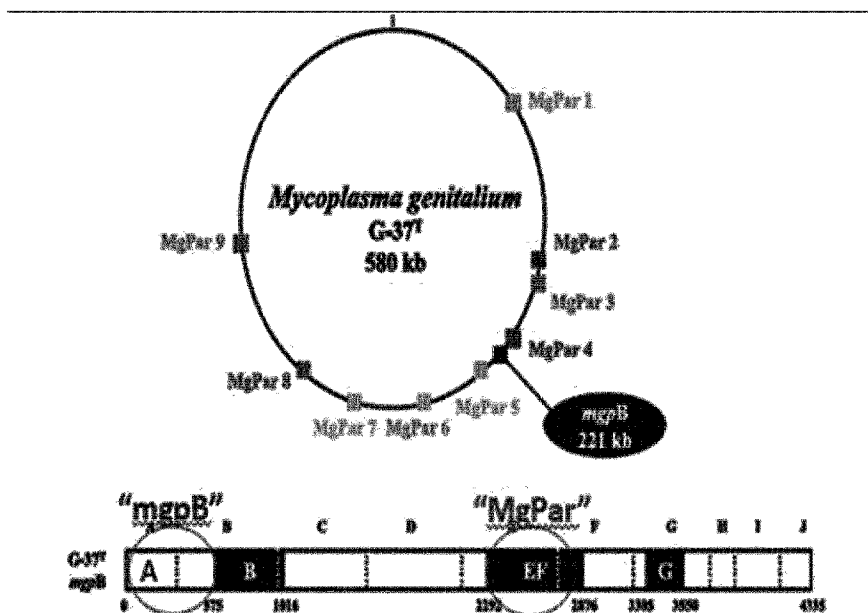




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Methods for the rapid detection of the presence or absence of Mycoplasma genitalium (MG) in a biological or non-biological sample are described. The methods can include performing an amplifying step, a hybridizing step, and a detecting step. Furthermore, primers, probes targeting the target MG gene, along with kits are provided that are designed for the detection of MG.

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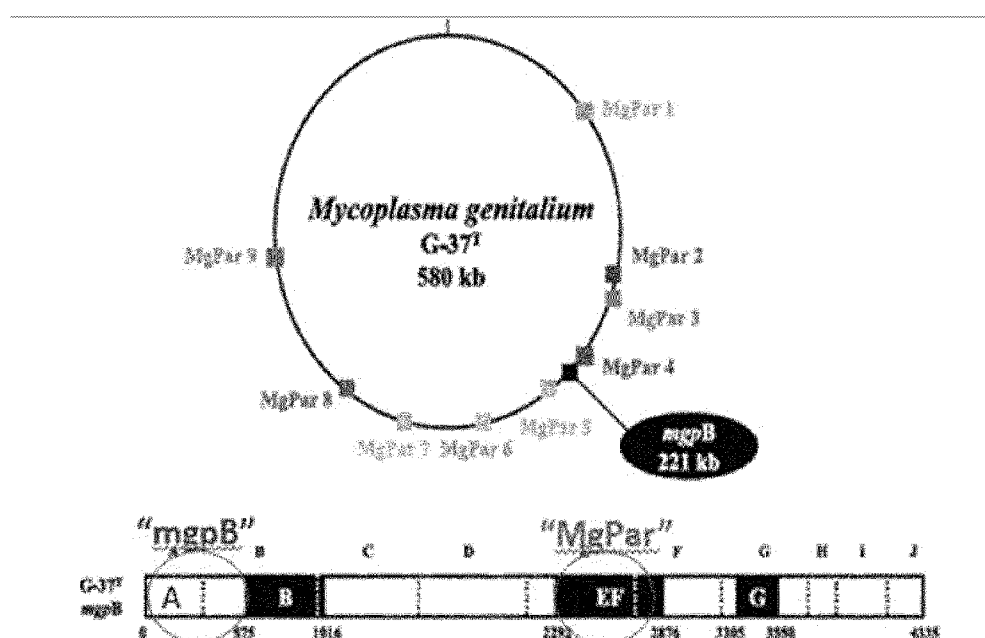


FIGURE 1

(57) Abstract: Methods for the rapid detection of the presence or absence of *Mycoplasma genitalium* (MG) in a biological or non-biological sample are described. The methods can include performing an amplifying step, a hybridizing step, and a detecting step. Furthermore, primers, probes targeting the target MG gene, along with kits are provided that are designed for the detection of MG.

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COMPOSITIONS AND METHODS FOR DETECTION OF MYCOPLASMA GENITALIUM

FIELD OF THE INVENTION

The present disclosure relates to the field of molecular diagnostics, and more particularly to detection of *Mycoplasma genitalium*.

5 BACKGROUND OF THE INVENTION

Mycoplasma genitalium (MG) is a gram-negative bacterium that lacks a cell wall and lives on the surface and in the epithelial cells of the urinary and genital tracts of men and women. *M. genitalium* is a common cause of nongonococcal urethritis (NGU) in men and an increasingly recognized cause of cervicitis and pelvic inflammatory disease (PID) in women. A recent meta-
10 analysis has shown that infection with *M. genitalium* was associated with an approximately two-fold increase in risk for cervicitis, pelvic inflammatory disease, preterm birth, spontaneous abortion, and infertility in women. The prevalence of *M. genitalium* in lower risk populations in both men and women has been reported to be approximately 1% to 3%. In higher risk populations, prevalence of 10% to 41% in men and 7.3% to 14% in women has been reported.
15 The prevalence of *M. genitalium* in higher risk populations often exceeds that of *Neisseria gonorrhoeae* and is similar to the prevalence of *Chlamydia trachomatis*. *M. genitalium* infections largely go unrecognized, and infected individuals are either asymptomatic or have symptoms similar to those associated with other bacterial infections of the urogenital tract.

The diagnosis of *M. genitalium* infection has traditionally been culture of urogenital specimens
20 but culture is insensitive and slow and may take up to 6 months to recover the organism. Nucleic acid amplification tests (NAATs) for the diagnosis of *M. genitalium* infection in the United States and Europe NAATs have been made available as Laboratory Developed Procedures (LDPs) and have been shown to have superior sensitivity compared to culture.

The Center for Disease Control (CDC) recommends that *M. genitalium* should be suspected in
25 cases of persistent or recurrent urethritis and may be considered in persistent or recurrent cases of cervicitis and pelvic inflammatory disease (PID). The fact that *M. genitalium* is a slow-growing organism, culture is not readily available, slow and insensitive, NAATs are the preferred method

for *M. genitalium* detection. In research settings, *M. genitalium* is diagnosed by NAAT testing of urine, urethral, vaginal, and cervical swabs and through endometrial biopsies, typically using in-house PCR or assays intended for research use only. Thus there is a need in the art for a quick and reliable method to specifically detect MG in a sensitive manner.

5 SUMMARY OF THE INVENTION

Certain embodiments in the present disclosure relate to methods for the rapid detection of the presence or absence of MG in a biological or non-biological sample, for example, multiplex detection of MG by real-time polymerase chain reaction in a single test tube. Embodiments include methods of detection of MG comprising performing at least one cycling step, which may
10 include an amplifying step and a hybridizing step. Furthermore, embodiments include primers, probes, and kits that are designed for the detection of MG in a single tube. The detection methods are designed to target specific genes in the *M. genitalium* genome with a potential to discriminate against the nearest neighbor, *Mycoplasma pneumonia*, and also other pathogens or commensals found in the human mouth or urogenital tract.

15 A method for detecting MG in a sample is provided, including performing an amplifying step including contacting the sample with a set of primers designed to target a specific MG gene to produce an amplification product if MG is present in the sample; performing a hybridizing step including contacting the amplification product with one or more detectable probes to the target MG gene; and detecting the presence or absence of the amplified product, wherein the presence
20 of the amplified product is indicative of the presence of MG in the sample and wherein the absence of the amplified product is indicative of the absence of MG in the sample; wherein the target MG gene is selected from the group consisting of the 23s ribosomal RNA (23s) gene, the conserved region A of the mgpB gene within the MgPa adhesion operon (mgpB), and the variable EF region of the mgpB partial repeats (MgPar). Figure 1 shows a picture of the circular
25 *M. genitalium* genome and locations of the mgpB gene and the nine MgPar partial repeats.

In one aspect a method of detecting *Mycoplasma genitalium* (MG) in a sample is provided, the method comprising performing an amplifying step comprising contacting the sample with a set of target MG gene primers to produce an amplification product if a target MG gene nucleic acid is present in the sample; performing a hybridizing step comprising contacting the amplification

product with one or more detectable target MG gene probes; and detecting the presence or absence of the amplification product, wherein the presence of the amplification product is indicative of the presence of MG in the sample and wherein the absence of the amplification product is indicative of the absence of MG in the sample; wherein the set of target MG gene primers comprise a first primer comprising a first oligonucleotide sequence selected from the group consisting of SEQ ID NOs: 1-7, 29-35, and 47-56 or a complement thereof, and a second primer comprising a second oligonucleotide sequence selected from the group consisting of SEQ ID NOs: 8-17, 36-41, and 57-66, or a complement thereof; and wherein the one or more detectable target MG gene probes comprises a third oligonucleotide sequence selected from the group consisting of SEQ ID NOs: 18-28, 42-46, and 67-89, or the complement thereof.

In one embodiment, the primer set for amplification of the 23s gene target includes a first primer comprising or consisting of a first oligonucleotide sequence selected from the group consisting of SEQ ID NOs: 1, 2, 3, 4, 5, 6, and 7, or a complement thereof, and a second primer comprising or consisting of a second oligonucleotide sequence selected from the group consisting of SEQ ID NOs: 8, 9, 10, 11, 12, 13, 14, 15, 16, and 17, or a complement thereof, and the detectable probe for detection of the 23s gene amplification product includes or consists of the nucleic acid sequences of SEQ ID NOs: 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, and 28, or a complement thereof. In certain embodiments, the primer set for amplification of the 23s gene target includes a first primer comprising or consisting of a first oligonucleotide sequence selected from the group consisting of SEQ ID NOs: 3 and 4, or a complement thereof, and a second primer comprising or consisting of a second oligonucleotide sequence selected from the group consisting of SEQ ID NOs: 8 and 9, or a complement thereof, and the detectable probe for detection of the 23s gene amplification product includes or consists of the nucleic acid sequences of SEQ ID NO: 24, or a complement thereof.

In another embodiment, the primer set for amplification of the mgpB gene target includes a first primer comprising or consisting of a first oligonucleotide sequence selected from the group consisting of SEQ ID NOs: 29, 30, 31, 32, 33, 34, and 35, or a complement thereof, and a second primer comprising or consisting of a second oligonucleotide sequence selected from the group consisting of SEQ ID NOs: 36, 37, 38, 39, 40, and 41, or a complement thereof, and the detectable

- probe for detection of the mgpB gene amplification product includes or consists of the nucleic acid sequences of SEQ ID NOs: 42, 43, 44, 45, and 46, or a complement thereof. In certain embodiments, the primer set for amplification of the mgpB gene target includes a first primer comprising or consisting of a first oligonucleotide sequence selected from the group consisting of
- 5 SEQ ID NOs: 34 and 35, or a complement thereof, and a second primer comprising or consisting of a second oligonucleotide sequence selected from the group consisting of SEQ ID NOs: 40 and 41, or a complement thereof, and the detectable probe for detection of the mgpB gene amplification product includes or consists of the nucleic acid sequences of SEQ ID NOs: 45 and 46, or a complement thereof.
- 10 In another embodiment, the primer set for amplification of the MgPar gene target includes a first primer comprising or consisting of a first oligonucleotide sequence selected from the group consisting of SEQ ID NOs: 47, 48, 49, 50, 51, 52, 53, 54, 55, and 56, or a complement thereof, and a second primer comprising or consisting of a second oligonucleotide sequence selected from the group consisting of SEQ ID NOs: 57, 58, 59, 60, 61, 62, 63, 64, 65, and 66, or a complement
- 15 thereof, and the detectable probe for detection of the MgPar gene amplification product includes or consists of the nucleic acid sequences of SEQ ID NOs: 67, 68, 69, 70, 71, 72, 73, 74, 75, 76, 77, 78, 79, 80, 81, 82, 83, 84, 85, 86, 87, 88, and 89, or a complement thereof. In certain embodiments, the primer set for amplification of the MgPar gene target includes a first primer comprising or consisting of a first oligonucleotide sequence selected from the group consisting of SEQ ID NOs:
- 20 48 and 56, or a complement thereof, and a second primer comprising or consisting of a second oligonucleotide sequence selected from the group consisting of SEQ ID NOs: 65 and 66, or a complement thereof, and the detectable probe for detection of the MgPar gene amplification product includes or consists of the nucleic acid sequences of SEQ ID NOs: 80 and 89, or a complement thereof.
- 25 In some embodiments, the hybridizing step comprises contacting the amplification product with the detectable target MG gene probe that is labeled with a donor fluorescent moiety and a corresponding acceptor moiety; and the detecting step comprises detecting the presence or absence of fluorescence resonance energy transfer (FRET) between the donor fluorescent moiety and the acceptor moiety of the probe, wherein the presence or absence of fluorescence is

indicative of the presence or absence of MG in the sample. In some embodiments the amplifying and the hybridizing steps are repeated. Herein, the number of repetitions depends, e.g., on the nature of the sample. If the sample is a complex mixture of nucleic acids, more amplifying and hybridizing steps will be required to amplify the target sequence sufficient for detection. In some
5 embodiments, the amplifying and the hybridizing steps are repeated at least about 20 times, but may be repeated as many as at least 25, 30, 40, 50, 60, or even 100 times. Further, detecting the presence or absence of the amplification product may be performed during or after each amplifying and hybridizing step, during or after every other amplifying and hybridizing step, during or after particular amplifying and hybridizing steps or during or after particular
10 amplifying and hybridizing steps, in which – if present – sufficient amplification product for detection is expected. In some embodiments, the amplifying step employs a polymerase enzyme having 5' to 3' nuclease activity. In some embodiments, the donor fluorescent moiety and the corresponding acceptor moiety are within no more than 8-20 nucleotides of each other on the probe. In some embodiments, the acceptor moiety is a quencher.

15 In some embodiments the oligonucleotides comprise or consist of a sequence of nucleotides selected from SEQ ID NOs: 1-89, or a complement thereof have 100 or fewer nucleotides, 50 or fewer nucleotides, 40 or fewer nucleotides or 30 or fewer nucleotides. In some embodiments, the first and second target MG gene primers and detectable target MG gene probe have 40 or fewer nucleotides (e.g. 35 or fewer nucleotides, 30 or fewer nucleotides, etc.). In another embodiment,
20 the present disclosure provides an oligonucleotide that includes a nucleic acid having at least 70% sequence identity (e.g., at least 75%, 80%, 85%, 90% or 95%, etc.) to one of SEQ ID NOs: 1-89, or a complement thereof, which oligonucleotide has 100 or fewer nucleotides. Generally, these oligonucleotides may be primer nucleic acids, probe nucleic acids, or the like in these embodiments. In some embodiments, the oligonucleotides comprise at least one modified
25 nucleotide, e.g., to alter nucleic acid hybridization stability relative to unmodified nucleotides. Optionally, the oligonucleotides comprise at least one label and/or at least one quencher moiety. In some embodiments, the oligonucleotides include at least one conservatively modified variation. “Conservatively modified variations” or, simply, “conservative variations” of a particular nucleic acid sequence refers to those nucleic acids, which encode identical or

essentially identical amino acid sequences, or, where the nucleic acid does not encode an amino acid sequence, to essentially identical sequences. One of skill will recognize that individual substitutions, deletions or additions which alter, add or delete a single amino acid or a small percentage of amino acids (typically less than 5%, more typically less than 4%, 2% or 1%) in an encoded sequence are “conservatively modified variations” where the alterations result in the deletion of an amino acid, addition of an amino acid, or substitution of an amino acid with a chemically similar amino acid. In some embodiments, at least one of the first and second target MG gene primers and detectable target MG gene probe comprises at least one modified nucleotide.

10 In some embodiments, amplification (the amplification step) can employ a polymerase enzyme having 5' to 3' nuclease activity. Thus, the donor fluorescent moiety and the acceptor moiety, e.g., a quencher, may be within no more than 5 to 20 nucleotides (e.g., 8 or 10) of each other along the length of the probe. In another aspect, the detectable probe includes a nucleic acid sequence that permits secondary structure formation. Such secondary structure formation generally results in spatial proximity between the first and second fluorescent moiety. According to this method, the second fluorescent moiety on the probe can be a quencher.

The present disclosure provides for methods of detecting the presence or absence of MG in a biological sample from an individual. Such methods generally include performing at least one cycling step, which includes an amplifying step and a dye-binding step. Typically, the amplifying step includes contacting the sample with a plurality of pairs of primers designed to target a specific MG gene to produce one or more target MG gene amplification products if the target MG gene nucleic acid molecule is present in the sample, and the dye-binding step includes contacting the target MG gene amplification product with a double-stranded DNA binding dye. Such methods also include detecting the presence or absence of binding of the double-stranded DNA binding dye into the amplification product, wherein the presence of binding is indicative of the presence of MG in the sample, and wherein the absence of binding is indicative of the absence of MG in the sample. A representative double-stranded DNA binding dye is ethidium bromide. In addition, such methods also can include determining the melting temperature between the target MG gene amplification product and the double-stranded DNA binding dye,

wherein the melting temperature confirms the presence or absence of MG. The target MG gene may include but is not limited to the 23s gene, the mgpB gene, and the MgPar partial repeats.

In another aspect, a kit for detecting one or more nucleic acids of MG is provided. The kit can include one or more sets of primers specific for amplification of the target MG gene; and one or
5 more detectable probes specific for detection of the target MG gene amplification products. The target MG gene may include but is not limited to the 23s gene, the mgpB gene, and the MgPar partial repeats. In particular, the oligonucleotide primers and probes disclosed above in connection with the method according to the invention are suitable to being included in a kit according to the invention. Herein, a kit for detecting a nucleic acid of *Mycoplasma genitalium*
10 (MG) in a sample is provided comprising a first primer comprising or consisting of a first oligonucleotide sequence selected from the group consisting of SEQ ID NOs: 1-7, 29-35, and 47-56 or a complement thereof; a second primer comprising or consisting of a second oligonucleotide sequence selected from the group consisting of SEQ ID NOs: 8-17, 36-41, and 57-66, or a complement thereof; and a fluorescently detectably labeled probe comprising or consisting
15 of a third oligonucleotide sequence selected from the group consisting of SEQ ID NOs: 18-28, 42-46, and 67-89, or a complement, the detectably labeled probe configured to hybridize to an amplicon generated by the first primer and the second primer. In one aspect, the kit can include probes already labeled with donor and corresponding acceptor moiety, e.g., another fluorescent moiety or a dark quencher, or can include fluorophoric moieties for labeling the probes. The kit
20 can also include at least one of nucleoside triphosphates, nucleic acid polymerase, and buffers necessary for the function of the nucleic acid polymerase. The kit can also include a package insert and instructions for using the primers, probes, and fluorophoric moieties to detect the presence or absence of MG in a sample. In some embodiments, the third detectably labeled oligonucleotide sequence comprises a donor fluorescent moiety and a corresponding acceptor
25 moiety. In some embodiments, the acceptor moiety is a quencher. In some embodiments, at least one of the first, second, and third oligonucleotides comprises at least one modified nucleotide. In some embodiments, the first, second, and third oligonucleotides have 40 or fewer nucleotides.

In another aspect, compositions are provided comprising a set of oligonucleotide primers for amplifying a target MG gene as disclosed above. In some embodiments, the set of target MG gene

primers comprises a first primer comprising a first oligonucleotide sequence selected from the group consisting of SEQ ID NOs: 1-7, 29-35, and 47-56 or a complement thereof, and a second primer comprising a second oligonucleotide sequence selected from the group consisting of SEQ ID NOs: 8-17, 36-41, and 57-66, or a complement thereof. In certain embodiments, the composition further comprises one or more detectable target MG gene probes comprising or consisting of a third oligonucleotide sequence selected from the group consisting of SEQ ID NOs: 18-28, 42-46, and 67-89, or the complement thereof.

Unless otherwise defined, all technical and scientific terms used herein have the same meaning as commonly understood by one of ordinary skill in the art to which this invention belongs. Although methods and materials similar or equivalent to those described herein can be used in the practice or testing of the present subject matter, suitable methods and materials are described below. In addition, the materials, methods, and examples are illustrative only and not intended to be limiting. The details of one or more embodiments of the invention are set forth in the accompanying drawings and the description below. Other features, objects, and advantages of the invention will be apparent from the drawings and detailed description, and from the claims.

BRIEF DESCRIPTION OF THE FIGURES

FIGURE 1 is a graphical representation of the *M. genitalium* strain G37 genome with the locations of the *mgpB* gene and the MgPar partial repeats being shown.

FIGURE 2 shows PCR growth curves of a real-time PCR experiment in the presence of various concentrations of genomic *M. genitalium* DNA template (present in 1000 [black], 100 [light grey] and 10 [grey] genomic equivalent concentrations per PCR reaction).

DETAILED DESCRIPTION OF THE INVENTION

Diagnosis of MG infection by nucleic acid amplification provides a method for rapidly and accurately detecting the bacterial infection. A real-time assay for detecting MG in a sample is described herein. Primers and probes for detecting MG are provided, as are articles of manufacture or kits containing such primers and probes. The increased sensitivity of real-time PCR for detection of MG compared to other methods, as well as the improved features of real-time PCR including sample containment and real-time detection of the amplified product, make

feasible the implementation of this technology for routine diagnosis of MG infections in the clinical laboratory.

The present disclosure includes oligonucleotide primers and fluorescent labeled hydrolysis probes that hybridize to a specific gene locus of the MG genome in order to specifically identify MG using TaqMan[®] amplification and detection technology. Target selection for MG required a comprehensive search of the public sequence database, as well as literature search for MG targets with a potential to discriminate against the nearest neighbor, *Mycoplasma pneumoniae*. Targets were selected for inclusivity purposes as well as for sensitivity purposes. As a result of the analysis, possible target MG genes include the 23s ribosomal RNA gene (GenBank accession number NR077054), the conserved region A of the mgpB gene within the MgPa adhesion operon (mgpB, GenBank accession number FJ872586), and the variable EF region of the mgpB partial repeats (MgPar, GenBank accession number FJ872587). In certain aspects, a dual target approach may be implemented using the well conserved mgpB gene target. Herein, the well conserved region A of the mgpB gene may be selected for inclusivity purposes, and the variable EF region of the mgpB partial repeats multi-copy target may be selected for sensitivity purposes.

The disclosed methods may include performing at least one cycling step that includes amplifying one or more portions of the nucleic acid molecule gene target from a sample using one or more pairs of primers. "Primer(s)" as used herein refer to oligonucleotide primers that specifically anneal to the target gene in MG, and initiate DNA synthesis therefrom under appropriate conditions producing the respective amplification products. Each of the discussed primers anneals to a target within or adjacent to the respective target nucleic acid molecule such that at least a portion of each amplification product contains nucleic acid sequence corresponding to the target. The one or more amplification products are produced provided that one or more of the target MG gene nucleic acid is present in the sample, thus the presence of the one or more of target MG gene amplification products is indicative of the presence of MG in the sample. The amplification product should contain the nucleic acid sequences that are complementary to one or more detectable probes for target MG gene. "Probe(s)" as used herein refer to oligonucleotide probes that specifically anneal to nucleic acid sequence encoding the target MG gene. Each cycling step includes an amplification step, a hybridization step, and a detection step, in which

the sample is contacted with the one or more detectable probes for detection of the presence or absence of MG in the sample.

As used herein, the term “amplifying” refers to the process of synthesizing nucleic acid molecules that are complementary to one or both strands of a template nucleic acid molecule. Amplifying a nucleic acid molecule typically includes denaturing the template nucleic acid, annealing primers to the template nucleic acid at a temperature that is below the melting temperatures of the primers, and enzymatically elongating from the primers to generate an amplification product. Amplification typically requires the presence of deoxyribonucleoside triphosphates, a DNA polymerase enzyme (e.g., Platinum[®] Taq) and an appropriate buffer and/or co-factors for optimal activity of the polymerase enzyme (e.g., MgCl₂ and/or KCl).

The term “primer” as used herein is known to those skilled in the art and refers to oligomeric compounds, primarily to oligonucleotides but also to modified oligonucleotides that are able to “prime” DNA synthesis by a template-dependent DNA polymerase, i.e., the 3'-end of the, e.g., oligonucleotide provides a free 3'-OH group whereto further "nucleotides" may be attached by a template-dependent DNA polymerase establishing 3' to 5' phosphodiester linkage whereby deoxynucleoside triphosphates are used and whereby pyrophosphate is released. Therefore, there is – except possibly for the intended function – no fundamental difference between a “primer”, an “oligonucleotide”, or a “probe”.

The term “hybridizing” refers to the annealing of one or more probes to an amplification product. Hybridization conditions typically include a temperature that is below the melting temperature of the probes but that avoids non-specific hybridization of the probes.

The term “5' to 3' nuclease activity” refers to an activity of a nucleic acid polymerase, typically associated with the nucleic acid strand synthesis, whereby nucleotides are removed from the 5' end of nucleic acid strand.

The term “thermostable polymerase” refers to a polymerase enzyme that is heat stable, i.e., the enzyme catalyzes the formation of primer extension products complementary to a template and does not irreversibly denature when subjected to the elevated temperatures for the time necessary to effect denaturation of double-stranded template nucleic acids. Generally, the synthesis is initiated at the 3' end of each primer and proceeds in the 5' to 3' direction along the template

strand. Thermostable polymerases have been isolated from *Thermus flavus*, *T. ruber*, *T. thermophilus*, *T. aquaticus*, *T. lacteus*, *T. rubens*, *Bacillus stearothermophilus*, and *Methanothermus fervidus*. Nonetheless, polymerases that are not thermostable also can be employed in PCR assays provided the enzyme is replenished.

- 5 The term “complement thereof” refers to nucleic acid that is both the same length as, and exactly complementary to, a given nucleic acid.

The term “extension” or “elongation” when used with respect to nucleic acids refers to when additional nucleotides (or other analogous molecules) are incorporated into the nucleic acids. For example, a nucleic acid is optionally extended by a nucleotide incorporating biocatalyst, such
 10 as a polymerase that typically adds nucleotides at the 3’ terminal end of a nucleic acid.

The terms “identical” or percent “identity” in the context of two or more nucleic acid sequences, refer to two or more sequences or subsequences that are the same or have a specified percentage of nucleotides that are the same, when compared and aligned for maximum correspondence, e.g., as measured using one of the sequence comparison algorithms available to persons of skill or by
 15 visual inspection. Exemplary algorithms that are suitable for determining percent sequence identity and sequence similarity are the BLAST programs, which are described in, e.g., Altschul et al. (1990) “Basic local alignment search tool” *J. Mol. Biol.* 215:403-410, Gish et al. (1993) “Identification of protein coding regions by database similarity search” *Nature Genet.* 3:266-272, Madden et al. (1996) “Applications of network BLAST server” *Meth. Enzymol.* 266:131-141,
 20 Altschul et al. (1997) “Gapped BLAST and PSI-BLAST: a new generation of protein database search programs” *Nucleic Acids Res.* 25:3389-3402, and Zhang et al. (1997) “PowerBLAST: A new network BLAST application for interactive or automated sequence analysis and annotation” *Genome Res.* 7:649-656.

A “modified nucleotide” in the context of an oligonucleotide refers to an alteration in which at
 25 least one nucleotide of the oligonucleotide sequence is replaced by a different nucleotide that provides a desired property to the oligonucleotide. Exemplary modified nucleotides that can be substituted in the oligonucleotides described herein include, e.g., a C5-methyl-dC, a C5-ethyl-dC, a C5-methyl-dU, a C5-ethyl-dU, a 2,6-diaminopurine, a C5-propynyl-dC, a C5-propynyl-dU, a C7-propynyl-dA, a C7-propynyl-dG, a C5-propargylamino-dC, a C5-propargylamino-dU, a C7-

propargylamino-dA, a C7-propargylamino-dG, a 7-deaza-2-deoxyxanthosine, a pyrazolo-pyrimidine analog, a pseudo-dU, a nitro pyrrole, a nitro indole, 2'-O-methyl Ribo-U, 2'-O-methyl Ribo-C, an N4-ethyl-dC, an N6-methyl-dA, and the like. Many other modified nucleotides that can be substituted in the oligonucleotides are referred to herein or are otherwise known in the art.

5 In certain embodiments, modified nucleotide substitutions modify melting temperatures (T_m) of the oligonucleotides relative to the melting temperatures of corresponding unmodified oligonucleotides. To further illustrate, certain modified nucleotide substitutions can reduce non-specific nucleic acid amplification (e.g., minimize primer dimer formation or the like), increase the yield of an intended target amplicon, and/or the like in some embodiments. Examples of
10 these types of nucleic acid modifications are described in, e.g., U.S. Pat. No. 6,001,611.

Detection of MG

The present disclosure provides methods to detect MG by amplifying, for example, a portion of the target MG gene nucleic acid sequence. Nucleic acid sequences of the 23s ribosomal RNA gene, the mgpB gene and the MgPar partial repeats are publicly available (e.g., GenBank). Specifically,
15 primers and probes to amplify and detect specific MG nucleic acid molecule targets are provided by the embodiments in the present disclosure.

For detection of MG, primers and probes to amplify the target MG gene are provided. Nucleic acids other than those exemplified herein can also be used to detect MG in a sample. For example, functional variants can be evaluated for specificity and/or sensitivity by those of skill in the art
20 using routine methods. Representative functional variants can include, e.g., one or more deletions, insertions, and/or substitutions in the target MG gene nucleic acids disclosed herein.

More specifically, embodiments of the oligonucleotides each include a nucleic acid with a sequence selected from SEQ ID NOs: 1-89, a substantially identical variant thereof in which the variant has at least, e.g., 80%, 90%, or 95% sequence identity to one of SEQ ID NOs: 1-89, or a
25 complement of SEQ ID NOs: 1-89 and the variant.

TABLE I: 23s Forward Primers

Forward Primers			
Oligo Name	SEQ ID NO:	Sequence	Modifications
JH419BUA	1	GGGGTGGATCACCTCCTTTC<t_BB_dA>	t-butylbenzyl dA

JH407BUC	2	CAATGTTTGGTCTCACAACATAACA<t_BB_dC>	t-butylbenzylDC
JH409BUA	3	TCCAGTTCTGAAAGAATGTTTTTGA<t_BB_dA>	t-butylbenzylDA
JH411BUA	4	AAACGACAATCTTTCTAGTTCCAAA<t_BB_dA>	t-butylbenzylDA
JH413BUC	5	ATGTTTGGTCTCACAACATAACA<t_BB_dC>	t-butylbenzylDC
JH415BUA	6	CAGTTCTGAAAGAATGTTTTTGA<t_BB_dA>	t-butylbenzylDA
JH417BUA	7	CGACAATCTTTCTAGTTCCAAA<t_BB_dA>	t-butylbenzylDA

TABLE II: 23s Reverse Primers

Reverse Primers			
Oligo Name	SEQ ID NO:	Sequence	Modifications
JH408BUC	8	CGGATCTCAGGTTTTTACCACCT<t_BB_dC>	t-butylbenzylDC
JH410BUA	9	CAGATTGCTCCATTCGGAC<t_BB_dA>	t-butylbenzylDA
JH412BUC	10	CAGATTGCTCCATTCGGACA<t_BB_dC>	t-butylbenzylDC
JH414BUC	11	AGATTGCTCCATTCGGACA<t_BB_dC>	t-butylbenzylDC
JH416BUA	12	CACGTCCTTCATCGCCTTTT<t_BB_dA>	t-butylbenzylDA
JH418BUC	13	GATCTCAGGTTTTTACCACCT<t_BB_dC>	t-butylbenzylDC
JH420BUA	14	ATTGCTCCATTCGGAC<t_BB_dA>	t-butylbenzylDA
JH422BUC	15	ATTGCTCCATTCGGACA<t_BB_dC>	t-butylbenzylDC
JH424BUC	16	ATTGCTCCATTCGGACA<t_BB_dC>	t-butylbenzylDC
JH426BUA	17	CGTCCTTCATCGCCTTTT<t_BB_dA>	t-butylbenzylDA

TABLE III: 23s Probes

Probes			
Oligo Name	SEQ ID NO:	Sequence	Modifications
JH437HQ6	18	<H>GGTCAG<Q>TTTGTATCCAGTTCTGAAAGA ATGTTTTTGAAC<P>	P=phosphate, H=th- HEX, Q=BHQ2
JH434HQ6	19	<H>GTTCAA<Q>AAACATTCTTTCAGAACTGGA TACAAACTGACC<P>	P=phosphate, H=th- HEX, Q=BHQ2
JH439HQ6	20	<H>GAATGT<Q>TTTTGAACAGTTCTTTCAAAAC TGAAAACGACA<P>	P=phosphate, H=th- HEX, Q=BHQ2
JH449HQ6	21	<H>TCAGTT<Q>TGTATCCAGTTCTGAAAGAAT GTTTTTGAACCAG<P>	P=phosphate, H=th- HEX, Q=BHQ2
JH438HQ6	22	<H>TGTTCA<Q>AAAACATTCTTTCAGAACTGG ATACAAACTGACC<P>	P=phosphate, H=th- HEX, Q=BHQ2,
JH451HQ6	23	<H>AGAATG<Q>TTTTTGAACAGTTCTTTCAAA ACTGAAAACGACA<P>	P=phosphate, H=th- HEX, Q=BHQ2
JH441HQ6	24	<H>CTAAAA<Q>GGCGATGAAGGACGTGTTAAC CTG<P>	P=phosphate, H=th- HEX, Q=BHQ2
JH443HQ6	25	<H>GGTCAG<Q>TTTGTATCCAGTTCTGAAAGA	P=phosphate, H=th-

		ATG<P>	HEX, Q=BHQ2
JH436HQ6	26	<H>GTTCAA<Q>AAACATTCTTTCAGAACTGGA TACA<P>	P=phosphate, H=th- HEX, Q=BHQ2
JH445HQ6	27	<H>GAATGT<Q>TTTTGAACAGTTCTTTCAAAAC TGA<P>	P=phosphate, H=th- HEX, Q=BHQ2
JH447HQ6	28	<H>CTAAAA<Q>GGCGATGAAGGACGTGTTAAC <P>	P=phosphate, H=th- HEX, Q=BHQ2

TABLE IV: mgpB Forward Primers

Forward Primers			
Oligo Name	SEQ ID NO:	Sequence	Modifications
JH311BUC	29	GACTTGAAACAATAACAACCTTCTCTT<t_BB_dC>	t-butylbenzylidC
JH313BUA	30	GACTTGAAACAATAACAACCTTCTCTTC<t_BB_dA>	t-butylbenzylidA
JH315BUA	31	AACAATAACAACCTTCTCTTCACTAAAG<t_BB_dA>	t-butylbenzylidA
JH317BUA	32	CAATAACAACCTTCTCTTCACTAAAGATT<t_BB_dA>	t-butylbenzylidA
JH319BUA	33	ACCCCTTGGACTTGAAACAATAACA<t_BB_dA>	t-butylbenzylidA
JH321BUA	34	AGAGAACCCAGGATCATTGG<t_BB_dA>	t-butylbenzylidA
JH323BUA	35	CTGGAGAGAACCCAGGATC<t_BB_dA>	t-butylbenzylidA

TABLE V: mgpB Reverse Primers

Reverse Primers			
Oligo Name	SEQ ID NO:	Sequence	Modifications
JH310BUA	36	GTTGTTATCATACCTTCTGATTGCA<t_BB_dA>	t-butylbenzylidA
JH312BUA	37	CTACCGTTGTTATCATACCTTCTG<t_BB_dA>	t-butylbenzylidA
JH314BUA	38	CATATAAAGCTCTACCGTTGTTATCAT<t_BB_dA>	t-butylbenzylidA
JH316BUA	39	AATATCATATAAAGCTCTACCGTTGTT<t_BB_dA>	t-butylbenzylidA
JH320BUA	40	TTTTCCATTTTGGCTAAGTTAATATCATATA<t_BB_dA>	t-butylbenzylidA
JH322BUA	41	GGGGTTTTCCATTTTGGCTAAGTTA<t_BB_dA>	t-butylbenzylidA

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TABLE VI: mgpB Probes

Probes			
Oligo Name	SEQ ID NO:	Sequence	Modifications
JH335HQ6	42	<H>GGAGAG<Q>AACCCAGGATCATTGGATTA GTAAGAAGC<P>	P=phosphate, H=th- HEX, Q=BHQ2
JH337HQ6	43	<H>AAGATT<Q>ACTGGAGAGAACCCAGGATCA TTTGGATTAGTAAG<P>	P=phosphate, H=th- HEX, Q=BHQ2

JH339HQ6	44	<H>CTGGAG<Q>AGAACCCAGGATCATTTGGAT TAGTAAGAAG<P>	P=phosphate, H=th- HEX, Q=BHQ2
JH341HQ6	45	<H>CAGCAA<Q>AACTTTGCAATCAGAAGGTAT GATAACAACG<P>	P=phosphate, H=th- HEX, Q=BHQ2
JH342HQ6	46	<H>CGTTGT<Q>TATCATACCTTCTGATTGCAAA GTTTGCTG<P>	P=phosphate, H=th- HEX, Q=BHQ2

TABLE VII: MgPar Forward Primers

Forward Primers			
Oligo Name	SEQ ID NO:	Sequence	Modifications
JH501BUA	47	TTTCTCCCCTGAATCGGCA<t_BB_dA>	t-butylbenzyl dA
JH503BUA	48	CAACTCCCCCTCCCCTTCA<t_BB_dA>	t-butylbenzyl dA
JH505BUC	49	TCCCCCTCCCCTTCAACTT<t_BB_dC>	t-butylbenzyl dC
JH507BUC	50	ATCCCAATTCAGATGATAATAAAGTCA<t_BB_dC>	t-butylbenzyl dC
JH509BUA	51	ATCCCAATTCAGATGATAATAAAGTC<t_BB_dA>	t-butylbenzyl dA
JH511BUA	52	TCCCACCACTGACTGGATCA<t_BB_dA>	t-butylbenzyl dA
JLH531	53	CAACTCCCACACTGCTTCC<t_BB_dC>	t-butylbenzyl dC
KMMGP560F	54	TCCAACTCCCACACTGCTTCCC<t_BB_dC>	t-butylbenzyl dC
KMMGP562F	55	TCCAACTCCCACACTGCTTC<t_BB_dC>	t-butylbenzyl dC
KMMGP564F	56	CAACTCCCACACTGCTTC<t_BB_dC>	t-butylbenzyl dC

TABLE VIII: MgPar Reverse Primers

Reverse Primers			
Oligo Name	SEQ ID NO:	Sequence	Modifications
JH502BUA	57	GGTGAAAAGTTAGGTATAAACACCC<t_BB_dA>	t-butylbenzyl dA
JH504BUA	58	CTGCTCCTGTTTCAGATGTC<t_BB_dA>	t-butylbenzyl dA
JH506BUA	59	TGCTCACTATCCTTGTTAAATTG<t_BB_dA>	t-butylbenzyl dA
JH508BUA	60	CACCTCCCCAAACCCAGGTAA<t_BB_dA>	t-butylbenzyl dA
JH510BUA	61	ACCTCCCCAAACCCAGGTAA<t_BB_dA>	t-butylbenzyl dA
JLH536	62	CCTGCTCCCGTTCAGATGT<t_BB_dC>	t-butylbenzyl dC
JLH540	63	CCTGCTCCCGTT<L>AAATGT<t_BB_dC>	t-butylbenzyl dC, L=9-(aminoethoxy)- phenoxazine-2'-dC
JLH538R	64	CCTGCTCCCGTTCA<R>ATGT<t_BB_dC>	t-butylbenzyl dC R= A or G
JLH538R_A	65	CCTGCTCCCGTTCAAATGT<t_BB_dC>	t-butylbenzyl dC
JLH538R_G	66	CCTGCTCCCGTTCAGATGT<t_BB_dC>	t-butylbenzyl dC

TABLE IX: MgPar Probes

Probes			
Oligo Name	SEQ ID NO:	Sequence	Modifications
JH521HQ6	67	<H>CTCCCC<Q>ACTTTTCTAACATC AATGTTGGGGTTAAATCAA<P>	P=phosphate, H=th-HEX, Q=BHQ2
JH522HQ6	68	<H>TTGATT<Q>TAACCCCAACATTG ATGTTAGAAAAAGTGGGGAG<P>	P=phosphate, H=th-HEX, Q=BHQ2
JH523HQ6	69	<H>CGCAAT<Q>CAACTGTTGCTCAG AAGCTTACTAGGAA<P>	P=phosphate, H=th-HEX, Q=BHQ2
JH524HQ6	70	<H>AGTTC<Q>TAGTAAGCTTCTGA GCAACAGTTGATTGC<P>	P=phosphate, H=th-HEX, Q=BHQ2
JLH540HQ6	71	<H>GATTTA<Q>ACCCCAACATTGAT GTTAGAAAAAGTGGGGAG<P>	P=phosphate, H=th-HEX, Q=BHQ2
JLH540PDUHQ6	72	<H>GA<U><U><U>A<Q>ACCCCAACA <U><U>GA<U>G<U><U>AGAAAAAG< U>GGGGAG<P>	P=phosphate, H=th-HEX, Q=BHQ2, U=propynylU
JLH544HQ6	73	<H>ATTTAA<Q>CCCCAACATTGATG TTAGAAAAAGTGGGGAG<P>	P=phosphate, H=th-HEX, Q=BHQ2
JLH544PDUHQ6	74	<H>A<U><U><U>AA<Q>CCCCAACA< U><U>GA<U>G<U><U>AGAAAAAG< U>GGGGAG<P>	P=phosphate, H=th-HEX, Q=BHQ2, U=propynylU
JLH546HQ6	75	<H>GATTTA<Q>ACCCCAACATTGAT GTTAGAAAAAGTGGTGAG<P>	P=phosphate, H=th-HEX, Q=BHQ2
JLH546PDUHQ6	76	<H>GATTTA<Q>ACCCCAACA<U><U> GA<U>G<U><U>AGAAAAAG<U>GGT GAG<P>	P=phosphate, H=th-HEX, Q=BHQ2, U=propynylU
JLH548HQ6	77	<H>ATTTAA<Q>CCCCAACATTGATG TTAGAAAAAGTGGTGAG<P>	P=phosphate, H=th-HEX, Q=BHQ2
JLH548PDUHQ6	78	<H>ATTTAA<Q>CCCCAACA<U><U>G A<U>G<U><U>AGAAAAAG<U>GGTG AG<P>	P=phosphate, H=th-HEX, Q=BHQ2, U=propynylU
JLH550HQ6	79	<H>ATTTAA<Q>CCCCAACATTGATG TTAGAAAAAGT<Y>GGGAG<P>	P=phosphate, H=th-HEX, Q=BHQ2, Y=7' deazadG
JLH552HQ6	80	<H>ATTTAA<Q>CCCCAACATTGATG TTAGAAAAAGTG<Y>GGAG<P>	P=phosphate, H=th-HEX, Q=BHQ2, Y=7' deazadG
JLH554HQ6	81	<H>ATTTAA<Q>CCCCAACATTGATG TTAGAAAAAGTG<Y>GAG<P>	P=phosphate, H=th-HEX, Q=BHQ2, Y=7' deazadG
JLH556HQ6	82	<H>ATTTAA<Q>CCCCAACATTGATG TTAGAAAAAGTGGG<Y>AG<P>	P=phosphate, H=th-HEX, Q=BHQ2, Y=7' deazadG
JLH550PDUHQ6	83	<H>A<U><U><U>AA<Q>CCCCAACA<	P=phosphate, H=th-HEX,

		U><U>GA<U>G<U><U>AGAAAAAG<U><Y>GGGAG<P>	Q=BHQ2, U=propynyldU Y=7' deazadG
JLH552PDUHQ6	84	<H>A<U><U><U>AA<Q>CCCCAACA<U><U>GA<U>G<U><U>AGAAAAAG<U>G<Y>GGAG<P>	P=phosphate, H=th-HEX, Q=BHQ2, U=propynyldU Y=7' deazadG
JLH554PDUHQ6	85	<H>A<U><U><U>AA<Q>CCCCAACA<U><U>GA<U>G<U><U>AGAAAAAG<U>GG<Y>GAG<P>	P=phosphate, H=th-HEX, Q=BHQ2, U=propynyldU Y=7' deazadG
JLH558HQ6	86	<H>ATTTAA<Q>CCCCAACATTGATGTTAGAAAAAGTG<Y>G<P>	P=phosphate, H=th-HEX, Q=BHQ2, Y=7' deazadG
KMMGP560HQ6	87	<H>ATTTAA<Q>CCCCAACATTGATGTTAGAAAAAGTGGG<P>	P=phosphate, H=th-HEX, Q=BHQ2
KMMGP562HQ6	88	<H>A<U><U><U>AA<Q>CCCCAACA<U><U>GA<U>G<U><U>AGAAAAAGTGGG<P>	P=phosphate, H=th-HEX, Q=BHQ2, U=propynyldU
KMMGP564HQ6	89	<H>A<U><U><U>AA<Q>C<X>C<X>AA<X>A<U><U>GA<U>G<U><U>AGAAAAGTGGG<P>	P=phosphate, H=th-HEX, Q=BHQ2, U=propynyldU X=propynyldC

In one embodiment, the above described sets of primers and probes are used in order to provide for detection of MG in a biological sample suspected of containing MG. The sets of primers and probes may comprise or consist of the primers and probes specific for the nucleic acid sequences of the 23s gene, mgpB gene, and the MgPar partial repeats comprising or consisting of the

5 nucleic acid sequences of SEQ ID NOs: 1-89. In another embodiment, the primers and probes for the target MG genes comprise or consist of a functionally active variant of any of the primers and probes of SEQ ID NOs: 1-89.

A functionally active variant of any of the primers and/or probes of SEQ ID NOs: 1-89 may be

10 identified by using the primers and/or probes in the disclosed methods. A functionally active variant of a primer and/or probe of any of the SEQ ID NOs: 1-89 pertains to a primer and/or probe which provides a similar or higher specificity and sensitivity in the described method or kit as compared to the respective sequence of SEQ ID NOs: 1-89.

The variant may, e.g., vary from the sequence of SEQ ID NOs: 1-89 by one or more nucleotide

15 additions, deletions or substitutions such as one or more nucleotide additions, deletions or substitutions at the 5' end and/or the 3' end of the respective sequence of SEQ ID NOs: 1-89. As detailed above, a primer (and/or probe) may be chemically modified, i.e., a primer and/or probe

may comprise a modified nucleotide or a non-nucleotide compound. A probe (or a primer) is then a modified oligonucleotide. “Modified nucleotides” (or “nucleotide analogs”) differ from a natural “nucleotide” by some modification but still consist of a base or base-like compound, a pentofuranosyl sugar or a pentofuranosyl sugar-like compound, a phosphate portion or phosphate-like portion, or combinations thereof. For example, a “label” may be attached to the base portion of a “nucleotide” whereby a “modified nucleotide” is obtained. A natural base in a “nucleotide” may also be replaced by, e.g., a 7-deazapurine whereby a “modified nucleotide” is obtained as well. The terms “modified nucleotide” or “nucleotide analog” are used interchangeably in the present application. A “modified nucleoside” (or “nucleoside analog”) differs from a natural nucleoside by some modification in the manner as outlined above for a “modified nucleotide” (or a “nucleotide analog”).

Oligonucleotides including modified oligonucleotides and oligonucleotide analogs that amplify a nucleic acid molecule encoding the target MG gene, e.g. the 23s gene, can be designed using, for example, a computer program such as OLIGO (Molecular Biology Insights Inc., Cascade, Colo.). Important features when designing oligonucleotides to be used as amplification primers include, but are not limited to, an appropriate size amplification product to facilitate detection (e.g., by electrophoresis), similar melting temperatures for the members of a pair of primers, and the length of each primer (i.e., the primers need to be long enough to anneal with sequence-specificity and to initiate synthesis but not so long that fidelity is reduced during oligonucleotide synthesis). Typically, oligonucleotide primers are 8 to 50 nucleotides in length (e.g., 8, 10, 12, 14, 16, 18, 20, 22, 24, 26, 28, 30, 32, 34, 36, 38, 40, 42, 44, 46, 48, or 50 nucleotides in length).

In addition to a set of primers, the methods may use one or more probes in order to detect the presence or absence of MG. The term “probe” refers to synthetically or biologically produced nucleic acids (DNA or RNA), which by design or selection, contain specific nucleotide sequences that allow them to hybridize under defined predetermined stringencies specifically (i.e., preferentially) to “target nucleic acids”, in the present case to a target MG gene nucleic acid. A “probe” can be referred to as a “detection probe” meaning that it detects the target nucleic acid.

In some embodiments, the described target MG gene probes can be labeled with at least one fluorescent label. In one embodiment, the target MG gene probes can be labeled with a donor

fluorescent moiety, e.g., a fluorescent dye, and a corresponding acceptor moiety, e.g., a quencher. In one embodiment, the probe comprises or consists of a fluorescent moiety and the nucleic acid sequences comprise or consist of SEQ ID NOs: 18-28, 42-46, and 67-89.

Designing oligonucleotides to be used as probes can be performed in a manner similar to the design of primers. Embodiments may use a single probe or a pair of probes for detection of the amplification product. Depending on the embodiment, the probe(s) use may comprise at least one label and/or at least one quencher moiety. As with the primers, the probes usually have similar melting temperatures, and the length of each probe must be sufficient for sequence-specific hybridization to occur but not so long that fidelity is reduced during synthesis. Oligonucleotide probes are generally 15 to 40 (e.g., 16, 18, 20, 21, 22, 23, 24, or 25) nucleotides in length. In some embodiments oligonucleotide primers are 40 or fewer nucleotides in length

Constructs can include vectors each containing one of target MG gene primers and probes nucleic acid molecules. Constructs can be used, for example, as control template nucleic acid molecules. Vectors suitable for use are commercially available and/or produced by recombinant nucleic acid technology methods routine in the art. Target MG gene nucleic acid molecules can be obtained, for example, by chemical synthesis, direct cloning from MG, or by PCR amplification.

Constructs suitable for use in the methods typically include, in addition to the target MG gene nucleic acid molecules (e.g., a nucleic acid molecule that contains one or more sequences of SEQ ID NOs: 1-89), sequences encoding a selectable marker (e.g., an antibiotic resistance gene) for selecting desired constructs and/or transformants, and an origin of replication. The choice of vector systems usually depends upon several factors, including, but not limited to, the choice of host cells, replication efficiency, selectability, inducibility, and the ease of recovery.

Constructs containing target MG gene nucleic acid molecules can be propagated in a host cell. As used herein, the term host cell is meant to include prokaryotes and eukaryotes such as yeast, plant and animal cells. Prokaryotic hosts may include *E. coli*, *Salmonella typhimurium*, *Serratia marcescens*, and *Bacillus subtilis*. Eukaryotic hosts include yeasts such as *S. cerevisiae*, *S. pombe*, *Pichia pastoris*, mammalian cells such as COS cells or Chinese hamster ovary (CHO) cells, insect cells, and plant cells such as *Arabidopsis thaliana* and *Nicotiana tabacum*. A construct can be

introduced into a host cell using any of the techniques commonly known to those of ordinary skill in the art. For example, calcium phosphate precipitation, electroporation, heat shock, lipofection, microinjection, and viral-mediated nucleic acid transfer are common methods for introducing nucleic acids into host cells. In addition, naked DNA can be delivered directly to cells (see, e.g., U.S. Pat. Nos. 5,580,859 and 5,589,466).

Polymerase Chain Reaction (PCR)

U.S. Pat. Nos. 4,683,202, 4,683,195, 4,800,159, and 4,965,188 disclose conventional PCR techniques. PCR typically employs two oligonucleotide primers that bind to a selected nucleic acid template (e.g., DNA or RNA). Primers useful in some embodiments include oligonucleotides capable of acting as points of initiation of nucleic acid synthesis within the described target MG gene nucleic acid sequences (e.g., SEQ ID NOs: 1-17, 29-41, and 47-66). A primer can be purified from a restriction digest by conventional methods, or it can be produced synthetically. The primer is preferably single-stranded for maximum efficiency in amplification, but the primer can be double-stranded. Double-stranded primers are first denatured, i.e., treated to separate the strands. One method of denaturing double stranded nucleic acids is by heating.

If the template nucleic acid is double-stranded, it is necessary to separate the two strands before it can be used as a template in PCR. Strand separation can be accomplished by any suitable denaturing method including physical, chemical or enzymatic means. One method of separating the nucleic acid strands involves heating the nucleic acid until it is predominately denatured (e.g., greater than 50%, 60%, 70%, 80%, 90% or 95% denatured). The heating conditions necessary for denaturing template nucleic acid will depend, e.g., on the buffer salt concentration and the length and nucleotide composition of the nucleic acids being denatured, but typically range from about 90°C to about 105°C for a time depending on features of the reaction such as temperature and the nucleic acid length. Denaturation is typically performed for about 30 sec to 4 min (e.g., 1 min to 2 min 30 sec, or 1.5 min).

If the double-stranded template nucleic acid is denatured by heat, the reaction mixture is allowed to cool to a temperature that promotes annealing of each primer to its target sequence on the described target MG gene nucleic acid molecules. The temperature for annealing is usually from about 35°C to about 65°C (e.g., about 40°C to about 60°C; about 45°C to about 50°C). Annealing

times can be from about 10 sec to about 1 min (e.g., about 20 sec to about 50 sec; about 30 sec to about 40 sec). The reaction mixture is then adjusted to a temperature at which the activity of the polymerase is promoted or optimized, i.e., a temperature sufficient for extension to occur from the annealed primer to generate products complementary to the template nucleic acid. The temperature should be sufficient to synthesize an extension product from each primer that is annealed to a nucleic acid template, but should not be so high as to denature an extension product from its complementary template (e.g., the temperature for extension generally ranges from about 40°C to about 80°C (e.g., about 50°C to about 70°C; about 60°C). Extension times can be from about 10 sec to about 5 min (e.g., about 30 sec to about 4 min; about 1 min to about 3 min; about 1 min 30 sec to about 2 min).

PCR assays can employ nucleic acid such as RNA or DNA (cDNA). The template nucleic acid need not be purified; it may be a minor fraction of a complex mixture, such as nucleic acid contained in human cells. Nucleic acid molecules may be extracted from a biological sample by routine techniques such as those described in *Diagnostic Molecular Microbiology: Principles and Applications* (Persing et al. (eds), 1993, American Society for Microbiology, Washington D.C.). Nucleic acids can be obtained from any number of sources, such as plasmids, or natural sources including bacteria, yeast, viruses, organelles, or higher organisms such as plants or animals.

The oligonucleotide primers are combined with PCR reagents under reaction conditions that induce primer extension. For example, chain extension reactions generally include 50 mM KCl, 10 mM Tris-HCl (pH 8.3), 15 mM MgCl₂, 0.001% (w/v) gelatin, 0.5-1.0 µg denatured template DNA, 50 pmoles of each oligonucleotide primer, 2.5 U of Taq polymerase, and 10% DMSO). The reactions usually contain 150 to 320 µM each of dATP, dCTP, dTTP, dGTP, or one or more analogs thereof.

The newly synthesized strands form a double-stranded molecule that can be used in the succeeding steps of the reaction. The steps of strand separation, annealing, and elongation can be repeated as often as needed to produce the desired quantity of amplification products corresponding to the target nucleic acid molecules. The limiting factors in the reaction are the amounts of primers, thermostable enzyme, and nucleoside triphosphates present in the reaction. The cycling steps (i.e., denaturation, annealing, and extension) are preferably repeated at least

once. For use in detection, the number of cycling steps will depend, e.g., on the nature of the sample. If the sample is a complex mixture of nucleic acids, more cycling steps will be required to amplify the target sequence sufficient for detection. Generally, the cycling steps are repeated at least about 20 times, but may be repeated as many as 40, 60, or even 100 times.

5 **Fluorescence Resonance Energy Transfer (FRET)**

FRET technology (see, for example, U.S. Pat. Nos. 4,996,143, 5,565,322, 5,849,489, and 6,162,603) is based on a concept that when a donor fluorescent moiety and a corresponding acceptor fluorescent moiety are positioned within a certain distance of each other, energy transfer takes place between the two fluorescent moieties that can be visualized or otherwise detected and/or
10 quantitated. The donor typically transfers the energy to the acceptor when the donor is excited by light radiation with a suitable wavelength. The acceptor typically re-emits the transferred energy in the form of light radiation with a different wavelength. In certain systems, non-fluorescent energy can be transferred between donor and acceptor moieties, by way of biomolecules that include substantially non-fluorescent donor moieties (see, for example, US Pat. No. 7,741,467).

15 In one example, an oligonucleotide probe can contain a donor fluorescent moiety and a corresponding quencher, which may or not be fluorescent, and which dissipates the transferred energy in a form other than light. When the probe is intact, energy transfer typically occurs between the donor and acceptor moieties such that fluorescent emission from the donor fluorescent moiety is quenched the acceptor moiety. During an extension step of a polymerase
20 chain reaction, a probe bound to an amplification product is cleaved by the 5' to 3' nuclease activity of, e.g., a Taq Polymerase such that the fluorescent emission of the donor fluorescent moiety is no longer quenched. Exemplary probes for this purpose are described in, e.g., U.S. Pat. Nos. 5,210,015, 5,994,056, and 6,171,785. Commonly used donor-acceptor pairs include the FAM-TAMRA pair. Commonly used quenchers are DABCYL and TAMRA. Commonly used
25 dark quenchers include BlackHole Quenchers™ (BHQ), (Biosearch Technologies, Inc., Novato, Cal.), Iowa Black™, (Integrated DNA Tech., Inc., Coralville, Iowa), BlackBerry™ Quencher 650 (BBQ-650), (Berry & Assoc., Dexter, Mich.).

In another example, two oligonucleotide probes, each containing a fluorescent moiety, can hybridize to an amplification product at particular positions determined by the complementarity

of the oligonucleotide probes to the target nucleic acid sequence. Upon hybridization of the oligonucleotide probes to the amplification product nucleic acid at the appropriate positions, a FRET signal is generated. Hybridization temperatures can range from about 35° C. to about 65° C. for about 10 sec to about 1 min.

- 5 Fluorescent analysis can be carried out using, for example, a photon counting epifluorescent microscope system (containing the appropriate dichroic mirror and filters for monitoring fluorescent emission at the particular range), a photon counting photomultiplier system, or a fluorimeter. Excitation to initiate energy transfer, or to allow direct detection of a fluorophore, can be carried out with an argon ion laser, a high intensity mercury (Hg) arc lamp, a fiber optic
10 light source, or other high intensity light source appropriately filtered for excitation in the desired range.

As used herein with respect to donor and corresponding acceptor moieties "corresponding" refers to an acceptor fluorescent moiety or a dark quencher having an absorbance spectrum that overlaps the emission spectrum of the donor fluorescent moiety. The wavelength maximum of
15 the emission spectrum of the acceptor fluorescent moiety should be at least 100 nm greater than the wavelength maximum of the excitation spectrum of the donor fluorescent moiety. Accordingly, efficient non-radiative energy transfer can be produced there between.

Fluorescent donor and corresponding acceptor moieties are generally chosen for (a) high efficiency Forster energy transfer; (b) a large final Stokes shift (>100 nm); (c) shift of the emission
20 as far as possible into the red portion of the visible spectrum (>600 nm); and (d) shift of the emission to a higher wavelength than the Raman water fluorescent emission produced by excitation at the donor excitation wavelength. For example, a donor fluorescent moiety can be chosen that has its excitation maximum near a laser line (for example, Helium-Cadmium 442 nm or Argon 488 nm), a high extinction coefficient, a high quantum yield, and a good overlap of its
25 fluorescent emission with the excitation spectrum of the corresponding acceptor fluorescent moiety. A corresponding acceptor fluorescent moiety can be chosen that has a high extinction coefficient, a high quantum yield, a good overlap of its excitation with the emission of the donor fluorescent moiety, and emission in the red part of the visible spectrum (>600 nm).

Representative donor fluorescent moieties that can be used with various acceptor fluorescent moieties in FRET technology include fluorescein, Lucifer Yellow, B-phycoerythrin, 9-acridineisothiocyanate, Lucifer Yellow VS, 4-acetamido-4'-isothio-cyanatostilbene-2,2'-disulfonic acid, 7-diethylamino-3-(4'-isothiocyanatophenyl)-4-methylcoumarin, succinimidyl 1-pyrenebutyrate, and 4-acetamido-4'-isothiocyanatostilbene-2,2'-disulfonic acid derivatives. Representative acceptor fluorescent moieties, depending upon the donor fluorescent moiety used, include LC Red 640, LC Red 705, Cy5, Cy5.5, Lissamine rhodamine B sulfonyl chloride, tetramethyl rhodamine isothiocyanate, rhodamine x isothiocyanate, erythrosine isothiocyanate, fluorescein, diethylenetriamine pentaacetate, or other chelates of Lanthanide ions (e.g., Europium, or Terbium). Donor and acceptor fluorescent moieties can be obtained, for example, from Molecular Probes (Junction City, Oreg.) or Sigma Chemical Co. (St. Louis, Mo.).

The donor and acceptor fluorescent moieties can be attached to the appropriate probe oligonucleotide via a linker arm. The length of each linker arm is important, as the linker arms will affect the distance between the donor and acceptor fluorescent moieties. The length of a linker arm can be the distance in Angstroms (Å) from the nucleotide base to the fluorescent moiety. In general, a linker arm is from about 10 Å to about 25 Å. The linker arm may be of the kind described in WO 84/03285. WO 84/03285 also discloses methods for attaching linker arms to a particular nucleotide base, and also for attaching fluorescent moieties to a linker arm.

An acceptor fluorescent moiety, such as an LC Red 640, can be combined with an oligonucleotide which contains an amino linker (e.g., C6-amino phosphoramidites available from ABI (Foster City, Calif.) or Glen Research (Sterling, VA)) to produce, for example, LC Red 640-labeled oligonucleotide. Frequently used linkers to couple a donor fluorescent moiety such as fluorescein to an oligonucleotide include thiourea linkers (FITC-derived, for example, fluorescein-CPG's from Glen Research or ChemGene (Ashland, Mass.)), amide-linkers (fluorescein-NHS-ester-derived, such as CX-fluorescein-CPG from BioGenex (San Ramon, Calif.)), or 3'-amino-CPGs that require coupling of a fluorescein-NHS-ester after oligonucleotide synthesis.

Detection of MG

The present disclosure provides methods for detecting the presence or absence of MG in a biological or non-biological sample. Methods provided avoid problems of sample contamination, false negatives, and false positives. The methods include performing at least one cycling step that includes amplifying a portion of target nucleic acid molecules from a sample using one or more pairs of primers, and a FRET detecting step. Multiple cycling steps are performed, preferably in a thermocycler. Methods can be performed using the primers and probes to detect the presence of MG, and the detection of the target MG gene indicates the presence of MG in the sample.

As described herein, amplification products can be detected using labeled hybridization probes that take advantage of FRET technology. One FRET format utilizes TaqMan® technology to detect the presence or absence of an amplification product, and hence, the presence or absence of MG. TaqMan® technology utilizes one single-stranded hybridization probe labeled with, e.g., one fluorescent dye and one quencher, which may or may not be fluorescent. When a first fluorescent moiety is excited with light of a suitable wavelength, the absorbed energy is transferred to a second fluorescent moiety or a dark quencher according to the principles of FRET. The second moiety is generally a quencher molecule. During the annealing step of the PCR reaction, the labeled hybridization probe binds to the target DNA (i.e., the amplification product) and is degraded by the 5' to 3' nuclease activity of, e.g., the Taq Polymerase during the subsequent elongation phase. As a result, the fluorescent moiety and the quencher moiety become spatially separated from one another. As a consequence, upon excitation of the first fluorescent moiety in the absence of the quencher, the fluorescence emission from the first fluorescent moiety can be detected. By way of example, an ABI PRISM® 7700 Sequence Detection System (Applied Biosystems) uses TaqMan® technology, and is suitable for performing the methods described herein for detecting the presence or absence of MG in the sample.

Molecular beacons in conjunction with FRET can also be used to detect the presence of an amplification product using the real-time PCR methods. Molecular beacon technology uses a hybridization probe labeled with a first fluorescent moiety and a second fluorescent moiety. The second fluorescent moiety is generally a quencher, and the fluorescent labels are typically located at each end of the probe. Molecular beacon technology uses a probe oligonucleotide having

sequences that permit secondary structure formation (e.g., a hairpin). As a result of secondary structure formation within the probe, both fluorescent moieties are in spatial proximity when the probe is in solution. After hybridization to the target nucleic acids (i.e., amplification products), the secondary structure of the probe is disrupted and the fluorescent moieties become separated from one another such that after excitation with light of a suitable wavelength, the emission of the first fluorescent moiety can be detected.

Another common format of FRET technology utilizes two hybridization probes. Each probe can be labeled with a different fluorescent moiety and are generally designed to hybridize in close proximity to each other in a target DNA molecule (e.g., an amplification product). A donor fluorescent moiety, for example, fluorescein, is excited at 470 nm by the light source of the LightCycler® Instrument. During FRET, the fluorescein transfers its energy to an acceptor fluorescent moiety such as LightCycler®-Red 640 (LC Red 640) or LightCycler®-Red 705 (LC Red 705). The acceptor fluorescent moiety then emits light of a longer wavelength, which is detected by the optical detection system of the LightCycler® instrument. Efficient FRET can only take place when the fluorescent moieties are in direct local proximity and when the emission spectrum of the donor fluorescent moiety overlaps with the absorption spectrum of the acceptor fluorescent moiety. The intensity of the emitted signal can be correlated with the number of original target DNA molecules (e.g., the number of MG genomes). If amplification of target nucleic acid occurs and an amplification product is produced, the step of hybridizing results in a detectable signal based upon FRET between the members of the pair of probes.

Generally, the presence of FRET indicates the presence of MG in the sample, and the absence of FRET indicates the absence of MG in the sample. Inadequate specimen collection, transportation delays, inappropriate transportation conditions, or use of certain collection swabs (calcium alginate or aluminum shaft) are all conditions that can affect the success and/or accuracy of a test result, however. Using the methods disclosed herein, detection of FRET within, e.g., 45 cycling steps is indicative of a MG infection.

Representative biological samples that can be used in practicing the methods include, but are not limited to respiratory specimens, fecal specimens, blood specimens, dermal swabs, nasal swabs, wound swabs, blood cultures, skin, and soft tissue infections. Collection and storage methods of

biological samples are known to those of skill in the art. Biological samples can be processed (e.g., by nucleic acid extraction methods and/or kits known in the art) to release MG nucleic acid or in some cases, the biological sample can be contacted directly with the PCR reaction components and the appropriate oligonucleotides.

- 5 Melting curve analysis is an additional step that can be included in a cycling profile. Melting curve analysis is based on the fact that DNA melts at a characteristic temperature called the melting temperature (T_m), which is defined as the temperature at which half of the DNA duplexes have separated into single strands. The melting temperature of a DNA depends primarily upon its nucleotide composition. Thus, DNA molecules rich in G and C nucleotides
- 10 have a higher T_m than those having an abundance of A and T nucleotides. By detecting the temperature at which signal is lost, the melting temperature of probes can be determined. Similarly, by detecting the temperature at which signal is generated, the annealing temperature of probes can be determined. The melting temperature(s) of the probes from the amplification products can confirm the presence or absence of MG in the sample.
- 15 Within each thermocycler run, control samples can be cycled as well. Positive control samples can amplify target nucleic acid control template (other than described amplification products of target genes) using, for example, control primers and control probes. Positive control samples can also amplify, for example, a plasmid construct containing the target nucleic acid molecules. Such a plasmid control can be amplified internally (e.g., within the sample) or in a separate
- 20 sample run side-by-side with the patients' samples using the same primers and probe as used for detection of the intended target. Such controls are indicators of the success or failure of the amplification, hybridization, and/or FRET reaction. Each thermocycler run can also include a negative control that, for example, lacks target template DNA. Negative control can measure contamination. This ensures that the system and reagents would not give rise to a false positive
- 25 signal. Therefore, control reactions can readily determine, for example, the ability of primers to anneal with sequence-specificity and to initiate elongation, as well as the ability of probes to hybridize with sequence-specificity and for FRET to occur.

In an embodiment, the methods include steps to avoid contamination. For example, an enzymatic method utilizing uracil-DNA glycosylase is described in U.S. Pat. Nos. 5,035,996,

5,683,896 and 5,945,313 to reduce or eliminate contamination between one thermocycler run and the next.

Conventional PCR methods in conjunction with FRET technology can be used to practice the methods. In one embodiment, a LightCycler® instrument is used. The following patent applications describe real-time PCR as used in the LightCycler® technology: WO 97/46707, WO 5 97/46714, and WO 97/46712.

The LightCycler® can be operated using a PC workstation and can utilize a Windows NT operating system. Signals from the samples are obtained as the machine positions the capillaries sequentially over the optical unit. The software can display the fluorescence signals in real-time 10 immediately after each measurement. Fluorescent acquisition time is 10-100 milliseconds (msec). After each cycling step, a quantitative display of fluorescence vs. cycle number can be continually updated for all samples. The data generated can be stored for further analysis.

As an alternative to FRET, an amplification product can be detected using a double-stranded DNA binding dye such as a fluorescent DNA binding dye (e.g., SYBR® Green or SYBR® Gold 15 (Molecular Probes)). Upon interaction with the double-stranded nucleic acid, such fluorescent DNA binding dyes emit a fluorescence signal after excitation with light at a suitable wavelength. A double-stranded DNA binding dye such as a nucleic acid intercalating dye also can be used. When double-stranded DNA binding dyes are used, a melting curve analysis is usually performed for confirmation of the presence of the amplification product.

20 It is understood that the embodiments of the present disclosure are not limited by the configuration of one or more commercially available instruments.

Articles of Manufacture/Kits

Embodiments of the present disclosure further provide for articles of manufacture, compositions or kits to detect MG. An article of manufacture can include primers and probes used to detect the 25 target MG gene, together with suitable packaging materials. Compositions can include primers used to amplify the target MG gene. In certain embodiments compositions can also comprise probes for detecting the target MG gene. Representative primers and probes for detection of MG are capable of hybridizing to target nucleic acid molecules. In addition, the kits may also include suitably packaged reagents and materials needed for DNA immobilization, hybridization, and

detection, such solid supports, buffers, enzymes, and DNA standards. Methods of designing primers and probes are disclosed herein, and representative examples of primers and probes that amplify and hybridize to target nucleic acid molecules are provided.

Articles of manufacture can also include one or more fluorescent moieties for labeling the probes or, alternatively, the probes supplied with the kit can be labeled. For example, an article of manufacture may include a donor and/or an acceptor fluorescent moiety for labeling the probes. Examples of suitable FRET donor fluorescent moieties and corresponding acceptor fluorescent moieties are provided above.

Articles of manufacture can also contain a package insert or package label having instructions thereon for using the primers and probes to detect MG in a sample. Articles of manufacture and compositions may additionally include reagents for carrying out the methods disclosed herein (e.g., buffers, polymerase enzymes, co-factors, or agents to prevent contamination). Such reagents may be specific for one of the commercially available instruments described herein.

Embodiments of the present disclosure will be further described in the following examples, which do not limit the scope of the invention described in the claims.

EXAMPLES

The following examples, tables and figures are provided to aid the understanding of the subject matter, the true scope of which is set forth in the appended claims. It is understood that modifications can be made in the procedures set forth without departing from the spirit of the invention.

EXAMPLE I

Target selection for MG was the result of a comprehensive search of the public sequence database. Multiple methods were used to search for *Mycoplasma genitalium* sequences and its nearest neighbor, *Mycoplasma pneumoniae*, to design for assay exclusivity. The MG targets selected had the most coverage in the public database (mgpB 120 sequences, MgPar 5 whole genome assemblies). MG has a small compact genome, which limited regions to target for NAT design. The mgpB surface protein gene (called the MgPar target) was selected for the assay due to its multi-copy number. Surface proteins are known to undergo recombination, which can result in a

failed assay. To mitigate the associated risks, a dual target approach was implemented using a well conserved target (called the mgpB target).

The MgPa operon codes three genes: mgpA, mgpB and mgpC (black circle labeled as mgpB 221kb in Figure 1). mgpB (4335 bp) is present in the complete operon but there are nine partial repeats (MgPar's) outside of the operon. The repeats are partial copies of mgpB (Figure 1). The well conserved region A of the mgpB gene (called the mgpB target) was selected for inclusivity purposes, and the variable region EF (called the MgPar target) multi-copy target was selected for sensitivity purposes (Figure 1).

Real-time PCR detection of MG were performed using either the **cobas**[®] 4800 system or the **cobas**[®] 6800/8800 systems platforms (Roche Molecular Systems, Inc., Pleasanton, CA). The final concentrations of the amplification reagents are shown below:

TABLE X PCR Amplification Reagents

<i>Master Mix Component</i>	<i>Final Conc (50uL)</i>	
DMSO	0-5.4	%
NaN3	0.027-0.030	%
Potassium acetate	120.0	mM
Glycerol	3.0	%
Tween [™] 20	0.02	%
EDTA	0-43.9	uM
Tricine	60.0	mM
Aptamer	0.18-0.22	uM
UNG Enzyme	5.0-10.0	U
Z05-SP-PZ Polymerase	30.0-45.0	U
dATP	400.0-521.70	uM
dCTP	400.0-521.70	uM
dGTP	400.0-521.70	uM
dUTP	800.0-1043.40	uM
Forward primer oligonucleotides	0.15-0.50	μM
Reverse primer oligonucleotides	0.15-0.50	μM
Probe oligonucleotides	0.10	μM
Manganese Acetate	3.30-3.80	mM

The following table shows the typical thermoprofile used for PCR amplification reaction:

TABLE XVII PCR Thermoprofile

Program Name	Target (°C)	Acquisition Mode	Hold (hh:mm:ss)	Ramp Rate (°C / s)	Cycles	Analysis Mode
Pre-PCR	50	None	00:02:00	4.4	1	None
	94	None	00:00:05	4.4		
	55	None	00:02:00	2.2		
	60	None	00:06:00	4.4		
	65	None	00:04:00	4.4		
1st Measurement	95	None	00:00:05	4.4	5	Quantification
	55	Single	00:00:30	2.2		
2nd Measurement	91	None	00:00:05	4.4	45	Quantification
	58	Single	00:00:25	2.2		
Cooling	40	None	00:02:00	2.2	1	None

The Pre-PCR program comprised initial denaturing and incubation at 55°C, 60°C and 65°C for reverse transcription of RNA templates. Incubating at three temperatures combines the advantageous effects that at lower temperatures slightly mismatched target sequences (such as genetic variants of an organism) are also transcribed, while at higher temperatures the formation of RNA secondary structures is suppressed, thus leading to a more efficient transcription. PCR cycling was divided into two measurements, wherein both measurements apply a one-step setup (combining annealing and extension). The first 5 cycles at 55°C allow for an increased inclusivity by pre-amplifying slightly mismatched target sequences, whereas the 45 cycles of the second measurement provide for an increased specificity by using an annealing/extension temperature of 58°C. Figure 2 depicts a typical amplification experiment where PCR growth curves are shown in various concentrations of genomic MG template DNA.

The amplification and detection of the target MG genes, 23s rRNA, mgpB, and MgPar were performed using the conditions described above. The results of the experiments using several selected oligonucleotide primers and probes against genomic MG DNA present at a concentration of 1000 genomic equivalent/PCR are shown below as Ct values (threshold cycle) for the amplification reactions.

TABLE XVIII Amplification and Detection of target MG genes

Target MG Gene	Forward primer SEQ ID NO	Reverse primer SEQ ID NO	Probe SEQ ID NO	Ct values 1000 ge/PCR of MG
23s rRNA	3	8	24	28.0
	3	9	24	28.1
	4	8	24	27.3
	4	9	24	28.3
mgpB	34	40	45	27.9
	35	41	45	27.5
	34	40	46	27.2
	35	41	46	27.5
MgPar	48	66	80	28.2
	56	65	80	32.4
	48	66	89	28.7
	56	65	89	33.1

While the foregoing invention has been described in some detail for purposes of clarity and understanding, it will be clear to one skilled in the art from a reading of this disclosure that various changes in form and detail can be made. For example, all the techniques and apparatus

5 described above can be used in various combinations.

CLAIMS:

1. A method of detecting *Mycoplasma genitalium* (MG) in a sample, the method comprising:

- performing an amplifying step comprising contacting the sample with a set of target MG gene primers to produce an amplification product if a target MG gene nucleic acid is present in the sample;
- performing a hybridizing step comprising contacting the amplification product with one or more detectable target MG gene probes; and
- detecting the presence or absence of the amplification product, wherein the presence of the amplification product is indicative of the presence of MG in the sample and wherein the absence of the amplification product is indicative of the absence of MG in the sample;

wherein the set of target MG gene primers and the one or more detectable target MG gene probes amplify and detect the variable EF region of the mgbB partial repeats (MgPar); and

wherein the set of target MG gene primers comprise a first MgPar gene primer comprising a first oligonucleotide sequence selected from the group consisting of SEQ ID NOs: 47-56, and a second MgPar gene primer comprising a second oligonucleotide sequence selected from the group consisting of SEQ ID NOs: 57-66; and

wherein the one or more detectable target MgPar gene probes comprises a third oligonucleotide sequence selected from the group consisting of SEQ ID NOs: 67-89, or the complement thereof.

2. The method of claim 1, wherein:

- the hybridizing step comprises contacting the amplification product with the detectable target MgPar gene probe that is labeled with a donor fluorescent moiety and a corresponding acceptor moiety; and
- the detecting step comprises detecting the presence or absence of fluorescence resonance energy transfer (FRET) between the donor fluorescent moiety and the acceptor moiety of the probe, wherein the

presence or absence of fluorescence is indicative of the presence or absence of MG in the sample.

3. The method according to claim 1 or 2, wherein said amplifying step employs a polymerase enzyme having 5' to 3' nuclease activity.
4. The method of any one of claims 2 to 3, wherein the donor fluorescent moiety and the corresponding acceptor moiety are within no more than 8-20 nucleotides of each other on the probe.
5. The method of any one of claims 2 to 4, wherein the acceptor moiety is a quencher.
6. The method of any one of claims 1 to 5, wherein the first MgPar gene primer comprises an oligonucleotide sequence of SEQ ID NO:48, the second MgPar gene primer comprises an oligonucleotide sequence of SEQ ID NO:64 and the detectable target MgPar gene probe comprises an oligonucleotide sequence of SEQ ID NO:89 or the complement thereof.
7. The method of claim 6 further comprising a second first MgPar gene primer comprising an oligonucleotide sequence of SEQ ID NO:56.
8. The method of any one of claims 1 to 7 further comprising a set of target MG mgpB gene primers and one or more detectable target MG mgpB gene probes for amplifying and detecting the conserved region A of the mgpB gene within the MgPa adhesion operon.
9. The method of claim 8, wherein the set of target MG mgpB gene primers comprises a first MG mgpB gene primer comprising a first oligonucleotide sequence selected from the group consisting of SEQ ID NOs: 29-35 and a second MG mgpB gene primer comprising a second oligonucleotide sequence selected from the group consisting of SEQ ID NOs: 36-41, and wherein the one or more detectable target MG mgpB gene probes comprises a third oligonucleotide sequence selected from the group consisting of SEQ ID NOs: 42-46, or the complement thereof.
10. The method of claim 9, wherein the first MG mgpB gene primer comprises an oligonucleotide sequence of SEQ ID NO: 34, the second MG

mgpB gene primer comprises an oligonucleotide sequence of SEQ ID NOs: 40; and the detectable target MG mgpB gene probe comprises an oligonucleotide sequence of SEQ ID NO: 45, or the complement thereof.

11. A kit for detecting a nucleic acid of *Mycoplasma genitalium* (MG) comprising:

- a first MgPar gene primer comprising a first oligonucleotide sequence selected from the group consisting of SEQ ID NOs: 47-56;
- a second MgPar gene primer comprising a second oligonucleotide sequence selected from the group consisting of SEQ ID NOs: 57-66; and
- a fluorescently detectably labeled target MgPar gene probe comprising a third oligonucleotide sequence selected from the group consisting of SEQ ID NOs: 67-89, or a complement, the detectably labeled probe configured to hybridize to an amplicon generated by the first primer and the second primer.

12. The kit of claim 11, wherein the third detectably labeled oligonucleotide sequence comprises a donor fluorescent moiety and a corresponding acceptor moiety.

13. The kit of claim 12, wherein the acceptor moiety is a quencher.

14. The kit of any one of claims 11 to 13 further comprising at least one of nucleoside triphosphates, nucleic acid polymerase, and buffers necessary for the function of the nucleic acid polymerase.

15. The kit of any one of claims 11 to 14, wherein the first MgPar gene primer comprises an oligonucleotide sequence of SEQ ID NO:48, the second MgPar gene primer comprises an oligonucleotide sequence of SEQ ID NO:64 and the detectable target MgPar gene probe comprises an oligonucleotide sequence of SEQ ID NO:89 or the complement thereof.

16. The kit of claim 15 further comprising a second first MgPar gene primer comprising an oligonucleotide sequence of SEQ ID NO:56.

17. The kit of any one of claims 11 to 16 further comprising a set of target MG mgpB gene primers and one or more detectable target MG mgpB

gene probes for amplifying and detecting the conserved region A of the mgpB gene within the MgPa adhesion operon.

18. The kit of claim 17, wherein the set of target MG mgpB gene primers comprises a first MG mgpB gene primer comprising a first oligonucleotide sequence selected from the group consisting of SEQ ID NOs: 29-35, and a second MG mgpB gene primer comprising a second oligonucleotide sequence selected from the group consisting of SEQ ID NOs: 36-41; and wherein the one or more detectable target MG mgpB gene probes comprises a third oligonucleotide sequence selected from the group consisting of SEQ ID NOs: 42-46, or the complement thereof.

19. The kit of claim 18, wherein the first MG mgpB gene primer comprises an oligonucleotide sequence of SEQ ID NO: 34, the second MG mgpB gene primer comprises an oligonucleotide sequence of SEQ ID NOs: 40; and the detectable target MG mgpB gene probe comprises an oligonucleotide sequence of SEQ ID NO: 45, or the complement thereof.

20. The kit of any one of claims 11 to 19, wherein at least one of the first MgPar gene primer, the second MgPar gene primer, and the fluorescently detectably labeled target MgPar gene probe comprises at least one modified nucleotide.

21. The kit of any one of claims 11 to 20, wherein at least one of the first MG mgpB gene primer, the second MG mgpB gene primer, and the one or more detectable target MG mgpB gene probes comprises at least one modified nucleotide.

22. The kit of any one of claims 11 to 21, wherein the first MgPar gene primer, the second MgPar gene primer, and the fluorescently detectably labeled target MgPar gene probe have 40 or fewer nucleotides.

23. The kit of any one of claims 11 to 22, wherein at least one of the first MG mgpB gene primer, the second MG mgpB gene primer, and the one or more detectable target MG mgpB gene probes have 40 or fewer nucleotides.

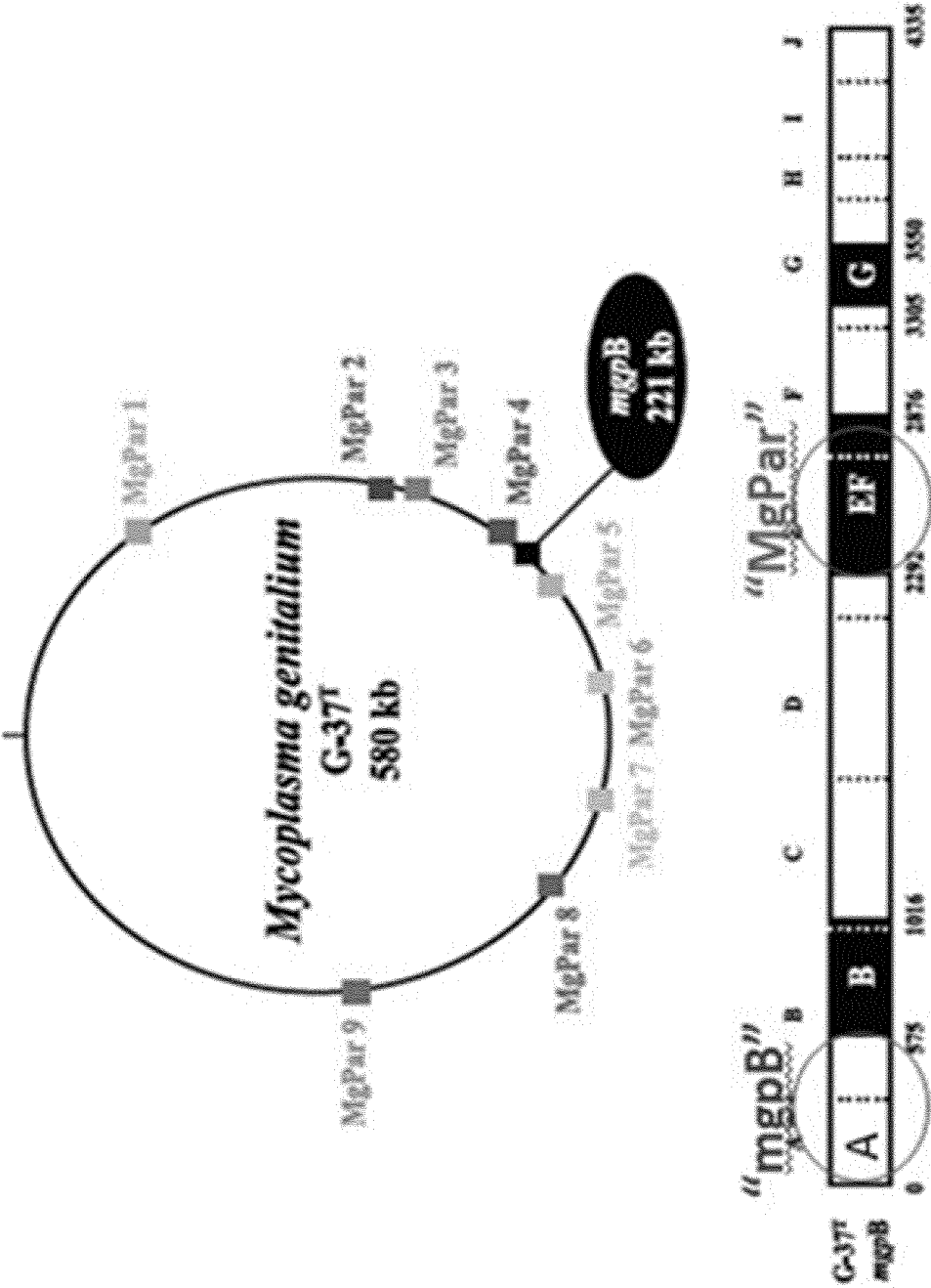


FIGURE 1

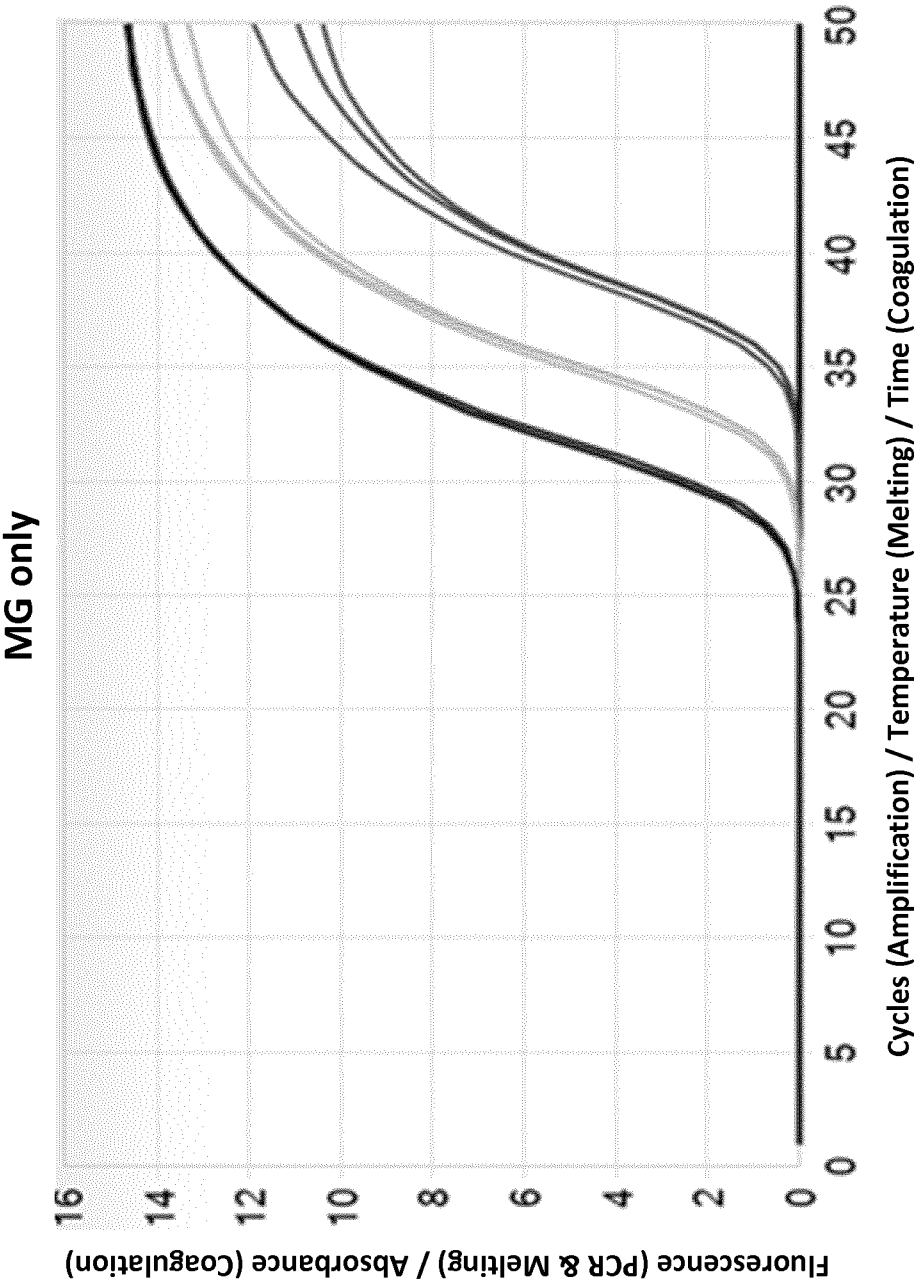


FIGURE 2

