAATGTTGCTGGTAATAAGGGGGGAGGAGTT
GCTGCTGTCAAAGATGGTCAGGGGGCAGGAGGGGCGACTGATCTATCGGTTAATTTTGCC
AATAATACTGCTGTAGAATTTGAGGGAAATAGTGCTCGAATAGGTGGAGGGATCTACTCG
GACGGAAATATTTCTTTTTTAGGGAATGCAAAGACAGTTTTCTTAAGTAACGTAGCTTCG
CCTATTTATGTTGACCCTGCTGCTGCAGGAGGACAGCCCCCTGCAGATAAAGATAACTAT
GGAGATGGAGGAGCCATCTTCTGCAAAAATGATACTAACATAGGTGAAGTCTCTTTCAA
GACGAGGGGTGTTGTTTTCTTTAGTAAAAATATTGCCGAGGAAAGGGGGGCGCTATTTAT
GCTAAGAACTGACAATTTCTGACTGTGGTCCGGTCCAGTTTCTTGGAATGTGCGGAAT
GACGGGGGCGCTATTTATCTAGTAGATCAGGGGGAACTTAGTCTATCTGCTGATCGCGGA
GATATTATTTTTGATGGAATTTAAAGAGAATGGCTACGCAAGGCGCTGCCACCGTCCAT
GATGTAATGGTTGCATCGAATGCTATCTCTATGGCTACAGGGGGGCAAATCACAACATTA
AGGGCTAAGGAAGGTGCGCGAATTTCTTTTTAATGACCCTATTGAAATGGCGAATGGACAA
CCTGTAATACAACTCTTACAGTAAACGAGGGCGAAGGATATACGGGGGACATTGTTTTT
GCTAAAGTGATAATGTTTTGTACTCAAGTATTGAGCTGAGTCAGGGAAGAATTATTCTC
CGAGAGCAAACAAATATTGGTTAACTCCCTGACTCAGACTGGAGGGAGTGACATATG
GAAGGGGGGAGTACACTAGACTTTGCGAGTAACAACGCCACCAGCTGCTAATTCGATGGCT
CTTACTAATGTACACTTCTCCTTAGCTTCTTTACTAAAAATAATGGGGTTACAAATCCT
CCAACGAATCCTCCAGTACAGGTTTCTAGTCCAGCTGTAATTGGTAATACAGCTGCTGGT
ACTGTTACGATTTCTGGTCCGATCTTTTTTGAAGATTTAGATGAACTGCTTACGATAAT
AATCAGTGGTTAGGTGCGGATCAAATATTGATGTGCTGCAGTTGCATTTAGGAGCGAAT
CCTCCGGCTAACGCTCCAACTGATTTGACTTTAGGGAACGAAAGTTCTAAATATGGGTAT
CAAGGAAGTTGGACACTTCAATGGGAACCAGATCCTGCGAATCCTCCACAGAACAATAGC
TACATGTTGAAGGCAAGCTGGACTAAAACAGGTTATAATCCTGGTCCGGAGCGCGTAGCT
TCTCTGGTCTCTAATAGTCTTTGGGGATCCATTTTAGATGTGCGTTCCGCGCATTCTGCG
ATTCAAGCAAGTATAGATGGACGAGCTTATTGTCGGGGTATTTGGATTTCTGGGATTTCTG
AACTTTTTCTATCATGATCAGGATGCTTTAGGACAGGGGTATCGTCATATTAGTGGGGGA
TATTCGATAGGAGCAAACCTCTTATTTGGGTCTTCTATGTTTGACTTGCTTTTACTGAA
ACTTTTGGTAGGTCCAAAGATTATGTGGTCTGTGATCTAACGATCACACTTGTGTAGGC
TCTGTTTACTTATCCACTAGACAAGCGTTATGCGGATCCTGTTTATTTGGAGATGCTTTT
GTTCCGGCGAGTTACGGATTTGGAAATCAGCATATGAAGACCTCTTATACATTTGCTGAA
GAGAGTAATGTGCGTTGGGATAATAACTGTGTAGTGGGAGAAGTTGGAGCTGGGCTCCCT
ATCATGCTCGTGCATCTAAGCTTTATCTAAATGAGTTGCGTCCCTTCGTGCAAGCAGAG
TTTGCTTATGCAGAGCATGAATCTTTTACAGAGAGAGGGGATCAGGCTAGGGAGTTTAAG
AGTGGGCATCTTATGAATCTATCTATTCCAGTTGGGGTGAAGTTTGATCGATGCTCTAGT
AAACATCCTAACAAAGTATAGTTTTATGGGAGCTTATATCTGTGATGCTTACCGGTCCATT
TCTGGAACGGAGACAACACTCCTGTCTCATAAAGAGACTTGGACAACAGATGCTTTCCAT
TTAGCAAGGCATGGAGTTATGGTCAGAGGATCTATGTATGCTTCTTTAACAGGTAATATA
GAAGTCTATGGCCATGGAAAATATGAATACAGGGATGCCTCTCGAGGGTATGGTTTAAGT
ATTGGAAGTAAATCCGATTCTAA (SEQ ID NO:11)

FIGURE 1-8

L. *Chlamydia trachomatis* *pmpG* CT871

ATGCAAACGTCTTTCCATAAGTTCTTTCTTTCAATGATTCTAGCTTATTCTTGCTGCTCT
 TTAAGTGGGGGGGGGTATGCAGCAGAAATCATGATTCTCAAGGAATTTACGATGGGGAG
 ACGTTAACTGTATCATTTCCCTATACTGTTATAGGAGATCCGAGTGGGACTACTGTTTTT
 TCTGCAGGAGAGTTAACGTTAAAAAATCTTGACAATTCTATTGCAGCTTTGCCTTTAAGT
 TGTTTTGGGAACCTATTAGGGAGTTTTACTGTTTTAGGGAGAGGACACTCGTTGACTTTC
 GAGAACATACGGACTTCTACAAATGGAGCTGCACTAAGTGACAGCGCTAATAGCGGGTTA
 TTTACTATTGAGGGTTTTAAAGAATTATCTTTTTCCAATTGCAACTCATTACTTGCCGTA
 CTGCCTGCTGCAACGACTAATAATGGTAGCCAGACTCCGACGACAACATCTACACCGTCT
 AATGGTACTATTTATTCTAAAACAGATCTTTTGTTACTCAATAATGAGAAGTTCTCATTC
 TATAGTAATTTAGTCTCTGGAGATGGGGGAGCTATAGATGCTAAGAGCTTAACGGTTCAA
 GGAATTAGCAAGCTTTGTGTCTTCCAAGAAAATACTGCTCAAGCTGATGGGGGAGCTTGT
 CAAGTAGTCACCAGTTTCTCTGCTATGGCTAACGAGGCTCCTATTGCCTTTATAGCGAAT
 GTTGCAGGAGTAAGAGGGGGAGGGATTGCTGCTGTTGAGGATGGGCAGCAGGGAGTGTC
 TCATCTACTTCAACAGAAGATCCAGTAGTAAGTTTTTCCAGAAATACTGCGGTAGAGTTT
 GATGGGAACGTAGCCCGAGTAGGAGGAGGGATTTACTCCTACGGGAACGTTGCTTTCCTG
 AATAATGGAAAAACCTTGTTTCTCAACAATGTTGCTTCTCCTGTTTACATTGCTGCTGAG
 CAACCAACAAATGGACAGGCTTCTAATACGAGTGATAATTACGGAGATGGAGGAGCTATC
 TTCTGTAAGAATGGTGCGCAAGCAGCAGGATCCAATAACTCTGGATCAGTTTCTTTGAT
 GGAGAGGGAGTAGTTTCTTTAGTAGCAATGTAGCTGCTGGGAAAGGGGGAGCTATTTAT
 GCCAAAAAGCTCTCGGTTGCTAACTGTGGCCCTGTACAATTCTTAGGGAATATCGCTAAT
 GATGGTGGAGCGATTTATTTAGGAGAATCTGGAGAGCTCAGTTTATCTGCTGATTATGGA
 GATATTATTTTCGATGGGAATCTTAAAAGAACAGCCAAAGAGAATGCTGCCGATGTTAAT
 GGCCTAAGTGTGTCTCACAAGCCATTTGATGGGATCGGGAGGGAAAAATAACGACATTA
 AGAGCTAAAGCAGGGCATCAGATTCTCTTTAATGATCCCATCGAGATGGCAAACGGAAAT
 AACCAGCCAGCGCAGTCTTCCGAACCTCTAAAAATTAACGATGGTGAAGGATACACAGGG
 GATATTGTTTTTGCTAATGGAAACAGTACTTTGTACCAAATGTTACGATAGAGCAAGGA
 AGGATTGTTCTTCTGTAAGGCTGGGAGTACATTGGATTTTGTAAGTCCACAACCACCACAACAG
 CCTCCTGCCGCTAATCAGTTGATCACGCTTTCCAATCTGCATTTGTCTTTTCTTTG
 TTAGCAAACAATGCAGTTACGAATCCTCCTACCAATCCTCCAGCGCAAGATTCTCATCCT
 GCAATCATTGGTAGCACAACTGCTGGTTCTGTTACAATTAGTGGGCCTATCTTTTTTTGAG
 GATTTGGATGATACAGCTTATGATAGGTATGATTGGCTAGGTTCTAATCAAAAAATCGAT
 GTCCTGAAATTACAGTTAGGGACTCAGCCCTCAGCTAATGCCCCATCAGATTTGACTCTA
 GGGAAATGAGATGCCTAAGTATGGCTATCAAGGAAGCTGGAAGCTTGCGTGGGATCCTAAT
 ACAGCAAATAATGGTCCTTATACTCTGAAAGCTACATGGACTAAAACCTGGGTATAATCCT
 GGGCCTGAGCGAGTAGCTTCTTTGGTTCCAAATAGTTTATGGGGATCCATTTTAGATATA
 CGATCTGCGCATTCAGCAATTCAGCAAGTGTGGATGGGCGCTCTTATTGTGAGGATTA
 TGGGTTTTCTGGAGTTTTCGAATTTCTTCTATCATGACCGCGATGCTTTAGGTGAGGATAT
 CGGTATATTAGTGGGGGTTATTCCTTAGGAGCAAACCTCCTACTTTGGATCATCGATGTTT
 GGTCTAGCATTTACCGAAGTATTTGGTAGATCTAAAGATTATGTAGTGTGTCGTTCCAAT
 CATCATGCTTGCATAGGATCCGTTTATCTATCTACCAAACAAGCTTTATGTGGATCCTAT
 TTGTTCCGAGATGCGTTTATCCGTGCTAGCTACGGGTTTGGGAACCAGCATATGAAAACC
 TCATACACATTTGCAGAGGAGAGCGATGTTTCGTTGGGATAATAACTGTCTGGTTGGAGAG
 ATTGGAGTGGGATTACCGATTGTGATTACTCCATCTAAGCTCTATTTGAATGAGTTGCGT
 CCTTTCTGTCAGCTGAGTTTTCTTATGCCGATCATGAATCTTTTACAGAGGAAGGCGAT
 CAAGCTCGGGCATTGAGGAGTGGACATCTCATGAATCTATCAGTTCCTGTTGGAGTAAAA
 TTTGATCGATGTTCTAGTACACACCCTAATAAATATAGCTTTATGGGGGCTTATATCTGT
 GATGCTTATCGCACCATCTCTGGGACTCAGACAACACTCCTATCCCATCAAGAGACATGG
 ACAACAGATGCCTTTTCAATTTGGCAAGACATGGAGTCATAGTTAGAGGGTCTATGTATGCT
 TCTCTAACAAGCAATATAGAAGTATATGGCCATGGAAGATATGAGTATCGAGATACTTCT
 CGAGGTTATGGTTTGAGTGCAGGAAGTAAAGTCCGGTTCTAA (SEQ ID NO:12)

FIGURE 1-9

M. *Chlamydia muridarum* PmpH TC0264

MLVMPFSLRSTSFCLACLCSYSYGLASSPQVLTPNVIIIPFKGDDIYLNDCVFASIYAG
 AEQGSIIISANGQNLTIVGQNHTLSFTDSQGPALQNCAFISAEKISLRDFSSLLFSKNVS
 CGEKGMSIGKTVSISGGDSIVFKDNSVGYSSLPSVGQTPTTPIVGDVLKGSIFCVETGLE
 ISGVKKELVFDNTAGNFGAVFCSRAAQGDTTFTVKDCKGKILFQDNVSGCGGGVIYKGEV
 LFQDNEGEMLFGRNSAHDDLGLDANPQPPTTEVGGGGGVICTPEKTVTFKGNKGPITFDY
 NFAKGRGGAIQSQTFSLVADS AVVFSNNTAEKGGGAIYALEVNVSTNGGSILFEGNRASE
 GGAICVSEPIAANNGLTLHAADGDIIFSKNMTSDRPGERSAIRILDSGTNVSLNASGAS
 KMI FYDPVVQNNPATPPTGTSGEIKINESGSGSVVFTAETLTPSEKLNVINATSNFPGNL
 TVSSGELVVTKGATLTVGNITATSGRVTLGSGASLSAVAGTAGTCTVSKLGIDLESFLVP
 TYETAKLGADTTAVVNNNPTLDLVMANETEMYDNPLFMNAVITIPFVTLVSLQTTGGVTTTS
 AVTLNNADTAHYGYQGSWSADWRRPPLAPDPSPGMTPLDKSNTLYVTWRPSSNYGVYKLDP
 QRRGELVPNSLWVSGSALRTFTNGLKEHYVSRDVGFIASVQALGDYVLNYKQGNRDGFLA
 RYGGFQAVAASHYENGIGFVAFGQLYGQTKSRLYDSKDAGNITILSCFGRSYIDVKGTE
 TVVYWETAYGYSVHRMHTQYFNGKTNKFDHSKCRWHNNSYAFVGAEHNFLEYCIPTRQL
 ARDYDLTGFMRFEMSGGWSSGAKETGALPRHFDRTGHNMSLPIGVVAHAVSNRRSPPS
 KLTINMGYRPDIWRVTPHCNMKIIANGVKTPIQGSPLARHAFFLEVHDTLYVRHLGRAYM
 NYSLDARHRQTTHFVSLGLNRIF (SEQ ID NO:13)

N. *Chlamydia trachomatis* PmpH CT872

MPFSLRSTSFCLACLCSYSYGFASSPQVLTPNVTTTPFKGDDVYLNDCAFVNVYAGAEN
 GSIIISANGDNLTITGQNHTLSFTDSQGPVLQNYAFISAGETLTLKDFSSLMFSKNVSCGE
 KGMSIGKTVSISGAGEVIFWDNSVGYSPLSIVPASTPTPPAPAPAPAASSSLSPVSDAR
 KGSIFSVETSLEISGVKKGVMDNAGNFGTVFRGNSNNNAGSGGSGSATTPSFTVKNCK
 GKVSFTDNVASC GGGVVYKGTVLFKDNEGGIFFRGNTAYDDLGLAATS RDQNTETGGGG
 GVICSPDDSVKFEKNKSIVFDYNFAKGRGGSILTKEFSLVADDSVVFSSNNTAEKGGGAI
 YAPTIDISTNGGSILFERNRAEAGGAICVSEASSGSTGNLTLSASDGDIVFSGNMTSDRP
 GERSAARILSDGTTVSLNASGLSKLIFYDPVVQNN SAAGASTPSPSSSSMPGAVTINQSG
 NGSVIFTAESLTPSEKLQVLNSTSNFPGALT VSGGELVVTEGATLTTGTITATSGRVTLG
 SGASLSAVAGAANNNTCTVSKLGIDLESFLTPNYKTAILGADGTVTVNSGSTLDLVMS
 EAEVYDNPLFVGSLTIPFVTLSSSSASNGVTKN SVTINDADAAHYGYQGSWSADWTKPPL
 APDAKGMVPPNTNNTLYLTWRPASNYGEYRLDPQRKGELVPNSLWVAGSALRTFTNGLKE
 HYVSRDVG FVASLHALGDYILNYTQDDRDGFLARYGGFQATAASHYENGSI FGVAFGQLY
 GQTKSRMYYSKDAGNMTMLSCFGRSYVDIKGTETVMYWETAYGYSVHRMHTQYFNDKTQK
 FDH SKCHWHNNNYAFVGAEHNFLEYCIPTRQFARDYELTGFMRFEMAGGWSSSTRETGS
 LTRYFARGSGHNMSLPIGIVAHAVSHVRRSPPSKLT LNMGYRPDIWRVTPHCNMEIIANG
 VKTPIQGSPLARHAFFLEVHDTLYIHHFGRAYM NYSLDARRRQTAHFVSMGLNRIF

(SEQ ID NO:14)

FIGURE 1-10

O. *Chlamydia muridarum* pmpH TC0264

GTGTTAGTAATGCCTTTTTCTTTGAGATCTACATCATTTTTGTTTTTTAGCCTGTTTATGT
TCTTATTCATATGGATTAGCGAGTTCTCCTCAGGTAAGTACCCCCAATGTAATCATCCCT
TTTAAAGGAGACGATATCTATTTAAATGGGGATTGCGTTTTTGCAAGTATCTATGCAGGA
GCAGAGCAGGGATCGATTATTTCTGCTAATGGGCAAAATCTAACAATCGTAGGACAAAAC
CACACTTTATCATTTACGGATTCCCAAGGGCCAGCCCTTCAAATTTGTGCTTTTCAATTTCA
GCAGAAGAAAAGATCTCTCTAAGAGATTTTTTCGAGCCTTTTGTTCGAAAAATGTTTCT
TGCAGGGGAGAAAGGAATGATTTTCAGGGAAAACCGTAAGCATTTCAGGGGGAGATAGTATA
GTTTTTAAAGGATAACTCTGTTGGTTATTCTTCATTACCCTCTGTGGGGCAAACCTCTACA
ACTCCAATTGTTGGCGATGTTTTAAAGGGATCCATTTTTTGTGTGGAGACAGGTTTAGAG
ATTTCTGGAGTCAAAAAAGAGCTTGTTCGATAACACTGCTGGGAATTTTGGGGCAGTA
TTCTGTAGTCGTGCCGCTCAAGGAGACACGACTTTACAGTGAAAGACTGTAAGGGTAAA
ATTCTTTTTCAAGATAACGTAGGCTCTTGTGGAGGCGGCGTAATTTATAAAGGGGAAGTA
CTTTTCCAAGATAATGAAGGAGAAATGCTTTTCCGAGGAAATTCAGCTCATGATGATTTG
GGAATTCTCGATGCTAACCCACAGCCTCCTACTGAAGTAGGAGGTGGGGGTGGTGTCAAT
TGTACCCAGAGAAAACGGTAACCTTTTAAAGGGGAATAAAGGGCCTATTACCTTTGATTAT
AATTTTCAAAAAGGTGAGGAGGGCAATCCAATCACAGACCTTTCTTTGGTAGCTGAT
AGTGCTGTTGTTTTCAGTAATAATACAGCTGAGAAAGGTGGAGGCGCCATTTATGCTCTT
GAGGTTAACGTGAGCACAAATGGAGGATCTATTCTTTTTGAGGGAAATAGAGCTTCTGAG
GGTGGGGCTATCTGTGTGAGCGAGCCGATCGCTGCTAATAATGGAGGGCTCACTTTACAT
GCTGCTGATGGGGACATTATTTTTCTCGAAAAATATGACGAGTGATCGTCTGGAGAACGC
AGTGCAATCCGGATCTTAGATAGTGGAACAAATGTCTCTTTAAATGCTTCAGGGGCATCG
AAGATGATTTTTTATGATCCTGTTGTGCAAAATAATCCCGCAACTCCACCTACTGGTACG
TCTGGGGAAATTAAGATCAATGAGTCCGGGAGTGGATCGGTTGTGTTTACAGCAGAGACT
TTGACTCCTTCGGAATAATTGAATGTTATCAACGCTACTTCTAATTTCCAGGAAATTTA
ACGGTATCTAGTGGAGAATTAGTTGTTACGAAGGGAGCGACACTAACAGTAGGAAATATC
ACAGCAACATCAGGACGAGTAACCTTTAGGATCAGGGGCTTCGTTATCCGCCGTTGCAGGT
ACTGCTGGCACTTGTACGGTGTCTAAATTAGGGATTGATTTAGAGTCCTTCCTAGTCCCT
ACTTATGAGACTGCAAAGTTGGGTGCGGATACAACAGTAGCGGTGAATAACAATCCTACT
TTAGACCTAGTAATGGCGAATGAGACGGAGATGTATGATAATCCGCTTTTTATGAACGCT
GTTACAATCCCTTTTGTGACATTGGTTTCTCTCCAACTACTGGTGGTGTACTACAAGT
GCCGTTACTCTGAATAATGCAGATACTGCGCATTATGGGTATCAAGGATCTTGGTCTGCT
GATTGGAGAAGGCCTCCTTTAGCTCCTGATCCTAGCGGCATGACACCTCTTGATAAAAGT
AATACATTGTATGTGACATGGAGGCCATCCTCTAATACGGTGTGTATAAGTTAGATCCT
CAAAGAAGGGGTGAGTTGGTCCCGAATTCCTTATGGGTATCTGGATCTGCCTTAAGAACC
TTTACAAATGGTTTGAAGAACATTACGCTCTAGAGATGTCGGATTTATTGCATCTGTA
CAAGCCTTAGGGGATTATGTTCTGAATTATAAGCAGGGTAACCGAGATGGCTTTCTAGCT
AGGTACGGAGGTTTTCAAGCTGTTGCGGCTTCTCACTATGAAAATGGGGGGATCTTTGGG
GTAGCTTTCCGTCAACTTTATGGTCAAATAAGAGCCGTTTGTACGATTCTAAGGATGCT
GGAAACATTACGATTTTGTCTGTTTGGACGAAGTTATATCGATGTTAAAGGAACAGAA
ACCGTTGTGATTGGGAGACGGCTTATGGATATTCTGTTTATAGAAATGCATACGCAGTAT
TTCAATGGAAAAACGAATAAGTTTGATCATTGAAATGTCGTTGGCACAACAATAGTTAT
TATGCATTTGTAGGTGCAGAACATAATTTCTTGGAGTATTGTATTCTACTCGTCAATTA
GCTAGGGATTATGATCTTACAGGATTTATGCGTTTCGAAATGTCGGGAGGTTGGTGCAGT
GGTGCAAAAGAAACGGGTGCTTTACCTAGACATTTTGATCGAGGAACAGGGCATAATATG
TCTCTTCCAATAGGGGTTGTAGCTCATGCTGTTTCTAATGGACGAAGATCTCCTCCATCT
AAATTGACGATTAACATGGGATATAGACCAGACATTTGGCGGGTGAATCCACATTGCAAT
ATGAAAATTATTGCAAACGGAGTTAAGACTCCTATACAGGGATCTCCTCTAGCTCGGCAC
GCCTTCTTTTTAGAAGTTCATGATACTCTGTATGTTTCGTCAATTTGGGCAGAGCCTATATG
AATTATTCTTTAGATGCTCGTCATCGACAACTACGCATTTTCGTATCTTTAGGATTGAAT
CGTATCTTTTAA (SEQ ID NO:15)

FIGURE 1-11

P. Chlamydia trachomatis pmpH CT872

ATGCCTTTTTCTTTGAGATCTACATCATTTTTGTTTTTTAGCTTGTTTTGTGTTTCTATTTCG
 TATGGATTTCGCGAGCTCTCCTCAAGTGTTAACACCTAATGTAACCACTCCTTTTTAAGGGG
 GACGATGTTTACTTGAATGGAGACTGCGCTTTTGTCAATGTCTATGCAGGGGCAGAGAAC
 GGCTCAATTATCTCAGCTAATGGCGACAATTTAACGATTACCGGACAAAACCATACATTA
 TCATTTACAGATTCTCAAGGGCCAGTTCTTCAAAATTATGCCTTCATTTACAGCAGGAGAG
 ACACTTACTCTGAAAGATTTTTCGAGTTTGATGTTCTCGAAAAATGTTTCTTGCAGGAGAA
 AAGGGAATGATCTCAGGGAAAACCGTGAGTATTTCCGGAGCAGGCGAAGTGATTTTTTGG
 GATAACTCTGTGGGGTATTCTCCTTTGTCTATTGTGCCAGCATCGACTCCAACCTCCTCCA
 GCACCAGCACCAGCTCCTGCTGCTTCAAGCTCTTTATCTCCAACAGTTAGTGATGCTCGG
 AAAGGGTCTATTTTTCTGTAGAGACTAGTTTGGAGATCTCAGGCGTCAAAAAAGGGGTC
 ATGTTTCGATAATAATGCCGGGAATTTTGAACAGTTTTTTCGAGGTAATAGTAATAATAAT
 GCTGGTAGTGGGGTAGTGGGTCTGCTACAACACCAAGTTTTACAGTTAAAACTGTAAA
 GGGAAAGTTTCTTTCACAGATAACGTAGCCTCCTGTGGAGGCGGAGTAGTCTACAAAGGA
 ACTGTGCTTTTCAAAGACAATGAAGGAGGCATATTCTTCCGAGGGAACACAGCATAACGAT
 GATTTAGGGATTCTTGCTGCTACTAGTCGGGATCAGAATACGGAGACAGGAGGCGGTGGA
 GGAGTTATTTGCTCTCCAGATGATTCTGTAAAGTTTGAAGGCAATAAAGGTTCTATTGTT
 TTTGATTACAACTTTGCAAAGGCAGAGGCGGAAGCATCCTAACGAAAGAATTCTCTCTT
 GTAGCAGATGATTCGGTTGTCTTTAGTAACAATACAGCAGAAAAAGGCGGTGGAGCTATT
 TATGCTCCTACTATCGATATAAGCACGAATGGAGGATCGATTCTATTTGAAAGAAACCGA
 GCTGCAGAAGGAGGCGCCATCTGCGTGAGTGAAGCAAGCTCTGGTTCAACTGGAAATCTT
 ACTTTAAGCGCTTCTGATGGGGATATTGTTTTTCTGGGAATATGACGAGTGATCGTCTT
 GGAGAGCGCAGCGCAGCAAGAATCTTAAGTGATGGAACGACTGTTTCTTTAAATGCTTCC
 GGACTATCGAAGCTGATCTTTTATGATCCTGTAGTACAAAATAATTACAGCAGCGGGTGCA
 TCGACACCATCACCATCTTCTTCTTCTATGCCTGGTGCTGTACGATTAATCAGTCCGGT
 AATGGATCTGTGATTTTTTACCAGGAGTCAATTGACTCCTTCAGAAAACTTCAAGTTCTT
 AACTCTACTTCTAACTTCCAGGAGCTCTGACTGTGTGAGGAGGGGAGTTGGTTGTGACG
 GAAGGAGCTACCTTAACTACTGGGACCATTACAGCCACCTCTGGACGAGTGACTTTAGGA
 TCCGGAGCTTCGTTGTCTGCCGTTGCAGGTGCTGCAAATAATAATTATACTTGTACAGTA
 TCTAAGTTGGGGATTGATTTAGAATCCTTTTTTAACTCCTAACTATAAGACGGCCATACTG
 GGTGCGGATGGAACAGTTACTGTTAACAGCGGCTCTACTTTAGACCTAGTGATGGAGAGT
 GAGGCAGAGGTATATGATAATCCGCTTTTTTGTGGGATCGCTGACAATTCCTTTTGTACT
 CTATCTTCTAGTAGTGCTAGTAACGGAGTTACAAAAAATTCTGTCACTATTAATGATGCA
 GACGCTGCGCACTATGGGTATCAAGGCTCTTGGTCTGCAGATTGGACGAAACCGCCTCTG
 GCTCCTGATGCTAAGGGGATGGTACCTCCTAATACCAATAACACTCTGTATCTGACATGG
 AGACCTGCTTCGAATTACGGTGAATATCGACTGGATCCTCAGAGAAAGGGAGAACTAGTA
 CCCAACTCTCTTTGGGTAGCGGGATCTGCATTAAGAACCTTTACTAATGGTTTGAAAGAA
 CACTATGTTTCTAGAGATGTTGGATTTGTAGCATCTCTGCATGCTCTCGGGGATTATATT
 TTGAATTATACGCAAGATGATCGGGATGGCTTTTTAGCTAGATATGGGGGATTCCAGGCG
 ACCGCAGCCTCCCATTATGAAAATGGGTCAATATTTGGAGTGGCTTTTGGACAACCTCTAT
 GGTGAGACAAAGAGCAGAATGTATTACTCTAAAGATGCTGGGAACATGACGATGTTGTCC
 TGTTCGGAAGAAGTTACGTAGATATTAAAGGAACAGAACTGTTATGTATTGGGAGACG
 GCTTATGGCTATTCTGTGCACAGAATGCATACGCAGTATTTTAAATGACAAAACGCAGAAG
 TTCGATCATTCGAAATGTCATTGGCACACAATAACTATTATGCGTTTGTGGGTGCCGAG
 CATAATTTCTTAGAGTACTGCATTCTACTCGTCAGTTTCGCTAGAGATTATGAGCTTACA
 GGGTTTATGCGTTTTTGAATGGCCGGAGGATGGTCCAGTTCTACACGAGAACTGGCTCC
 CTAAGTAGATATTTTCGCTCGCGGGTCAGGGCATAATATGTCGCTTCCAATAGGAATTGTA
 GCTCATGCAGTTTCTCATGTGCGAAGATCTCCTCCTTCTAACTGACACTAAATATGGGA
 TATAGACCAGACATTTGGCGTGTCACTCCACATTGCAATATGGAAATTATTGCTAACGGA
 GTGAAGACACCTATACAAGGATCTCCGCTGGCACGGCATGCCTTCTTCTTAGAAGTGCAT
 GATACTTTGTATATTCATCATTTTTGGAAGAGCCTATATGAATATTTCGCTGGATGCTCGT
 CGTCGACAAACGGCACATTTTTGTATCCATGGGCTTGAATAGAATCTTTTAA
 (SEQ ID NO:16)

FIGURE 1-12

Q. *Chlamydia muridarum* MOMP TC052

MKKLLKSVLAFVAVLGSASSLHALPVGNPAPESLMIDGILWEGFGGDPDPCDPTTWCDALSL
 RLGYYGDFVDFRVLKTDVKNQFEMGAAPTGDADLTAPTASRENPAYGKHMQDAEMFTN
 AAYMALNIWDRFDFVCTLGATSGYLKGNSSAFNLVGLFGRDETAVAADDIPNVSLSQAVV
 ELYTDTAFAWSVGARAALWECGCATLGASFQYAQSKPKVEELNVLCNAAEFTINKPKGYV
 GQEFPLNIKAGTVSATDTKDASIDYHEWQASLALSYRLNMFTPYIGVKWSRASFDADTIR
 IAQPXLETSILXMTTWNPTISGSGIDVDTKITDTLQIVSLQLNKMKSRSKSCGLAIGTTIV
 DADKYAVTVETRLIDERAHVNAQFRF (SEQ ID NO:17)

R. *Chlamydia trachomatis* MOMP CT681

MKKLLKSVLVFAALSSASSLQALPVGNPAPESLMIDGILWEGFG
 GDPDPCATWCDALSMRVGYGDFVDFRVLKTDVNKEFQMGAKPTTDTGNSAAPSTLT
 ARENPAYGRHMQDAEMFTNAACMALNIWDRFDFVCTLGATSGYLKGNSSAFNLVGLFG
 DNENQKTVKAESVPNMSFDQSVVELYTDTTFAWSVGARAALWECGCATLGASFQYAQSK
 KPKVEELNVLCNAAEFTINKPKGYVGKEFPLDLTAGTDAATGTDASIDYHEWQASL
 LSYRLNMFTPYIGVKWSRASFDADTIRIAQPKSATAIFDTTTTLNPTIAGAGDVKTGAE
 GQLGDTMQIVSLQLNKMKSRSKSCGIAVGTIVDADKYAVTVETRLIDERAHVNAQFR
 (SEQ ID NO:18)

S. *Chlamydia muridarum* MOMP TC0052

ATGAAAAAACTCTTGAAATCGGTATTAGCATTTGCCGTTTTGGGTTCTGCTTCCTCCTTG
 CATGCTCTGCCTGTGGGGAATCCTGCTGAACCAAGCCTTATGATTGACGGGATTCTTTGG
 GAAGGTTTTCGGTGGAGATCCTTGCGATCCTTGACAACTTGGTGTGATGCCATCAGCCTA
 CGTCTCGGCTACTATGGGGACTTCGTTTTTGATCGTGTGTTTTGAAAACAGACGTGAACAAA
 CAGTTCGAAATGGGAGCAGCTCCTACAGGAGATGCAGACCTTACTACAGCACCTACTCCT
 GCATCAAGAGAGAATCCCGCTTATGGCAAGCATATGCAAGATGCAGAAATGTTCACTAAT
 GCTGCGTACATGGCTTTAAACATTTGGGACCGTTTCGATGTATTTGTACATTGGGAGCA
 ACTAGCGGATATCTTAAAGGTAATTCTGCCGCCTTTAACTTAGTTGGTCTGTTTGGAAGA
 GATGAAACTGCAGTTGCAGCTGACGACATACCTAACGTCAGCTTGTCTCAAGCTGTTGTC
 GAACTCTACACAGACACAGCTTTTCGCTTGGAGCGTCGGTGCTAGAGCAGCTTTATGGGAG
 TGGCGATGTGCAACTTTAGGAGCTTCCTTCCAATATGCTCAATCTAAGCCAAAAGTAGAG
 GAATTAAACGTTCTCTGTAATGCGGCAGAATTCATATTAAACAAGCCTAAAGGATACGTT
 GGACAAGAGTTTCTCTTAACATTAAAGCTGGAACAGTTAGCGCTACAGATACTAAAGAT
 GCTTCCATCGATTACCATGAGTGGCAAGCAAGCTTGGCTTTGTCTTACAGACTGAATATG
 TTCCTCCTTACATTGGAGTTAAGTGGTCTAGAGCAAGCTTTGATGCCGACACTATCCGC
 ATTGCGCAGCCTKAGCTTGAGACCTCTATCTTAAKAATGACCACTTGGAACCAACGATC
 TCTGGATCTGGTATAGACGTTGATACAAAAATCACGGATACATTACAAATTGTTTCCTTG
 CAGCTCAACAAGATGAAATCCAGAAAATCTTGCGGTCTTGCAATTGGAACAACAATTGTA
 GATGCTGATAAATATGCAGTTACTGTTGAGACACGCTTGATCGATGAAAGAGCAGCTCAC
 GTAAATGCTCAGTTCCGTTTCTAA (SEQ ID NO:19)

FIGURE 1-13

T. *Chlamydia trachomatis* MOMP CT681

ATGAAAAAACTCTTGAAATCGGTATTAGTATTTGCCGCTTTGAGTTCTGCTTCCTCCTTG
 CAAGCTCTGCCTGTGGGGAATCCTGCTGAACCAAGCCTTATGATCGACGGAATTCTGTGG
 GAAGGTTTCGGCGGAGATCCTTGCGATCCTTGCGCCACTTGGTGTGACGCTATCAGCATG
 CGTGTGGTTACTACGGAGACTTTGTTTTCGACCGTGTTTTGAAAACCTGATGTGAATAAA
 GAATTCAGATGGGTGCCAAGCCTACAACCTGATACAGGCAATAGTGCAGCTCCATCCACT
 CTTACAGCAAGAGAGAATCCTGCTTACGGCCGACATATGCAGGATGCTGAGATGTTTACA
 AATGCCGCTTGCATGGCATTGAATATTTGGGATCGTTTTGATGTATTCTGTACATTAGGA
 GCCACCACTGGATATCTTAAAGGAACTCTGCTTCTTTCAATTTAGTTGGATTGTTTGGA
 GATAATGAAAATCAAAAAACGGTCAAAGCGGAGTCTGTACCAAATATGAGCTTTGATCAA
 TCTGTTGTTGAGTTGTATACAGATACTACTTTTGCCTGGAGCGTCGGCGCTCGCGCAGCT
 TTGTGGGAATGTGGATGTGCAACTTTAGGAGCTTCATTCCAATATGCTCAATCTAAACCT
 AAAGTAGAAGAATTAAACGTTCTCTGCAATGCAGCAGAGTTTACTATTAATAAACCTAAA
 GGGTATGTAGGTAAGGAGTTTCTCTTGATCTTACAGCAGGAACAGATGCTGCGACAGGA
 ACTAAGGATGCCTCTATTGATTACCATGAATGGCAAGCAAGTTTAGCTCTCTCTTACAGA
 CTGAATATGTTCACTCCCTACATTGGAGTTAAATGGTCTCGAGCAAGCTTTGATGCCGAT
 ACGATTCTGATAGCCAGCCAAAATCAGCTACAGCTATTTTTGATACTACCACGCTTAAC
 CCAACTATTGCTGGAGCTGGCGATGTGAAAACCTGGCGCAGAGGGTCAGCTCGGAGACACA
 ATGCAAATCGTTTTCTTGCAATTGAACAAGATGAAATCTAGAAAATCTTGCGGTATTGCA
 GTAGGAACAACCTATTGTGGATGCAGACAAATACGCAGTTACAGTTGAGACTCGCTTGATC
 GATGAGAGAGCAGCTCACGTAAATGCACAATTCCGCTTCTAA (SEQ ID NO:20)

U. *Chlamydia muridarum* TC0825

MNISGSIKQKLLQFLKKQKSPPELLATYLFYLEQSLHLSPVVFVRDKVIFKSAEDAIALLE
 ADKKIWRETEIQISSGKPEVNEQTKRIYICPFTGKVFADNVYANPLDAVYDWLSSCPQNK
 ERQAGVAVKRFLVSDDEPEVIRAYIVPPKEPLIKTVYASAITGKLFHSLPTLLEDFKTSYL
 RPMTLEEVQNQNKFLQLESSFLTLLQDALEEEKIAEFVESLADDTAFHEYISQWVDTEE
 (SEQ ID NO:21)

V. *Chlamydia trachomatis* CT538

MNISGSIKQKLLQFLKKQKSPPELLATYLFYLEQSLHLSPVVFVRDKIIFKSAEDAIQILLE
 ADKKIWRETEIQISSGKPEVNEQTKRIYICPFTGKVFADNVYANPQDAIYDWLSSCPQNR
 ERQSGVAVKRFLVSDDEPEVIRAYIVPPKEPIIKTVYASAVTGKLFHSLPTLLEDFKTSYL
 RPMTLEEVQNQNKFLQLESSFLTLLQDALEEEKIAEFVESLADDTAFHKYISQWVDTEE
 (SEQ ID NO:22)

W. *Chlamydia muridarum* Tarp TC0741

MTTPISNSPSSIPTVTVSTTTASSGSLGTSTVSSTTTSTSVAQATTTTSSASTSIIQSSG
 ENIQSTTGTPSPITSSVSTSAPSPKASATANKTSSAVSGKITSQETSEESQATTSDGE
 VSSNYDDVDTPNSSDSTVDSYQDVETQYKTI SNNGENTYETIGSHGEKNTHVQESHAS
 GTGNPINNQQEAIQRLRSSTYTTS PRNENIFSPGPEGLPNMSLPSYSPTDKSSLLAFLSN
 PNTKAKMLEHSGHLVFI DTTRSSFI FVPNGNWDQVC SMKVQNGKTKEDLGLKDLEDCAK
 FCTGYNKFSSDWGNRVDPLVSSKAGIESGGHLPSSVI INNKFRTCVAYGPWNPKENGPNY
 TPSAWRRGHRVDFGKIFDGTAPFNKINWGSSPTPGDDGISFSNETIGSEPFATPPSSPSQ
 TPVINVN NVVGTVNIGDTNVS KSGTPTSSQSVD MSTDTSDLDTSIDTNNQTNNGDIN
 TNDNSNNVDGSLSDVDSRVEDDDGVSDTESTNGNDSGKTTSTEENGDPSPGDILAAVRKH
 LDTVYPGENGSGSTEGPLPANQNLGNVIHDVEQNGSAKETIITPGDTGPTDSSSSVDADAD
 VEDTSDTDSGIGDDDGVS DTESTNGNNSGKTTSTEENGDPSPGDILAAVRKHLDTVYPGE
 NGGSTEGPLPANQNLGNVIHDVEQNGAAQETIITPGDTESTDTSSSVNANADLEDVSDAD
 SGFGDDDGISDTESTNGNDSGKNTPVGDGGTSPGPDILAAVRKHLDTVYPGENGSGSTERP
 LPANQNLGDI IHDVEQNGSAKETVVS PYRGGGNTSSPIGLASLLPATPSTPLMTTPRTN
 GKAAASSLMIKGETQAKLVKNGGNI PGETTLAELL PRLRGHLDKVFTSDGKFTNLNGPQ
 LGAIIDQFRKETGSGGIIAHTDSVPGENG TASPLTGSSGEKVS LYDAAKNVTQALTSVTN
 KVTLAMQGQKLEGI INNNNTPSSIGQNLFAAARATTQSLSSLIGTVQ
 (SEQ ID NO:23)

FIGURE 1-14

X. *Chlamydia trachomatis* Tarp CT456

MTNSISGYQPTVTTSTSSSTTSASGASGSLGASSVSTTANATVTQTANATNSAATSSSIQTT
 GETVVNYTNSASAPNVTVSTSSSSTQATATSNTKTSQAVAGKITSPDTSSESSETSSTSSSD
 HIPSDYDDVGSNSGDISNNYDDVGSNNGDISSNYDDAAADYEPRTTENIYESIGGSRTS
 GPENTSGGAAAALNSLRGSSSYNYDDAAADYEPRTTENIYESIGGSRTSGPENTSGGAA
 AALNSLRGSSSYNYDDAAADYEPRTTENIYESIGGSRTSGPENTSDGAAAALNSLRGS
 SYTTGPRNEGVEFGPGPEGLPDMSLPSYDPTNKTSLTLFSLNPHVKS KMLEN SGHFV FIDT
 DRSSFILVPNGNWDQVCSIKVQNGKTKEDLDIKDLENMCAKFC TGF SKFSGDWDSLVEPM
 VSAKAGVASGGNLPNTVIINNKFCTCVAYGPWNSQEASSGYTPSAWRRGHRVDFGGIFEK
 ANDFNKINWGTQAGPSEDDGISFSNETPGAGPAAAPSTPSSIPIINVNVNVGGTNVNI
 GDTNVNTTNTPTTQSTDASTDTSIDDDINTNNQTDINTTDKSDGAGGVNGDISETES
 SSGDDSGSVSSSES DKNASVGNDGPAMKDILSAVRKHLDVVYPGENGGSTEGPLPANQTL
 GDVISDVENKGS AQDTKLSGNTGAGDDPTTTAAVNGAEEITLSDTDSGIGDDVSDTAS
 SSGDESGGVSSPSSSENKNTAVGNDGPGSLDILA A VRKHLDKVYPGDNGGSTEGPLQANQ
 TLGDIVQDMETTGTSTQETVVSPWKGSTSSSTESAGGSGSVQTL LPSPPPTPSTTTLRGTG
 ATTTSLMMGGPIKADIITGGGGRI PGGGTLEKLLPRIAHLDISFDAQGLDVSTEEPQL
 GSIVNKFRQETGSRGILAFVESAPGKPGSAQVLTGTGGDKGNLFQAAA AVTQALGNVAGK
 VNLAIQGGQLSSSLVNDDGKGSVGRDLFQAAAQTTQVLSALIDTVG (SEQ ID NO:24)

Y. *Chlamydia muridarum* TC0285

MRTLSISMLILALSCGENTCLCAADSPKAKVDASIGNGASFSPFTGEIKGNRVRLRLAPH
 TDSSIIKELSKGDC L AVLGESKDYVVA APEGVRGYVFRTFVLDNVIEGEKVNVRLEPST
 SAPI LARLSKGT VVKTLGAAQ GKWVEIALPKQCVFYVAKNFVKNVGALELYNQKEGQKKI
 ALDLLNSAMSFADAELQKKVEDIDLDAIYKKMNLAQAEFEKDVPG LQPLVQKALERVQEA
 FLAKSLEKGSHTKTVESYKPVETQAQLQ PQRQVIEEKNVSVVPEAPVLSQVEEPKSVLTSS
 SEVEPLQDVGP IKGSLLSHYIRKKGFVKTS PVVEGRESFERSLFEVWVNLQPEEIRNGLT
 MESFYRDEQKKRVL TGELEVYPHIVKNNPGDYLLKNGEDVVA FVYATSIDLSKWL GKRV
 VLECVSRPNNHFAFPAYIVLSIKEGA (SEQ ID NO:25)

Z. *Chlamydia trachomatis* CT017

MLIFALSGADAC LCAADLSKAKVEASVGDR AAFSPFTGEIKGNRVRLRLAPHTDSFIK
 ELSKGDC L AVLGESKDYVVA APEGVRGYVFRTFVLDNVIEGEKVNVRLEPST SAPI LAR
 LSKGT VVKTLGAAQ GKWIEIALPKQCVFYVAKNFVKNVGALDLYNQKEGQKKLALDLLSS
 AMDFADELQKKIEDIDLDAIYKKMNLAQSEEFKDVPG LQSLVQKALERVQEAFLAKSLE
 KSSVKVPEIRHKVLEEIAVVSPA VEETPVVTKTEEQKVTTVPVPAPAVVTEPAQDLSSVK
 GSLLSHYIRKKGFVKASPVIEGRESFERSLFAVWLSLQPEEIRHQLTMESFYRDEQKKR
 VLTGELEVYPHIVKNNPGDYLLKNGEDVVA FVYATSIDLSKWL GKSVVLECVSRPNNHFA
 FPAYIVLSVKEGA (SEQ ID NO:26)

AA. *Chlamydia muridarum* RplF TC0801

MSRKARDPIVLPQGVESIQNDEISVKGP KGS L TQVLAKEVEIAVKGNEVFVSPA AHIID
 RPGRMQGLYWALIANMVKG VHLGF EKRL EMIGVGFRASVQGSFLDLSIGVSHPTKMPIPT
 GLEVSVEKNTLISIKGINKQLVG EFAACVRAKRPPEPYKKGKIRYEN EYVRRKAGKAAKT
 GKK (SEQ ID NO:27)

BB. *Chlamydia trachomatis* RplF CT514

MSRKARDPIVLPQGVESIQNDEISVKGP KGS L TQVLAKEVEIAVKGNEVFVTPAAHVVD
 R PGRIQGLYWALIANMVKG VHTGF EKRL EMIGVGFRAAVQGSLLDLSIGVSHPTKMPIPT
 GLEVSVEKNTLISIKGINKQLVG EFAACVRAKRPPEPYKKGKIRYEN EYVRRKAGKAAKT
 GKK (SEQ ID NO:28)

FIGURE 1-15

CC. *Chlamydia muridarum* Aasf TC0707

MSNFQKEEQGQTGILHLQKLDGVSSPAVQESISESLSNMKNIIILDCAALDYISSAGIR
 VLLQSYHQVGKNAGKIALTSISKTVETQTLVVTGFLSYFKVFDSEALQALEKENS
 (SEQ ID NO:29)

DD. *Chlamydia trachomatis* Aasf CT424

MSNFQKEEQGQTGILHLQKLDGVSSPAVQESISESLSNMKNIIILDCGDLDYISSAGIR
 VLLQSYHQVGKNAGKIALTSISKTVETQTLVVTGFLSYFKVFDSEALQALEKENS
 (SEQ ID NO:30)

EE. *Chlamydia muridarum* TC0420

MKKNFLKGVPIPGGLSTDEGTGVKDQNLWLNATLNVRGDATVEDKVTGRDLNVTGPKIQ
 TDVDSLVRDVKGGRTTELGETVLKGDFSICKDMGQAPQFTNLSPLSARDAITFDYYRDR
 STQAYNCVTGYRVSVAGESFLDLHANNRSDVESFTPMYRNRFYWNGNDKQRLYLKSPGIY
 QVAFQILRNSGYHAGNDDPTVFLRLYTSEYEYTNLCTGDTRGFSQGNNTNTSLYSIFSIP
 SIGDEMPFVRVFTKIYIDIARTMINVIWFPFGSSYTEED (SEQ ID NO:31)

FF. *Chlamydia trachomatis* CT143

MKKPVFTGGAPIPGISTEEGTGVKDQNLWLRNATLKVEGDATIDDTLTSRDLKVTGPTIH
 TDLDSLVRDVKGGRTVLGETVLEGDFNIKCNGQVQPFTNLSPLSARDAITFDYYRDR
 STQAYNCATHRNGALVNGNRFIDLRLHNSDESSEYTPMYRNRFYWKDNDQKKLYLKSPGI
 YQVAFQIFRSGGYHSGNDDPTIFLRLYTSAYEYTNLCTGDTRGFNPGNTTNTSLYSIFSIP
 PSIGNEHPFIQVFTKIHVNIAYSMINVIWFPFGSSYKEAD (SEQ ID NO:32)

GG. *Chlamydia muridarum* TC0190

MKRSLLLLFFCSSSFLTSCSKSFQTIQDENPLTILTPALADQKIAKIIICPNGLPLMIVSS
 PKASESGAALVVKTGNNADPLEFPGLAHFTEHCVF LGNEKYPQPSGFPAFLSTHGGIYNA
 FTYPDKTCFLFSVNNSDLDTALDQFVHLFIHPLFRQEDLNKEVHAVEQEFAMHPTKDSRR
 MHRIQQIIAPKEHPLKRFSGCNLSTLDTVTSQDMQTFWSTHYPENMAAIVYTTAPLDVA
 VPYIAKIFSQIPKSSKYTPQTPFTKTQDTSSLNKLFINKAVERSPQLAIYWHLYDAPASL
 QGWAQSLVSVLSSEKEHSLIALLLKKEHLITHMEAGTYNTSLNTQDFEIIYKLTTKGEREY
 QKVLQLTFAFLDYVRDEQLPAYILPELHRINSLEYTYSTQTELFLTLTQMIPDFASEPLA
 TYPYQSTIYPKYSHEDQTFALLADPQQARYILSATLPSSLEDADEFYDPIFDITFYEK
 PLNFEPKIDYSSLGFTFPQPNKFIPQKVQLLSQKKQHEGFAFSPKLTYNQDAITLYTCED
 SFYTVPKMAMELRIRSPQIQRADVRSLVLRDLYSLLANETLVKHYDEALRAGMDFSVSPG
 ATGVDLSLFGYTETSPVLIDSLSSLRDLPLDKSLFLYKQDQLEQYQKGLISCPMRAGL
 NKLSEGLLEGGFFSLEEKQNALDIISYEEFEDFAHKMLTELSIEAFTLGTLSQDLSNVLA
 SLSHFSEASLPYDPPSYYPKRKPLFTTDFSFQYPLSGNGMLLLEQNEHPNQYEDSVATSM
 LLSWIHNLYYNDLRTNQQLGYMVGAKYQEFAPETPCGLFYIRSNKSSPEELVNKTQLFLQK
 IATDPEASGLSEEIFEQLRETYIQSVLLPSATPSAMARKLFSIAFETEKHDFSRPDKKIA
 AARSMNYSYFKEYCKEFFNQKFGPEIQLLIYGSDSQONE (SEQ ID NO:33)

FIGURE 1-16

HH. *Chlamydia trachomatis* CT806

MDNHPPVINDPTNDPKNMKRSLSLLLLCIPSFLTACSKSFQTIRDENPLTILTPALADQK
 IAKILCPNGLSLMIVSSPHAAESGAALVVKTGNNADPVEFPGLAHFTEHCVFLGNEKYPE
 PSGFPAFLSTHGGIYNAFTYPDKTCFLFSVNNADLDNALDQFVHLFIQPLFRQEDLNKEV
 HAVEQEFAMHPTKDSRRMHRIQQLIAPKNHPLKRFGCGNLSTLNSVTTQDMQTFATHYS
 PENMAAIVYTTAPLDTAVPYIASLSEIPISAQYTPQKFPKTDTTALNKLFINKAVEP
 SPQLAIYWHFYDAPQSLQGWAQSLISILSSEKENS LVALLKKEQLITEMEALYSTSHNT
 QDFEILYKLTNKGREYQRVLQLTFAFLDYVRHERLPAYSLPEIQKINSLEYTYSTQTEL
 FSTLSRMVFNFTSEPLATYPYRSLVYPEYSQEQTFATFLADPQQARYILSATLPSSWE
 NADEFYDPIFDDTFYEKPLDFTPIQDSSSLGFAFPNPNKFIPQTVQLLSQKKQHEGFAFS
 PQLTYDQNAITLYTCEDSFYTI PKMAMELRIRSPQIQRTDVRSLVLRDLYSLLANETLIK
 RYDDALKAGMTFAVSPGATGVDLSSLGYTETSPVLINALLSSLRDLPVEESLFLYKQDL
 SEQYQKNLIACPIRAGLNKLYSQILVDTVSLDKLNTLNTLSYEEFANFTNKLQELAVE
 SLALGTLSAQDLSNLLSTLSNFAEASSPYAAPSYYPQRKPLSSTKLSFOYPLSGNGMLLL
 EQNEDPHQYKDSVATSMLLSWIHNLVYFSDLRTEQQLGYMVGSKYLEFAETPCGLFYIRSN
 NYSPEELVHRTQLFIQKIATDPESAGLSEEIFEQLRETYIQSILLPSSTPLAMAKKLFISI
 AFETKKQDFSRPDQKIAAARSMDYSYFKKYCEEFLSQKFGPEIQLLVYGANSSEQE
 (SEQ ID NO:34)

II. *Chlamydia trachomatis* CT619

MSSYYLNFRTTTSVSGEGLFKIKLANPGSDFKNQARPAIDMEELNSGLYVLRRLAVALAEG
 YLGVGSVVNPSNRIFPGGDWGVRRAGGRTPAAGIISGSTIADIKQSTAKVLVTTITDSL
 NALIEDVPELPMTOVAGISSTLVLMATYQOKPSLDETDQKAIFGSAYIPADTSIKDVIKK
 EQEKELQEGKDRIQALTAQGASNQVIEKSLADYEKYYVNEYFDTHVKEALWKHRASIGE
 NIQEMLDQCLVLGLDVPDSLTKENINDANAKLVLAQWMEAFNNAMEVEPALGGSKEVIDS
 VLKMI PFAKPDANLSAEDISSIIYTAALPSPEVMDYYLTRQDAGVCKGEVVKAQQATQN
 LQSVRSNVEEQIKELEVKKTSLFLQAQASLESMLGKRLSDNKDFTSVRLTSVMECYAGL
 MALSQIAGVLEDEGLTLITKYVNQFLQLNNANTDQTLAHVISYMVAYCEVAESTMASTIS
 DENTVIQKVRNKWTELTKQKFFSSFNSTMPSEEELKKNYITNKN SVYQANFGNFVDNVIT
 RNLNLSDAVTKAQSMLETFQGKATEYLSKFQQEINELNRTYDTLDPAKASFNTSTGSTPS
 LRAQAVDSWIDSTSLGSAFIHLILNTQIPKQENFLNPLIQEVNFNNVAANAVNDLLSITN
 NFSTSSVYYNLSSYLVESKEGENLFCGDFFEFIGALAKEHEYIVRDINSCYRAEAFGEAL
 LARVEALAQGHKVTDAQANSMTQANLYLSFIRIIVEQLAVLDSLLRSLNVEVEKKDNNY
 DKDKYKITGPTDWISTLASLEGYAANGFDNASPSGGLGPMHTLVQTDQHDYLTQSQTQQL
 NLQNQMTNIQQEWTLVSTSMQVLNGILSHLAAEIYSN (SEQ ID NO:35)

FIGURE 1-17

A. *Chlamydia muridarum* PmpE-PmpF (TC0261-TC0262) fusion

REVPPSILLKPILNPYHMTGLFFPKVNLLGDTHNLTDYHLDNLKCILACLQRTPYEGAAFT
 VTDYLGFSDTQKDGIFCFKNLTPESGGVIGSPTQNTPTIKIHNTIGPVLFENNTCHRLWTQ
 TDPENEGNKAREGGAIHAGDVYISNNQNLVGFIFKNFAYVQGGAISANTFAYKENKSSFLCL
 NNSCIQTKTGKGGAIYVSTSCSFENNNKDLLFIQNSGCAGGAIFSPTCSLIGNQGDIVFY
 SNHGFKNVDNATNESGDGGAIKVTTRLDITNNGSQIFFSDNISRNFGGAIHAPCLHLVGN
 PTYFTNNIANHTGGAIYITGTETSKI SADHHAIIFDNNISANATNADGSSSNTNPPHRNAI
 TMDNSAGGIELGAGKSQNLIFYDPIQVTNAGVTVDENKDSQTGCVVFSGATVLSADISQA
 NLQTKTPATLTLSHGLLCIEDRAQLTVNNFTQTGGIVALGNGAVLSSYQHSTTDTATQTPPT
 TTTTDDASVTLNHIGLNLPSILKDGAEMPLLLWVEPISTTQGNNTTYTSDTAASFSLNGATLS
 LIDEDGNSSETDTLKLPLNLTFGGREIEFIVTPPSSIAAQYITYANVSNYRGNFTISSCTQD
 QWFSRGLSTTNSSGAFVESMTSFTAIDNADLFFCNNTYTHQGGGGAINATGLISFKNNQNI
 LFYNNNTTIGTQFTGVALRTERNRGGALYGSSIELINNHSNLFINNTSGDMGGAVSTIQNLV
 IKNTSGIVAFENNHTTDHIPNTFATILARGGAVGCQGACEISHNTGPVVFNSNYGGYGGAI
 STGGQCFIRDNDKDLIFINNSALGWHNTSAQONGAVISAGGEFGLLNKGPYFENNNASY
 IAGAISCNNLNFQENGPIYFLNNSALYGGAFHLFASPAANYIHTGSGDIIFNNNTELSSTG
 MSAGLRKLFYIPGTTNNNPITLSLGAKKDTRIIFYDLFQWGGLKKANTPPENS PHTVTINP
 SDEFSGAVVFSYKNISSDLQAHMIASKTHNQIKDSPTTLKFGTMSIENGAEFEFFNGPLTQ
 ESTSLLALGQDSILTGVGDASLTITHLGIILPGLLNDQGTAPRIRVNPQDMTQNTNSNQA
 PVSTENVATQKIFF (SEQ ID NO: 36)

B. *Chlamydia muridarum* PmpG-PmpH fusion (TC0263-TC0264)

ADISMPPGIYDGTTLTAPFPYTVIGDPRGKTVTSSGSLELKNLDNSIATLPLSCFGNLLGN
 FTIAGRHSLSLVFENIRTSTNGAALS NHAPSGLFVIEAFDELSLLNCNSLVSVVPQTGGTTT
 SVPSNGTIYSRTDLVLRDIKKVSFYSNLVSGDGGIDAQSLMVNGIEKLCTFQENVAQSDG
 GACQVTKTFSAVGNKVPLSFLGNVAGNKGGGVAAVKDGQAGGATDLSVNFANNTAVEFEG
 NSARIGGGIYSDGNI SFLGNAKTVFLSNVASPIYVDPAAAGGQPPADKDNYGDDGAI FCKN
 DTNIGEVSFKDEGVVFFSKNIAAGKGGAIYAKKLTISDCGPVQFLGNVANDGGAIYLVDDQ
 ELSLSADRGDII FDGNLKRMTQGAATVHDMVASNAISMATGGQITTLRAKEGRRIIFND
 PIEMANGQPVIQTLTVNEGEGYTGDIVFAKGDNVLYSSIELSQGRIILREQTKLLVNSLTQ
 TGGSVHMEGGSTLDFAVTTPPAANSMALTNVHFSLASLLKNNGVTNPPTNPPVQVSSPAVI
 GSSPQVLTPNVIIPFKGDDIYLNDCVFIYAGAEQGSII SANGQNLTIQVQNHTLSFTD
 SQGPALQNCAFISAEKISLRDFSSLLFSKNVSCGEKGMISGKTVSISGGDSIVFKDNSVG
 YSSLPSVGQTPTTPIVGDLKGSIFCVETGLEISGVKKELVFDNTAGNFGAVFCSRAAQGD
 TTFTVKDCKGKILFQDNVSGCGGGVIYKGEVLFDQNEGEMLFGRNSAHDDLGLLDANPQPP
 TEVGGGGGVICTPEKTVTFKGNKGPITFDYNFAKGRGGAIQSQTFSVLVADS AVVFSNNTAE
 KGGGAIYALEVNVSTNGGSILFEGNRASEGGAICVSEPIAANNGLTLHAADGDIIFSKNM
 TSDRPGERSAIRILDSGTNVSLNASGASKMIFYDPVQNNPATPPTGTSGEIKINESGSGS
 VVFTAETLTPSEKLNVINATSNFPGNLTVSSGELVVTKGATLTVGNITATSGRVTLGSGAS
 LSAVAGTAGTCTVSKLGIDLESFLVPTYETAKLGADTTAVVNNNPTLDLVMANETEMYDNP
 (SEQ ID NO: 37)

FIGURE 2-1

C. *Chlamydia muridarum* *pmpE*-*pmpF* (TC0261-TC0262) fusion

CGAGAAGTCCCTCCTTCGATTCTTTTAAAGCCTATACTAAATCCATACCATATGACCGGGTT
 ATTTTTTCCCAAGGTTAATTTGCTTGGAGACACACATAATCTCACTGATTACCATTTGGATA
 ATCTAAAATGCATTCTGGCTTGCCTACAAAGAACTCCTTATGAAGGAGCTGCTTTTACAGTA
 ACCGATTACTTAGGTTTTTTCAGATACACAAAAGGATGGTATTTTTTGTTTTAAAAATCTTAC
 TCCAGAGAGTGGAGGGGTTATTGGTTCCCAACTCAAAACACTCCTACTATAAAAATTCATA
 ATACAATCGGCCCCGTTCTTTTCGAAAATAATACCTGTCATAGACTGTGGACACAGACCGAT
 CCCGAAAATGAAGGAAACAAAGCACGCGAAGGCGGGGCAATTCATGCTGGGGACGTTTACAT
 AAGCAATAACCAGAACCTTGTGCGATTCTATAAAGAACTTTGCTTATGTTCAAGGTGGAGCTA
 TTAGTGCTAATACTTTTGCCTATAAAGAAAATAAATCGAGCTTTCTTTGCCTAAATAACTCT
 TGTATACAACTAAGACGGGAGGGAAAGGTGGTGTATTTACGTTAGTACGAGCTGCTCTTT
 CGAGAACAATAACAAGGATCTGCTTTTTCATCCAAACTCCGGCTGTGCAGGAGGAGCTATCT
 TCTCTCCAACCTGTTCTCTAATAGGAAACCAAGGAGATATTGTTTTTTACAGCAACCACGGT
 TTTAAAATGTTGATAATGCAACTAACGAATCTGGGGATGGAGGAGCTATTAAAGTAACTAC
 CCGCTTGGACATCACCAATAATGGTAGTCAAATCTTTTTTTCTGATAATATCTCAAGAAATT
 TTGGAGGAGCTATTCTGCTCCTTGTCTTCATCTTGTGGTAATGGGCCAACCTATTTTACA
 AACAATATAGCTAATCACACAGGTGGGGCTATTTATATAACAGGAACAGAAACCTCAAAGAT
 TTCTGCAGATCACCATGCTATTATTTTTGATAATAACATTTCTGCAAACGCCACCAATGCGG
 ACGGATCTAGCAGCAACACTAATCCTCCTCACAGAAATGCGATCACTATGGACAATTCGGCT
 GGAGGAATAGAACTTGGTGCAGGGAAGAGCCAGAATCTTATTTTCTATGATCCTATTCAAGT
 GACGAATGCTGGAGTTACCGTAGACTTCAATAAGGATGCCTCCCAAACCGGATGTGTAGTTT
 TCTCTGGAGCGACTGTCCTTTCTGCAGATATTTCTCAGGCTAATTTGCAAATAAACACCT
 GCAACGCTTACTCTCAGTCACGGTCTTCTGTGTATCGAAGATCGTGCTCAGCTCACAGTGAA
 CAATTTTACACAAACAGGAGGGATTGTAGCCTTAGGAAATGGAGCAGTTTAAAGCAGCTACC
 AACACAGCACTACAGACGCCACTCAAACCTCCCCCTACAACCACCACTACAGATGCTTCCGTA
 ACTCTTAATCAGATTGGATTAAATCTCCCCCTATTCTTAAGGATGGAGCAGAGATGCCTCT
 ATTTAGGGTACAGCTATAAGCACAACTCAAGGTAACACTACAACATATACGTAGATACCG
 CGGCTTCCTTCTCATTAAATGGAGCCACACTCTCTCTCATTGATGAAGATGGAATTCAGT
 GAAACCGATACACTCAAACCTTCCGAACCTTGACTTTTGGTGGTAGAGAGATTGAATTCATAGT
 TACTCCGCTAGCTCCATTGCTGCTCAATACATCACTTACGCAAATGTTTCTAATTATAGAG
 GGAACCTTACTATTTCAAGTTGTACGCAGGATCAATGGTTTTTCGAGAGGTTTAAAGCACTACA
 AACTCTAGTGGAGCTTTTGTGAGTCTATGACTTCTTTCACAGCCATTGACAATGCAGACTT
 GTTTTTTTGTAACAATTATTGCACCCATCAGGGAGGAGGGGGAGCTATAAATGCTACAGGCC
 TTATTAGCTTTAAAACAACCAAAACATATTGTTCTATAATAATACTAATTGGAACCTCAA
 TTTACAGGAGTAGCATTAAAGAACCGAAAGGAATCGCGGAGGGGCTTTATACGGATCAAGCAT
 CGAGCTAATTAATAATCATAGCTTAAATTTTATCAATAACACTTCTGGGGATATGGGAGGAG
 CCGTATCCACAATCCAAAACCTAGTTATCAAAAATACGTCCGGAATAGTTGCTTTTGAAAAAT
 AACCATACTACTGATCACATACCCAACACATTTGCTACAATTCTTGCTCGAGGAGGAGCTGT
 TGGCTGCCAAGGTGCCTGCGAAATCTCACACAATACTGGTCCGGTAGTCTTCAATTCCAACCT
 ATGGAGGATACGGAGGAGCTATCAGCACCGGGGGACAGTGTATTTTTAGAGATAATAAGGAT
 AAGCTTATTTTTATAAATAATAGCGCTTTAGGATGGCATAACACTAGTGCTCAAGGAAATGG
 AGCAGTTATAAGCGCAGGAGGAGAGTTTGGTCTTCTAAATAATAAAGGCCCTATCTACTTTG
 AGAATAATAATGCCTCATACATAGCAGGAGCTATTTCTGCAACAACCTTAATTTTCAAGAA
 AATGGTCTCTATCTATTTTCTTAATAATTGCGCTCTGTATGGAGGAGCTTTTACCTATTTGC
 AAGCCCAGTGCGAACTATATTCATACTGGCTCTGGGGATATTATCTTCAACAATAATACAG
 AGCTTTCAACTACCGGAATGTCAGCAGGTTTGCAGAAAACCTTTTTATATTCTTGAACAACC
 AACAATAACCTATCACCTATCTCTTGGTGCTAAGAAAAGATACTCGCATCTATTTTTATGA
 TCTTTTTTCAATGGGGAGGCTTAAAAAAGCTAATACACCCCTGAAAATAGCCCGCACACCG
 TTACCATCAATCCTTCGGATGAGTTCTCTGGCGCTGTTGTGTTTTCATACAAAAACATATCC
 AGTGATCTACAAGCTCACATGATTGCCAGTAAACTCATAACCAAATTAAGACTCCCCCAC
 TACCTTGAAGTTTGGGACTATGTCCATAGAAAATGGCGCAGAGTTTGAATTTTTCAATGGCC
 CTCTTACTCAAGAAAGCACTAGCCTTCTTGCTTTAGGACAAGATTCTATTCTTACTGTAGGG
 AAAGACGCTTCTCTCACTATTACGCATCTTGAATCATTTTGCCAGGTCTTCTCAATGACCA
 AGGTACTACAGCTCCACGTATTCTGTGTTAATCCCCAAGATATGACACAGAATACAACTCTA
 ACCAAGCTCCAGTAAGCACAGAGAACGTGGCAACTCAAAAGATCTTTTTTC (SEQ ID
 NO: 38)

FIGURE 2-2

D. *Chlamydia muridarum* *pmpG-pmpH* fusion (TC0263-TC0264)

GCAGATATTTCCATGCCTCCGGGAATTTATGATGGGACAACATTGACGGCGCCATTTCCCTA
 CACTGTGATCGGAGATCCCAGAGGGACAAAGGTTACTTCATCGGGATCGCTAGAGTTGAAAA
 ACCTGGACAATTCCATTGCGACTTTACCTCTAAGTTGTTTTGGTAATTTGTTGGGGAATTTT
 ACTATTGCAGGAAGAGGGCATTTCGTTAGTATTTGAGAATATACGAACATCTACAAATGGGGC
 GGCATTGAGTAATCATGCTCCTTCTGGACTGTTTGTAATTGAAGCTTTTGATGAACTCTCTC
 TTTTGAATTGTAATTCATTGGTATCTGTAGTTCCTCAAACAGGGGGTACGACTACTTCTGTT
 CCTTCTAATGGGACGATCTATTCTAGAACAGATCTTGTTCTAAGAGATATCAAGAAGGTTTC
 TTTCTATAGTAACCTAGTTTTCTGGAGATGGGGGAGCTATAGATGCACAAAGTTTAATGGTTA
 ACGGAATTGAAAAACTTTGTACCTTCCAAGAAAATGTAGCGCAGTCCGATGGGGGAGCGTGT
 CAGGTAACAAAGACCTTCTCTGCTGTGGGCAATAAGGTTCTTTTGTCTTTTTTAGGCAATGT
 TGCTGGTAATAAGGGGGAGGAGTTGCTGCTGTCAAAGATGGTCAGGGGGCAGGAGGGGCGA
 CTGATCTATCGGTTAATTTTGCCAATAATACTGCTGTAGAATTTGAGGGAAATAGTGCTCGA
 ATAGGTGGAGGGATCTACTCGGACGGAAATATTTCTTTTTAGGGAATGCAAAGACAGTTTT
 CCTAAGTAACGTAGCTTCGCCTATTTATGTTGACCCTGCTGCTGCAGGAGGACAGCCCCCTG
 CAGATAAAGATAACTATGGAGATGGAGGAGCCATCTTCTGCAAAAATGATACTAACATAGGT
 GAAGTCTCTTTCAAAGACGAGGGTGTTGTTTTCTTTAGTAAAAATATTGCCGCAGGAAAGGG
 GGGCGCTATTTATGCTAAGAACTGACAATTTCTGACTGTGGTCCGGTCCAGTTTCTTGGA
 ATGTCGCGAATGACGGGGGCGCTATTTATCTAGTAGATCAGGGGGAACCTAGTCTATCTGCT
 GATCGCGGAGATATTATTTTTGATGGAAATTTAAAGAGAATGGCTACGCAAGGCGCTGCCAC
 CGTCCATGATGTAATGGTTGCATCGAATGCTATCTCTATGGCTACAGGGGGGCAAATCACAA
 CATTAAGGGCTAAGGAAGGTCGCCGAATTCTTTTAATGACCCTATTGAAATGGCGAATGGA
 CAACCTGTAATACAACTCTTACAGTAAACGAGGGCGAAGGATATACGGGGGACATTGTTTT
 TGCTAAAGGTGATAATGTTTTGTACTCAAGTATTGAGCTGAGTCAGGGAAGAATTATTCTCC
 GAGAGCAAACAAAATTATTGGTTAACTCCCTGACTCAGACTGGAGGGAGTGACATATGGAA
 GGGGGGAGTACACTAGACTTTGCAGTAACAACGCCACCAGCTGCTAATTCGATGGCTCTTAC
 TAATGTACACTTCTCCTTAGCTTCTTTACTAAAAAATAATGGGGTTACAAATCCTCCAACGA
 ATCCTCCAGTACAGGTTTCTAGTCCAGCTGTAATTGGTAGTTCTCTCAGGTACTGACCCCC
 AATGTAATCATCCCTTTTAAAGGAGACGATATCTATTTAAATGGGGATTGCGTTTTTGCAAG
 TATCTATGCAGGAGCAGAGCAGGGATCGATTATTTCTGCTAATGGGCAAAATCTAACATCG
 TAGGACAAAACCACACTTTATCATTTACGGATTCCCAAGGGCCAGCCCTTCAAAATTGTGCT
 TTCATTTTCAGCAGAAGAAAAGATCTCTCTAAGAGATTTTTTCGAGCCTTTGTTTTGAAAAA
 TGTTTTCTTGGCGGGAGAAAGGAATGATTTTCAGGGAAAACCGTAAGCATTTCAGGGGGAGATA
 GTATAGTTTTTAAAGGATAACTCTGTTGGTTATTCTTCATTACCCTCTGTGGGGCAAACCTCT
 ACAACTCCAATTGTTGGCGATGTTTTAAAGGGATCCATTTTTTGTGTGGAGACAGGTTTAGA
 GATTTCTGGAGTCAAAAAGAGCTTGTTTTCGATAACACTGCTGGGAATTTTGGGGCAGTAT
 TCTGTAGTCGTGCCGCTCAAGGAGACACGACTTTCACAGTGAAAGACTGTAAGGGTAAAAAT
 CTTTTTCAAGATAACGTAGGCTCTTGTGGAGGCGGCGTAATTTATAAAGGGGAAGTACTTTT
 CCAAGATAATGAAGGAGAAATGCTTTTCCGAGGAAATTCAGCTCATGATGATTTGGGAATTC
 TCGATGCTAACCCACAGCCTCCTACTGAAGTAGGAGGTGGGGGTGGTGTCATTTGTACCCCCA
 GAGAAAACGGTAACTTTTAAGGGGAATAAAGGGCCTATTACCTTTGATTATAATTTTGCAAA
 AGGTCGAGGAGGGGCAATCCAATCACAGACCTTTTCTTTGGTAGCTGATAGTGCTGTTGTTT
 TCAGTAATAATACAGCTGAGAAAGGTGGAGGCGCCATTTATGCTCTTGAGGTTAACGTGAGC
 ACAATGGAGGATCTATTCTTTTTGAGGGAAATAGAGCTTCTGAGGGTGGGGCTATCTGTGT
 GAGCGAGCCGATCGCTGCTAATAATGGAGGGCTCACTTTACATGCTGCTGATGGGGACATTA
 TTTTCTCGAAAAATATGACGAGTGATCGTCTGGAGAACGCAGTGCAATCCGGATCTTAGAT
 AGTGGAACAAATGTCTCTTTAAATGCTTCAGGGGCATCGAAGATGATTTTTTATGATCCTGT
 TGTGCAAAATAATCCCGCAACTCCACCTACTGGTACGTCTGGGGAAATTAAGATCAATGAGT
 CCGGGAGTGATCGGTTGTGTTTACAGCAGAGACTTTGACTCCTTCGGAAAAATTGAATGTT
 ATCAACGCTACTTCTAATTTCCAGGAAATTTAACGGTATCTAGTGGAGAATTAGTTGTTAC
 GAAGGGAGCGACACTAACAGTAGGAAATATCACAGCAACATCAGGACGAGTAACCTTAGGAT
 CAGGGGCTTCGTTATCCGCCGTTGCAGGTACTGCTGGCACTTGACGGTGTCTAAATTAGGG
 ATTGATTTAGAGTCTTCTTAGTCCCTACTTATGAGACTGCAAAGTTGGGTGCGGATACAAC
 AGTAGCGGTGAATAACAATCCTACTTTAGACCTAGTAATGGCGAATGAGACGGAGATGTATG
 ATAATCCG (SEQ ID NO:39)

FIGURE 2-3

E. PmpE-PmpF (TC0261-TC0262) fusion

REVPPSILLKPIILNPYHMTGLFFPKVNLLGDTHNLT DYHLDNLKCILACLQRTPYEGAAFTVT DYLGFSDTQKDGIF
 CFKNLTPESGGVIGSPTQNTPTIKIHNTIGPVL FENNTCHRLWTQTD PENEGNKAREGGAIHAGDVYI SNNQNLVGF
 IKNFAYVQGGAI SANTFAYKENKSSFLCLNNSCIQTKTGKGGGAIYVSTSCSFENNNKDLLFIQNSGCAGGAIF SPT
 CSLIGNQGDIVFYSNHGFKNVDNATNESGDGGAIKVTTRLDITNNGSQIFFSNISRNFGGAIHAPCLHLVGNNGPTYF
 TNNIANHTGGAIYITGTETSKI SADHHAIIFDNNISANATNADGSSSNTNPPHRNAITMDNSAGGIELGAGKSQNLI
 FYDPIQVTNAGVTVD FNKDASQTGCVVFSGATVLSADISQANLQTKTPATLTLSHGLLCIEDRAQLTVNNFTQTGGI
 VALGN GAVLSSYQHSTT DATQTPPTTTT DASVTLNHIGLNLPSILKDGAEMPLLWVEPISTTQGN TTTTYSDTAAS
 FSLNGATLSLIDEDGNSPYENTDLSRALYAQ PMLAISEASDNQLQSESMDFSKVNVPHYGWQGLWTGWAKTENPTT
 TPPATITDPKKANQFHRTLLLTWLPAGYI P SPKHKSPLIANTLWGNILFATENLKNSSGOELLDRPFWSETDTLKL P
 NLTFGGREIEFIVTPSSIAAQYITYANVSNYRGNF TISSCTQDQWFSRGLSTTNSSGAFVESMTSFTAIDNADLFF
 CNNYCTHQGGGGAINATGLISFKNNQNILFYNN TTI GTQFTGVALRTERNRGGALYGSSIELINNHS LNFINNTSGD
 MGGAVSTIQNLVIKNTSGIVAFENNH TTDHIPNTFATILARGGAVGCQGACEISHNTGPVVFNSNYGGYGGAI STGG
 QCIFRDNKDKLIFINNSALGWHNTSAQGN GAVISAGGEFGLLNKGP IYFENNNASYIAGAI SCNNLN FQENGPIYF
 LNNSALYGGAFHLFASPAANYIHTGSGDI IFNNNTELTSTTGMSAGLRKLFYIPGTTNNNPITLSLGAKKDTRIYFYD
 LFQWGGLKKANTPPENS PHTVTINPSDEFSGAVVFSYKNISSDLQAHMIASKTHNQIKDSPTTLKFGTMSIENGAEF
 EFFNGPLTQESTSLLALGQDSILTVGKDASLTITHLGIILPGLLNDQGTTAPRIRVNPQDMTQNTNSNQAPVSTENV
 ATQKIFFSGLVSLVDENYESVYDSCDLSRGKANQ PILHIETTND AQLSNDWKNTLNTSLYSLPHYGYQGLWTSNWM T
 TTRTVSLTNSTETQTANNSIQEQKNTSETFDSNSTTTAKIPSIRASTGGTTPLATTDVTVTRHSLVVSWTPIGYIAD
 SEQ ID NO:40)

F. PmpG-PmpH fusion (TC0263-TC0264)

ADISMPPIYDGTTLTAPFPYTVIGDPRGKT VTS SSGSLELKNLDNSIATLPLSCFGNLLGNFTIAGRGHSLVFENIR
 TSTNGAALS NHAPSGLFVIEAFDELSLLNCNSLVSVVPQTGGTTTSVPSNGTIYSRTDLVLRDIKKVSFYSNLVSGD
 GGAI DAQSLMVNGIEKLCTFQENVAQSDGGACQVTKTFSAVGNKVPLSFLGNVAGNKGGGVA AVKDGQGAGGATDLS
 VNFANNTAVEFEGNSARIGGGIYSDGNISFLGNAKTVFLSNVASPIYVDPAAAGGQPPADKDN YGDGGAI FCKNDTN
 IGEVSFKDEGVVFFSKNIAAGKGGAIYAKKLTISDCGPVQFLGNVANDGGAIYLVDQGELSLSADRGDII FDGNLKR
 MATQGAATVHDVMVASNAIS MATGGQITTLRAKEGRRI LFNDPIEMANGQPVIQTLTVNEGEGYTGDIVFAKGD NVL
 YSSIELSQGRIILREQT KLLVNSLTQTGGSVHMEGGSTLDFAVTTPPAANSMALTNVHFSLASLLKNNGVTNPPTNP
 PVQVSSPAVIGNTAAGTVTISGPIFFEDLDETA YDNNQWL GADQTI DVLQLHLGANPPANAPTDLTLGNESSKYGYQ
 GSWTLQWEPDPANPPQNNSYMLKASWTKTGYNPGPERVASLVSNLSLWGSILDVRSASAIQASIDGRAYCRGSSPQV
 LTPNVIIIPFKGDDIYLN GDCVFAS IYAGAEQGSII SANGQNLTIVGQNHTLSFTDSQGPALQNC AFISAEKISLRD
 FSSLLFSKNVSCGEKGMISGKT VSI SGGDSIVFKDNSVGYS SLPVSGQTPTTPIVGDVLKGSIFCVETGLEISGVKK
 ELVFDNTAGNFGAVFCSRAAQGDTTFTVKDCKGKILFQDNVGS CGGGVIYKGEVL FQDNEGEMLFRGNSAHDDLGI L
 DANPQPPTVEVGGGGVICTPEKTVTFKGNKGPI TFDYNFAKGRGGAIQSQTFSLVADS AVVFSNNTAEKGGGAIYAL
 EVNVSTNGGSILFEGNRASEGGAICVSEPIAANN GGLTLHAADGDIIFSKNMTSDRPGERSAIRILDSGTNVSLNAS
 GASKMIFYDPVVQNNPATPPTGTSGEIKINESGSGSVVFTAETLTPSEKLNVINATSNFPGNLTVSSGELVVTKGAT
 LTVGNITATSGRVTLGSGASLSAVAGTAGTCTVSKLGIDLESFLVPTYETAKLGADTTVAVNNNP TDLV MANETEM
 YDNPLFMNAV TIFPVTLVSLQTTGGVTTSAVTLNNADTAHYGYQGSWSADWRRPPLAPDP SGMTPLDKSNTLYVTWR
 PSSNY (SEQ ID NO:41)

FIGURE 2-4

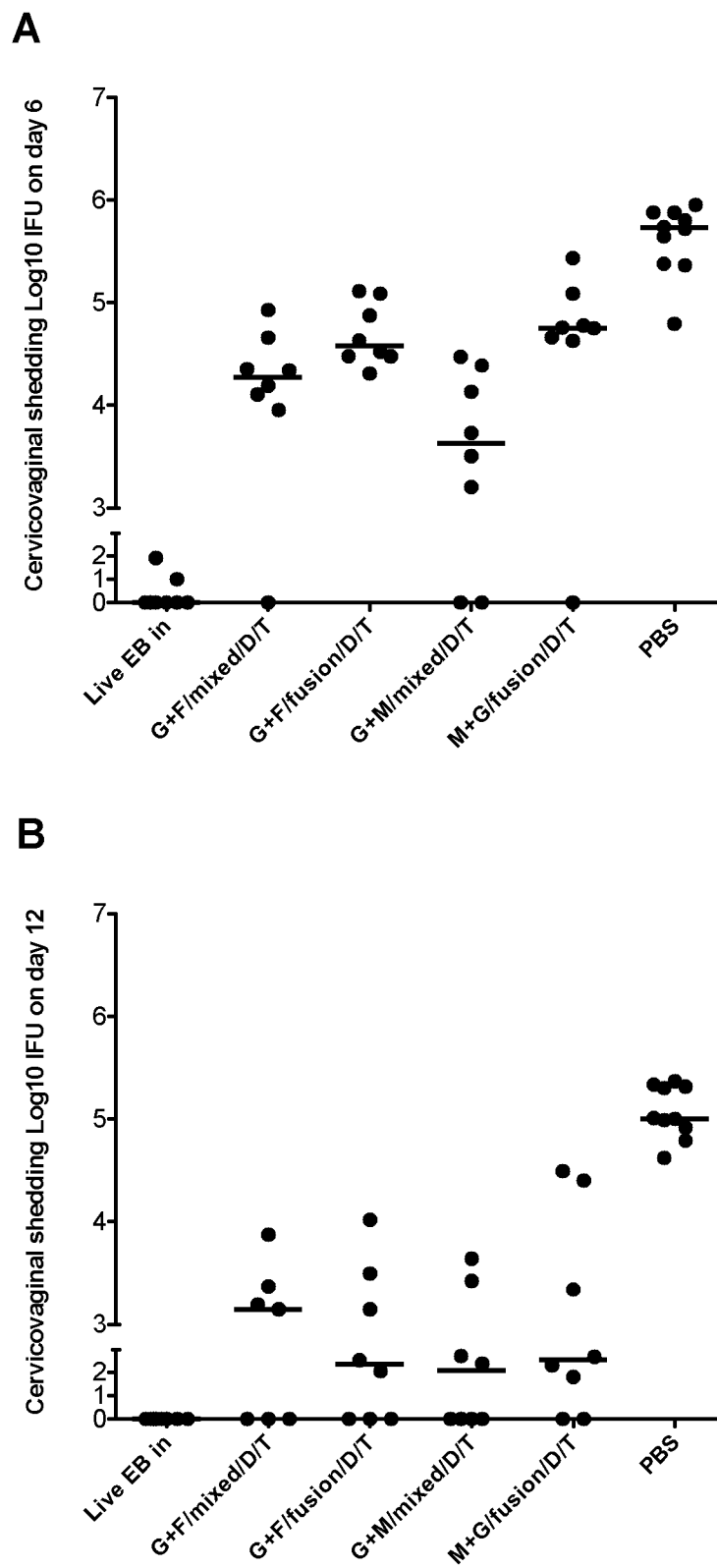


FIGURE 3

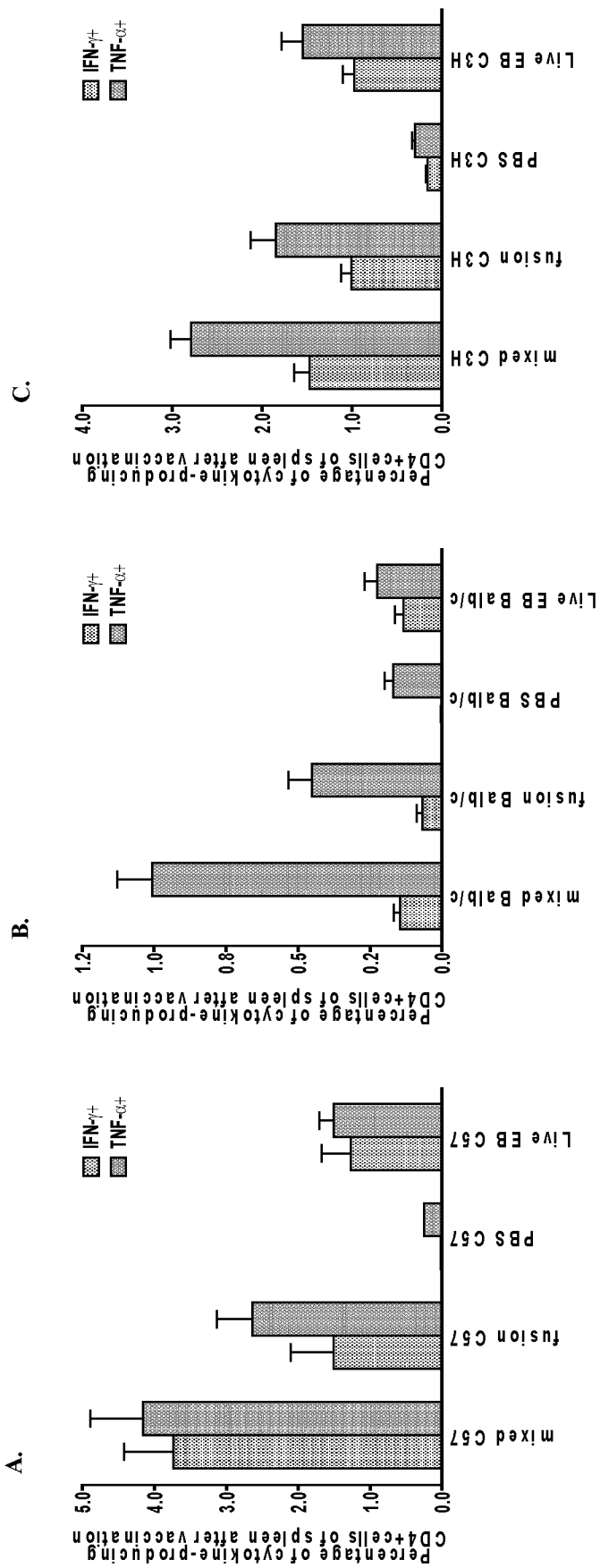


FIGURE 4

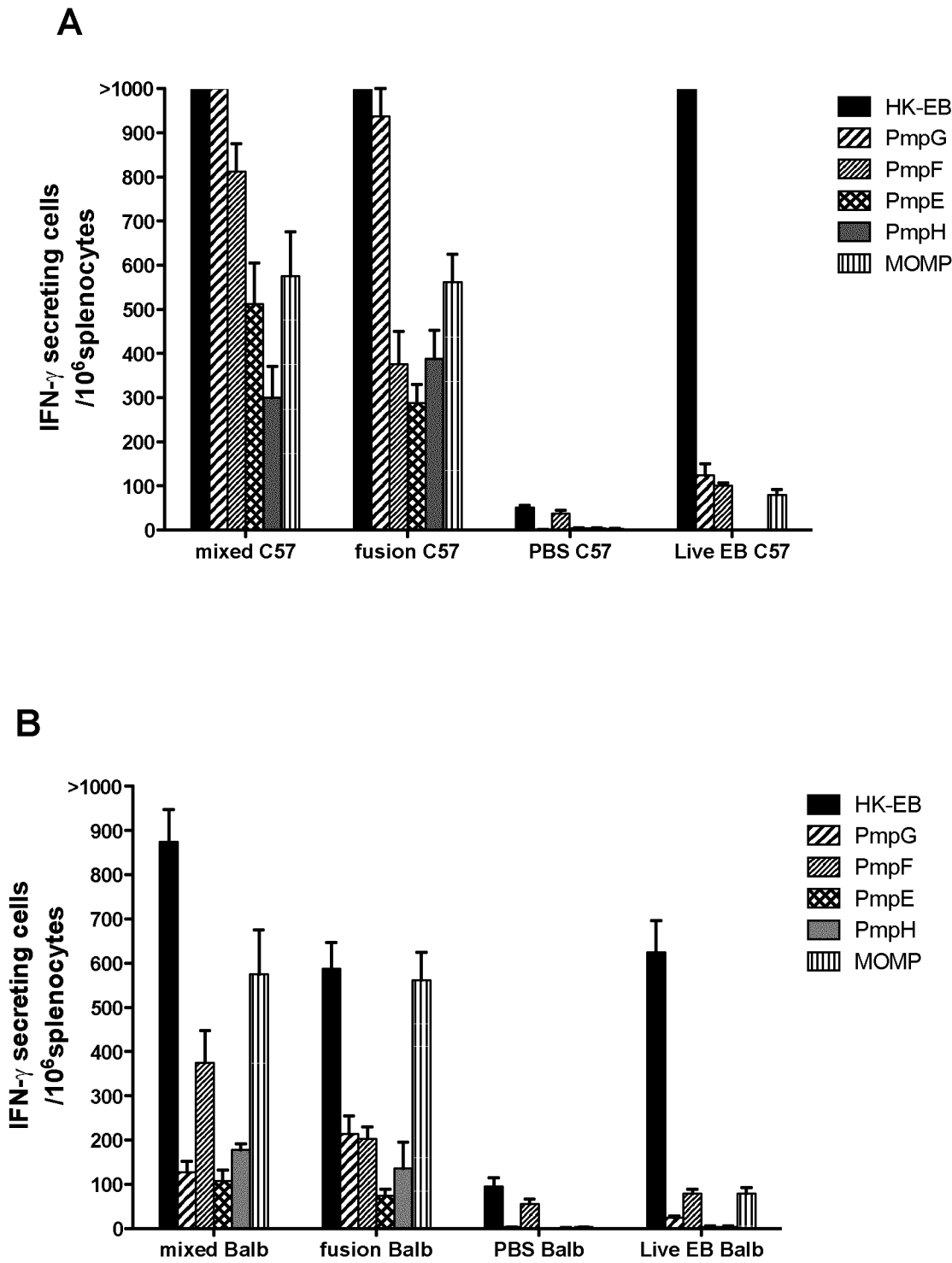


FIGURE 5-1

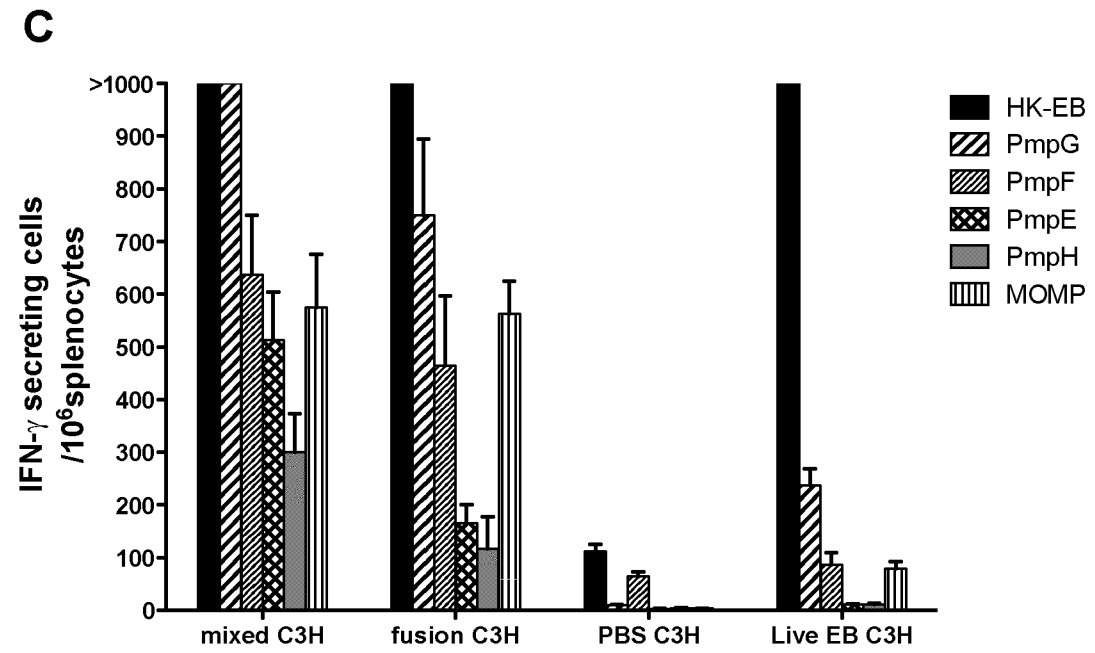


FIGURE 5-2

A

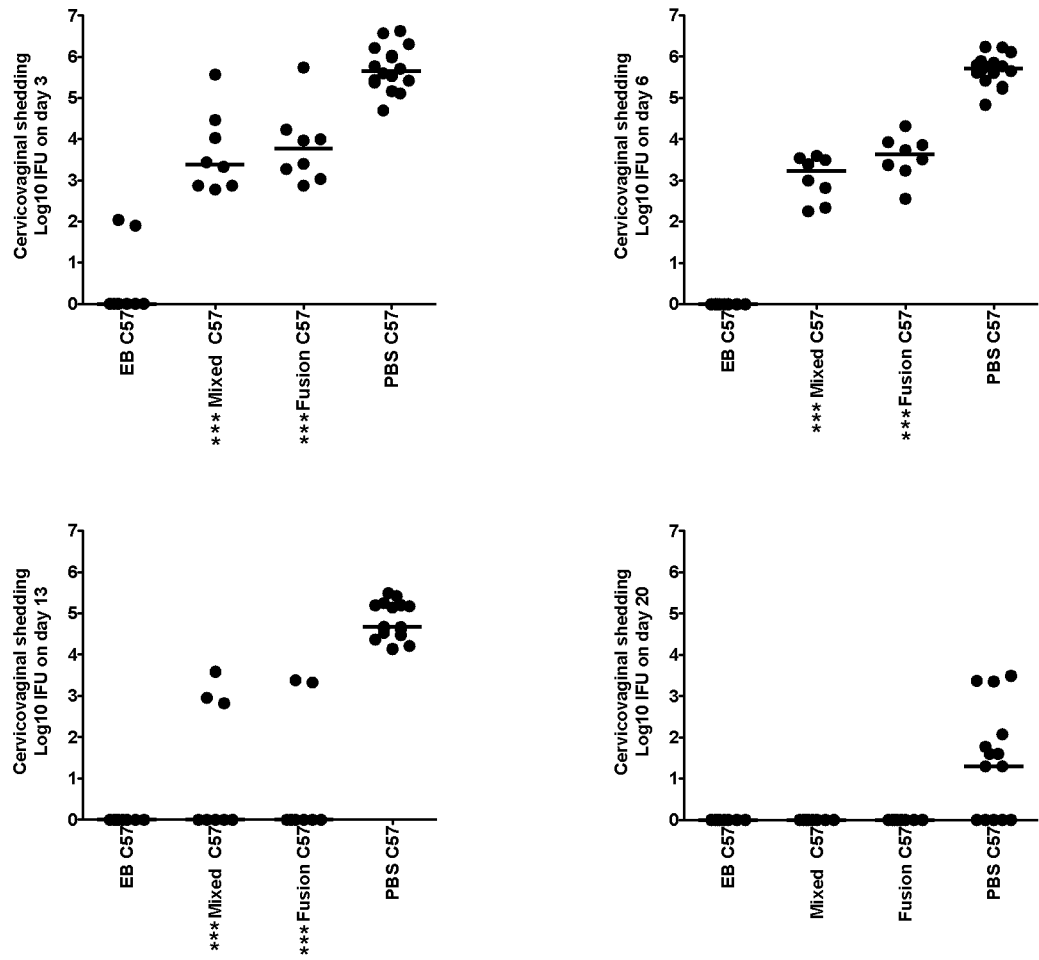


FIGURE 6-1

[illegible]

Scatter plot showing cervicovaginal shedding (Log₁₀ IFU on day 6) for four groups. The y-axis ranges from 0 to 7. The groups are EB Balb, ***Mixed Balb, ***Fusion Balb, and PBS Balb. The EB Balb group shows zero shedding. The other three groups show higher shedding levels, with means around 5.1, 5.3, and 6.1 respectively. Significance markers (***) are present for the three non-EB groups.

Group	Mean (approx.)	Significance
EB Balb	0.0	
***Mixed Balb	5.1	***
***Fusion Balb	5.3	***
PBS Balb	6.1	

[illegible]

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C

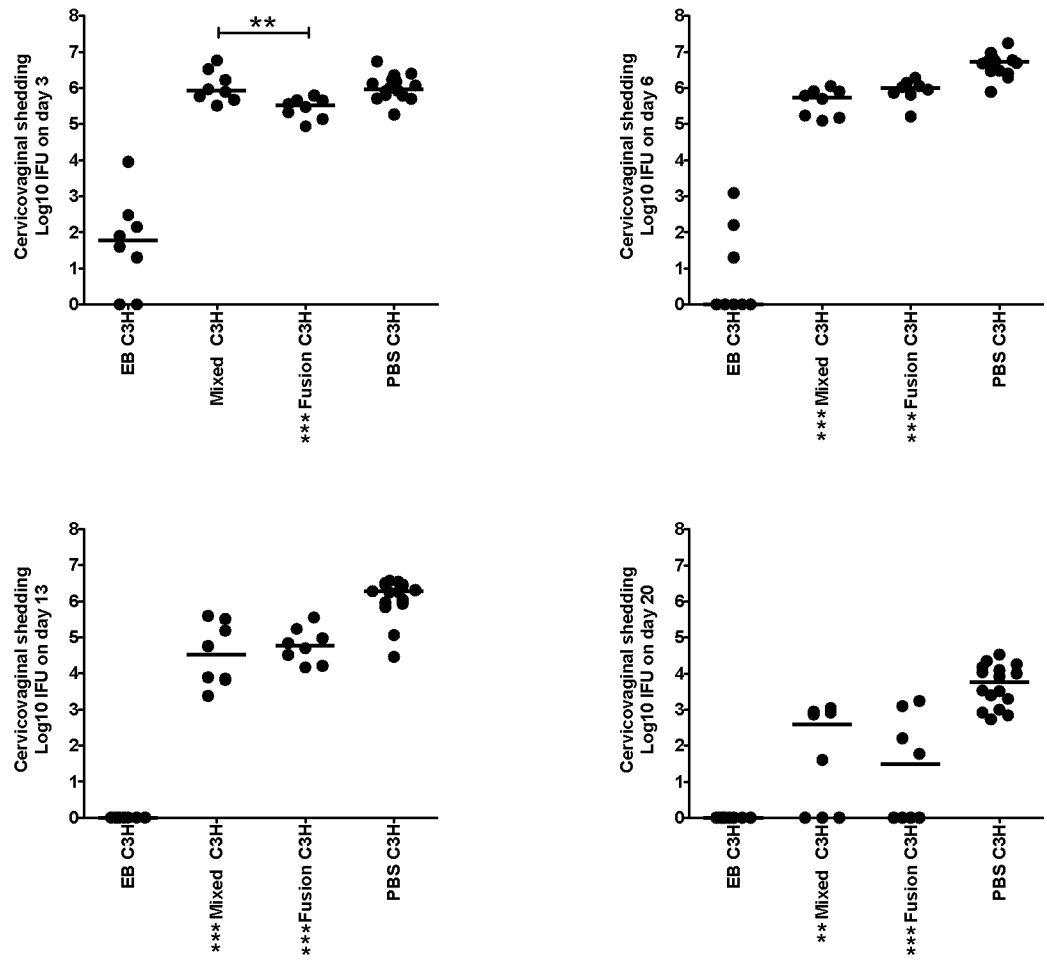


FIGURE 6-3

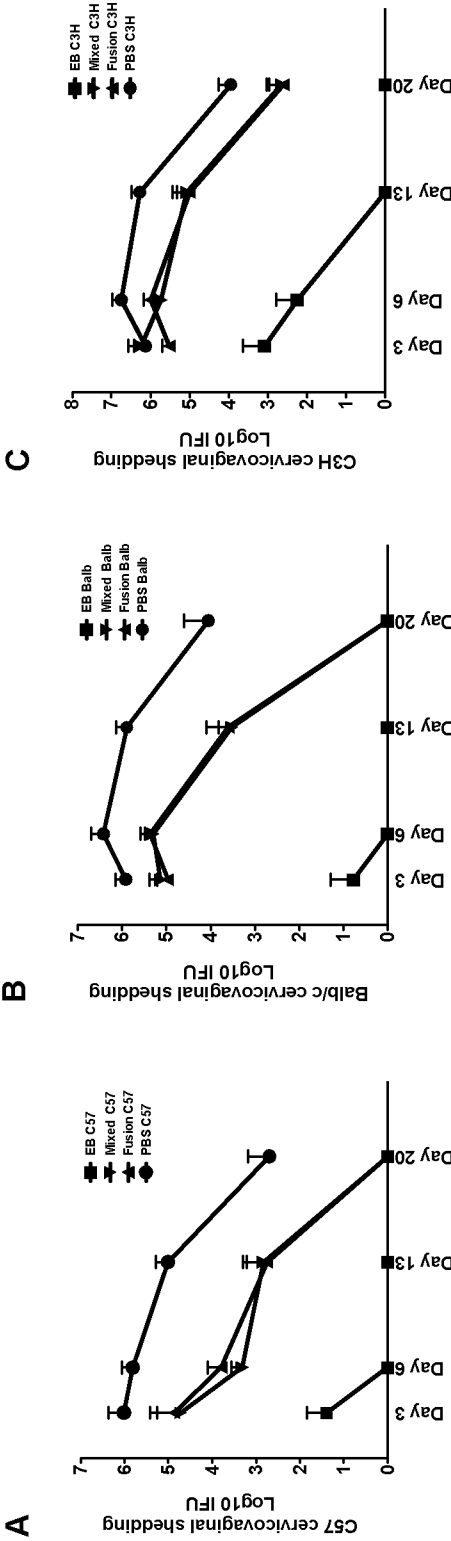


FIGURE 7

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CA2013/050610

A. CLASSIFICATION OF SUBJECT MATTER

IPC: **A61K 39/118** (2006.01) , **A61P 31/04** (2006.01) , **A61P 37/04** (2006.01)

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

A61K 39/118 (2006.01) , **A61P 31/04** (2006.01) , **A61P 37/04** (2006.01)

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic database(s) consulted during the international search (name of database(s) and, where practicable, search terms used)

TotalPatent, Canadian Patent Database, Pubmed

Keywords: chlamydia, fusion protein, vaccine, MOMP, ppm, polymorphic membrane protein, TARP, RplF, anti-anti-sigma factor

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2006/104890 A2 (BARTH, B. ET AL) 05 OCTOBER 2006 (05-10-2006). page 22, line 26-page 23, line 27; page 61, line 16-page 64, line 35.	1, 2 and 6-17
X	CA 2787697 A1 (BRUNHAM, R.C. AND FOSTER, L.J.) 05 AUG 2010 (05-08-2010). whole document.	1-3 and 5-17
X	YU, H. et al. "Chlamydia muridarum T-cell antigens formulated with the adjuvant DDA/TDB induce immunity against infection that correlates with a high frequency of gamma interferon (IFN- γ)/tumor necrosis factor alpha and IFN- γ /interleukin-17 double positive CD4 ⁺ T cells". INFECTION AND IMMUNITY. 15 MARCH 2010 (15-03-2010), V. 78(5), p. 2272-2282. ISSN: 0019-9567. whole document.	1-3 and 6-17
X	YU, H. et al. "Chlamydia muridarum T-cell antigens and adjuvants that induce protective immunity in mice". INFECTION AND IMMUNITY. 30 JANUARY 2012 (30-10-2012), V. 80(4), p.1510-1518. ISSN: 0019-9567. whole document.	1-17

☒ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents :	"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A" document defining the general state of the art which is not considered to be of particular relevance	"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"E" earlier application or patent but published on or after the international filing date	"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"&" document member of the same patent family
"O" document referring to an oral disclosure, use, exhibition or other means	
"P" document published prior to the international filing date but later than the priority date claimed	

Date of the actual completion of the international search

17 September 2013 (17-09-2013)

Date of mailing of the international search report

30 September 2013 (30-09-2013)

Name and mailing address of the ISA/CA
Canadian Intellectual Property Office
Place du Portage I, C114 - 1st Floor, Box PCT
50 Victoria Street
Gatineau, Quebec K1A 0C9
Facsimile No.: 001-819-953-2476

Authorized officer

Tera Mosher (819) 994-4248

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CA2013/050610

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	YU, H. et al. "Novel <i>Chlamydia muridarum</i> T cell antigens induce protective immunity against lung and genital tract infection in murine models". THE JOURNAL OF IMMUNOLOGY. 15 FEBRUARY 2009 (15-02-2009), V. 182, p. 1602-1608. ISSN: 0022-1767.	1-3 and 6-17
P,X	WO 2013/044398 A1 (BRUNHAM, R.C. AND FOSTER, L.J.) 04 April 2013 (04-04-2013).	
A	KARUNAKARAN, K.P. et al. "Development of a <i>Chlamydia trachomatis</i> T-cell vaccine". HUMAN VACCINE. AUGUST 2010 (08-2010), V. 6(8), p. 676-680. ISSN: 1554-8600. see Table 1	
A	EP 2218730 A1 (GRIFFAIS, R. et al.) 18 AUGUST 2010 (18-08-2010).	
A	WO 02/28998 A2 (JACKSON, W.J.) 11 APRIL 2002 (11-04-2002).	

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of the first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons :

1. ☒ Claim Nos. : 8-12

because they relate to subject matter not required to be searched by this Authority, namely :

Claims 8-12 are directed to a method for treatment of the human or animal body by surgery or therapy which the International Search Authority is not required to search. However, this Authority has carried out a search based on the alleged effect of the immunogenic composition defined in claims 1-7.

2. ☐ Claim Nos. :

because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically :

3. ☐ Claim Nos. :

because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows :

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claim Nos. :
4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claim Nos. :

Remark on Protest ☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.

☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.

☐ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CA2013/050610

Patent Document Cited in Search Report	Publication Date	Patent Family Member(s)	Publication Date
WO2006104890A2	05 October 2006 (05-10-2006)	AU2006229968A1 CA2602637A1 CN101184504A EP1868641A2 EP2386314A1 EP2392347A2 EP2392347A3 EP2392348A2 EP2392348A3 EP2392349A2 EP2392349A3 JP2008534594A JP2012180367A KR20070121814A US2009022755A1 US2011300206A1 WO2006104890A3	05 October 2006 (05-10-2006) 05 October 2006 (05-10-2006) 21 May 2008 (21-05-2008) 26 December 2007 (26-12-2007) 16 November 2011 (16-11-2011) 07 December 2011 (07-12-2011) 18 January 2012 (18-01-2012) 07 December 2011 (07-12-2011) 18 January 2012 (18-01-2012) 07 December 2011 (07-12-2011) 18 January 2012 (18-01-2012) 28 August 2008 (28-08-2008) 20 September 2012 (20-09-2012) 27 December 2007 (27-12-2007) 22 January 2009 (22-01-2009) 08 December 2011 (08-12-2011) 29 March 2007 (29-03-2007)
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EP2218730A1	18 August 2010 (18-08-2010)	AU1254599A AU754264B2 AU2002301331B2 AU2006249207A1 AU2006249207B2 AU2006252072A1 AU2006252072B2 AU2006252135A1 AU2006252135B2 AU2007200020A1 AU2007200020B2 AU2007200040A1 AU2007200040B2 CA2309228A1 CN1280619A EP1032676A2 EP2218731A1 EP2218732A1 EP2228384A1 EP2228385A1 JP2002517179A JP2009219494A KR20060109516A KR100735651B1 KR20060109359A KR100735652B1 KR20060109358A KR100735653B1 KR20060112696A KR100769103B1 KR20060112695A KR100769104B1 US7041490B1 US2006234260A1 US7575913B2 US2009274719A1 US7910329B2 US2011159041A1 US8143024B2 WO9928475A2 WO9928475A9 WO9928475A3	16 June 1999 (16-06-1999) 07 November 2002 (07-11-2002) 02 November 2006 (02-11-2006) 04 January 2007 (04-01-2007) 15 May 2008 (15-05-2008) 11 January 2007 (11-01-2007) 17 April 2008 (17-04-2008) 18 January 2007 (18-01-2007) 17 April 2008 (17-04-2008) 25 January 2007 (25-01-2007) 17 April 2008 (17-04-2008) 25 January 2007 (25-01-2007) 17 April 2008 (17-04-2008) 10 June 1999 (10-06-1999) 17 January 2001 (17-01-2001) 06 September 2000 (06-09-2000) 18 August 2010 (18-08-2010) 18 August 2010 (18-08-2010) 15 September 2010 (15-09-2010) 15 September 2010 (15-09-2010) 18 June 2002 (18-06-2002) 01 October 2009 (01-10-2009) 20 October 2006 (20-10-2006) 06 July 2007 (06-07-2007) 19 October 2006 (19-10-2006) 06 July 2007 (06-07-2007) 19 October 2006 (19-10-2006) 06 July 2007 (06-07-2007) 01 November 2006 (01-11-2006) 23 October 2007 (23-10-2007) 01 November 2006 (01-11-2006) 23 October 2007 (23-10-2007) 09 May 2006 (09-05-2006) 19 October 2006 (19-10-2006) 18 August 2009 (18-08-2009) 05 November 2009 (05-11-2009) 22 March 2011 (22-03-2011) 30 June 2011 (30-06-2011) 27 March 2012 (27-03-2012) 10 June 1999 (10-06-1999) 26 August 1999 (26-08-1999) 18 November 1999 (18-11-1999)

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CA2013/050610

Patent Document Cited in Search Report	Publication Date	Patent Family Member(s)	Publication Date
WO0228998A2	11 April 2002 (11-04-2002)	AU9483301A	15 April 2002 (15-04-2002)
		CA2424545A1	11 April 2002 (11-04-2002)
		EP1343514A2	17 September 2003 (17-09-2003)
		EP1343514A4	16 November 2005 (16-11-2005)
		EP1829552A2	05 September 2007 (05-09-2007)
		EP1829552A3	12 September 2007 (12-09-2007)
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		US2004037846A1	26 February 2004 (26-02-2004)
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		US2007292437A1	20 December 2007 (20-12-2007)
		US7851609B2	14 December 2010 (14-12-2010)
		WO0228998A3	03 July 2003 (03-07-2003)
WO2013044398A1	04 April 2013 (04-04-2013)	None	