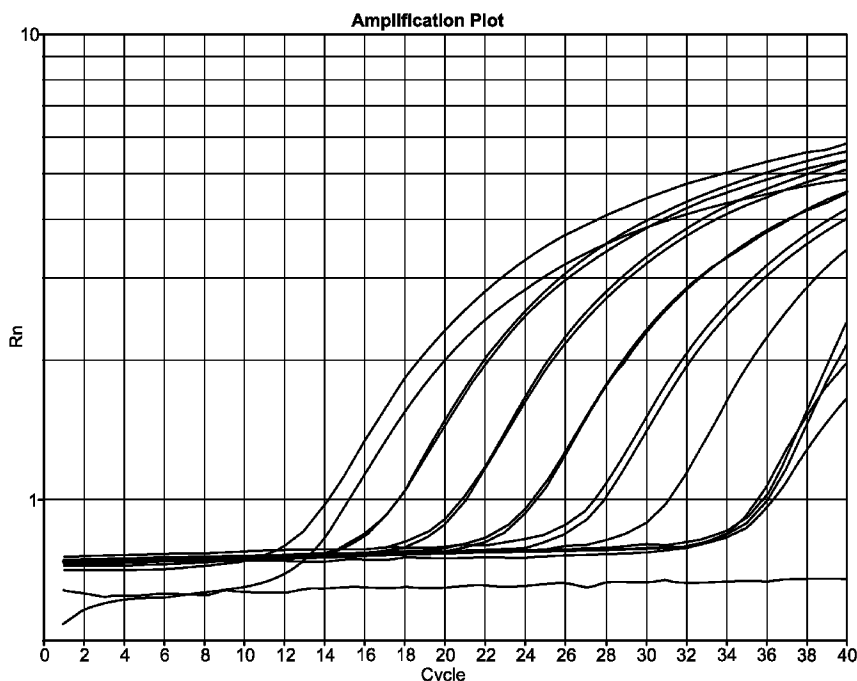




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(54) **Titre : METHODES ET COMPOSITIONS DE DETECTION D'UNE CONTAMINATION BACTERIENNE**
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(57) **Abrégé/Abstract:**

Compositions, reactions mixtures, kits, and systems for detecting bacterial contamination are provided, as well as methods of using the same.

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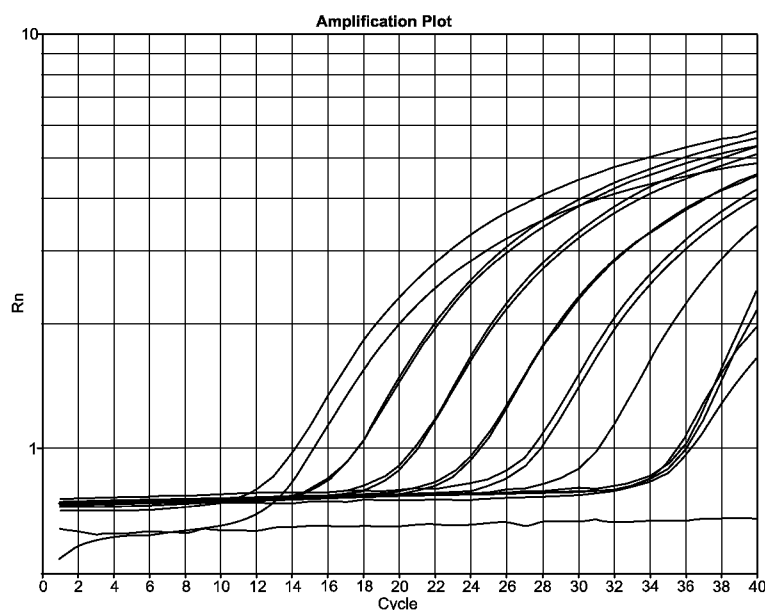


FIG. 1

(57) Abstract: Compositions, reactions
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METHODS AND COMPOSITIONS FOR DETECTING BACTERIAL CONTAMINATION

[0001]

BACKGROUND OF THE INVENTION

[0002] Microbial contamination of transplant tissues and blood transfusion products is a major medical problem. Blood banks are faced with a great challenge in testing each platelet bag for microbial contamination prior to release for infusion into a patient. Part of this challenge relates to the relatively short shelf-life of platelet samples, typically 5-7 days and sometimes shorter. The challenge with respect to platelets is further complicated by standard storage conditions. Platelets, unlike most other transplantable tissues, do not tolerate refrigeration and disappear rapidly from the circulation of recipients if subjected to even very short periods of chilling. This cooling effect on platelet survival is thought to be irreversible and renders platelets unsuitable for transfusion. When platelets are exposed to temperatures lower than 20° C., they rapidly undergo modifications in shape indicative of impairment. The need to keep platelets at room temperature (e.g. 22-25 C) prior to transfusion has imposed a unique set of costly and complex logistical requirements for platelet storage. Because platelets are metabolically active at room temperature, they are typically subjected to constant agitation in gas permeable containers to allow for the exchange of gases to prevent the toxic consequences of metabolic acidosis. These storage conditions encourage the growth of bacteria thereby creating a higher risk of bacterial infection. Because screening methods that rely on detection by culture can take longer than the usable shelf-life to detect contamination, contaminated platelets are often infused into patients, and the physician is notified subsequently that the platelets were contaminated as the culture results become available. Under the American Association of Blood Banks (A.A.B.B.) standard 5.1.5.1, blood banks or transfusion services are instructed to have methods to limit and detect bacterial contamination in all platelet concentrates. Nevertheless, the risk of transfusion with bacterially contaminated platelets may be as high as 1 in 1,000 units, with perhaps 10 to 25 of such incidents resulting in adverse effects on patients. While some contamination may derive from donor bacteraemia, contamination at the time of collection by bacteria present on the skin or in blood packs are main sources of contamination that cannot be addressed through donor diagnostic screening.

[0003] Common methods to mitigate contamination include preventative measures (e.g. arm cleansing, diverting a first portion of collected blood, and filtration) and culture methodologies. As evidenced by the current rate of contamination, these procedures remain inadequate. Moreover, because culture-based detection methods require significant incubation periods (sometimes days), samples may not be used for a significant portion of their useful life, and when they are used,

detection may not be complete. This is particularly true for contamination by bacteria that are relatively slow growing. For example, the mean detection times for *Bacillus sp.*, *Staphylococcal sp.*, *Streptococcal sp.*, *Micrococcus luteus*, *Kocuria varians*, *Corynebacterium sp.*, and *Propionibacterium sp.* have been estimated as 24 hours, 27 hours, 34 hours, 47 hours, 56 hours, 87 hours, and 97 hours, respectively, using standard culture methods.

[0004] One commercially available test is referred to as the BacT/ALERT test (bioMérieux, Inc., Durham, N.C.). Bacterial detection is based on the evolution of carbon dioxide by proliferating bacteria. A carbon-dioxide-sensitive liquid emulsion sensor at the bottom of the culture bottle changes color and is detected through alteration of light reflected on the sensor. Another method for bacterial detection involves measuring the oxygen content in a platelet preparation sample. An example is the Pall eBDS test (Pall Corporation, Port Washington, N.Y.). The approach to detection measures the oxygen content of air within the sample pouch as a surrogate marker for bacteria. An oxygen analyzer is used to measure the percent of oxygen in the headspace gas of the pouch or bag having the platelets. If bacteria are present in the platelet sample collected, an increasing amount of oxygen is consumed through the metabolic activity and proliferation of the bacteria in the sample during incubation, resulting in a measurable decrease in oxygen content of the plasma as well as the air within the sample pouch. While the non-specific measure of bacterial growth permits detection of many kinds of bacteria, the sensitivity is relatively low and requires long incubation times.

[0005] Alternative methods to the standard culture-based screens include bacterial antigen detection and nucleic acid-based screening. A major limitation on antigen-based methods is that they cannot be applied directly for testing of samples where the spectrum of bacterial pathogens is unknown. Detection of common bacterial nucleic acid sequences, such as 16S rRNA has been proposed to achieve a broader spectrum of detection, but such methods have so far been deemed less sensitive and specific than current culture methods and not appropriate for early testing of platelet samples.

SUMMARY OF THE INVENTION

[0006] The present disclosure provides methods, compositions, reaction mixtures, kits, and systems for detecting contamination of biological samples, such as platelet samples, with both a broad range and high specificity and sensitivity of detection. Detection of contamination according to the disclosure is also significantly more rapid than culture-based screening methodologies.

[0007] In one aspect, the disclosure provides a method of detecting bacterial contamination of a sample by any of a plurality of bacterial species, such as at least eight bacterial species. In one embodiment, the method comprises subjecting the sample or a portion thereof to a nucleic acid amplification reaction under conditions to yield a detectable amount of an amplicon of no more than about 800, 700, 600, 500, 400, 300, 200, 150, or 100 bases in a single reaction mixture, said reaction mixture comprising a single primer pair and a single detectable probe, wherein the primer pair flanks the amplicon, the amplicon comprises a conserved sequence to which the detectable probe hybridizes,

and the conserved sequence is identical among the at least eight bacterial species; and detecting hybridization to the amplicon by the probe, wherein the hybridization by the probe yields a detectable signal indicative of bacterial contamination of the sample by any of the at least eight bacterial species. In some embodiments, the sample is a blood sample or a buffy coat sample, and the contamination is predictive or diagnostic of sepsis in the subject. In some embodiments, the sample is a platelet sample. In some embodiments, the platelet sample is a platelet concentrate isolated by aphaeresis. In some embodiments, nucleic acids isolated from less than 5mL of the platelet concentrate are subjected to the nucleic acid amplification reaction. In some embodiments, the amplicon is generated from a bacterial 16S rRNA polynucleotide template. In some embodiments, the detecting of bacterial contamination is completed prior to transfusion into a recipient. In some embodiments, the amplification reaction yields a detectable amount of amplicon of no more than 300 bases, or no more than 150 bases. In some embodiments, the amplification reaction yields a detectable amount of amplicon of 100-200 bases. In some embodiments, all of the bacterial species are Gram-positive bacteria, Gram-negative bacteria, or a combination of both detected in the same reaction with probes having different detectable labels. In some embodiments, the at least eight bacterial species comprise a plurality of Gram-positive bacterial species and a plurality of Gram-negative bacterial species. In some embodiments, the bacterial species are selected from the group consisting of: *Staphylococcus aureus*, *Staphylococcus aureus* Mu3; *Staphylococcus epidermidis*, *Streptococcus agalactiae*, *Streptococcus pyogenes*, *Streptococcus pneumonia*, *Escherichia coli*, *Citrobacter koseri*, *Clostridium perfringens*, *Enterococcus faecalis*, *Klebsiella pneumonia*, *Lactobacillus acidophilus*, *Listeria monocytogenes*, *Propionibacterium granulosum*, *Pseudomonas aeruginosa*, *Serratia marcescens*, *Bacillus cereus* *Staphylococcus aureus* Mu50 *Yersinia enterocolitica* *Staphylococcus simulans* *Micrococcus luteus* and *Enterobacter aerogenes*. In some embodiments, the method comprises detecting bacterial contamination by any of at least ten or fifteen bacterial species in a sample. In some embodiments, the single primer pair comprises a first primer comprising at least 10 contiguous nucleotides of a sequence as set forth in Table 2 (e.g., SEQ ID NO: 4, 7, or 9) and a second primer comprising at least 10 nucleotides of a sequence as set forth in Table 2 (e.g., SEQ ID NO: 5, 6, 8, or 10). In some embodiments, the first and second primers are selected from the primer sets disclosed in Table 15, or any combinations thereof. In some embodiments, the first and second primer pairs exhibits at least 80 , 90 , 91 , 92 , 93 , 94 , 95 , 96 , 97 , 98 , or 99 sequence homology to any of the primers or complements thereof disclosed in Table 2 or Table 15, when optimally aligned. In some embodiments, the probe comprises at least 10 contiguous nucleotides of a sequence as set forth in Table 3, or a complement thereof. In some embodiments, the nucleic acid amplification reaction contains less than 5 pg of starting nucleic acids from the bacterial contamination. In some embodiments, the nucleic acid amplification reaction is performed using a method selected from the group consisting of: polymerase chain reaction, real-time polymerase chain reaction, isothermal amplification, strand displacement amplification, rolling circle amplification, ligase chain reaction,

transcription-mediated amplification, solid phase amplification, nucleic acid sequence-based amplification (NASBA), and linear amplification. In some embodiments, the nucleic acid amplification reaction is performed in a well, in a plate, in a tube, in a chamber, in a droplet, in a flow cell, in a slide, in a chip, attached to a solid substrate, attached to a bead, or in an emulsion. In some embodiments, the detectable signal has a linear range of detection across at least 5 logs. In some embodiments, the method further comprises determining the amount of bacterial contamination based on the probe signal.

[0008] In another aspect, the disclosure provides a method of detecting bacterial contamination of a sample. In one embodiment, the method comprises subjecting the sample or a portion thereof to a nucleic acid amplification reaction under conditions to yield a detectable amount of an amplicon of no more than about 800, 700, 600, 500, 400, 300, 200, 150, or 100 bases in a single reaction mixture, said reaction mixture comprising a single primer pair and a single detectable probe, wherein the primer pair flanks the amplicon, the amplicon comprises a conserved sequence to which the detectable probe hybridizes, and the sample or portion thereof has not been cultured at a temperature above 35 °C prior to amplification; and detecting hybridization to the amplicon by the probe, wherein the hybridization by the probe yields a detectable signal indicative of bacterial contamination of the sample. In some embodiments, the sample is a blood sample or a buffy coat sample, and the contamination is predictive or diagnostic of sepsis in the subject. In some embodiments, the sample is a platelet sample. In some embodiments, the platelet sample is a platelet concentrate isolated by apheresis. In some embodiments, nucleic acids isolated from less than 5mL of the platelet concentrate are subjected to the nucleic acid amplification reaction. In some embodiments, nucleic acids isolated from less than 5mL of the platelet concentrate are subjected to the nucleic acid amplification reaction. In some embodiments, the amplicon is generated from a bacterial 16S rRNA polynucleotide template. In some embodiments, the detecting of bacterial contamination is completed prior to transfusion into a recipient. In some embodiments, the amplification reaction yields a detectable amount of amplicon of no more than 300 bases, or no more than 150 bases. In some embodiments, the amplification reaction yields a detectable amount of amplicon of 100-200 bases. In some embodiments, the method comprises detecting bacterial contamination by any of at least ten or fifteen bacterial species in a sample. In some embodiments, the single primer pair comprises a first primer comprising at least 10 contiguous nucleotides of a sequence as set forth in SEQ ID NO: 4, 7, or 9 and a second primer comprising at least 10 nucleotides of a sequence as set forth in SEQ ID NO: 5, 6, 8, or 10. In some embodiments, the probe comprises at least 10 contiguous nucleotides of a sequence as set forth in Table 3, or a complement thereof. In some embodiments, the nucleic acid amplification reaction contains less than 5 pg of starting nucleic acids from the bacterial contamination. In some embodiments, the nucleic acid amplification reaction is performed using a method selected from the group consisting of: polymerase chain reaction, real-time polymerase chain reaction, isothermal amplification, strand displacement amplification, rolling circle amplification,

ligase chain reaction, transcription-mediated amplification, solid phase amplification, nucleic acid sequence-based amplification (NASBA), and linear amplification. In some embodiments, the nucleic acid amplification reaction is performed in a well, in a plate, in a tube, in a chamber, in a droplet, in a flow cell, in a slide, in a chip, attached to a solid substrate, attached to a bead, or in an emulsion. In some embodiments, the detectable signal has a linear range of detection across at least 5 logs. In some embodiments, the method further comprises determining the amount of bacterial contamination based on the probe signal.

[0009] In one aspect, the disclosure provides a method of rapidly detecting bacterial contamination in a sample within 24 hours after obtaining the sample. In one embodiment, the method comprises subjecting the sample or a portion thereof to a nucleic acid amplification reaction with a single primer pair and a single detectable probe in a single reaction mixture under conditions to yield a detectable amount of an amplicon of no more than about 800, 700, 600, 500, 400, 300, 200, 150, or 100 bases, wherein the primer pair flanks the amplicon, the amplicon comprises a conserved sequence to which the detectable probe hybridizes, and amplification of about 1pg-5pg of DNA from any one of the species has a cycle threshold value (C_T) of less than 30; and within about 24 hours after obtaining said sample, detecting hybridization to said amplicon by said probe, wherein said hybridization by said probe yields a detectable signal indicative of bacterial contamination of the sample, thereby detecting the contamination within about 24 hours from obtaining said sample. In some embodiments, the sample is a blood sample or a buffy coat sample, and the contamination is predictive or diagnostic of sepsis in the subject. In some embodiments, the sample is a platelet sample. In some embodiments, the platelet sample is a platelet concentrate isolated by apheresis. In some embodiments, nucleic acids isolated from less than 5mL of the platelet concentrate are subjected to the nucleic acid amplification reaction. In some embodiments, the detection yields a detectable signal indicative of bacterial contamination of a platelet sample having a bacterial load of about 1.0 colony forming unit per mL (CFU/mL). In some embodiments, nucleic acids isolated from less than 5mL of the platelet concentrate are subjected to the nucleic acid amplification reaction. In some embodiments, the amplicon is generated from a bacterial 16S rRNA polynucleotide template. In some embodiments, the detecting of bacterial contamination is completed prior to transfusion into a recipient. In some embodiments, the amplification reaction yields a detectable amount of amplicon of no more than 300 bases, or no more than 150 bases. In some embodiments, the amplification reaction yields a detectable amount of amplicon of 100-200 bases. In some embodiments, the method comprises detecting bacterial contamination by any of at least ten or fifteen bacterial species in a sample. In some embodiments, the single primer pair comprises a first primer comprising at least 10 contiguous nucleotides of a sequence as set forth in SEQ ID NO: 4, 7, or 9 and a second primer comprising at least 10 nucleotides of a sequence as set forth in SEQ ID NO: 5, 6, 8, or 10. In some embodiments, the probe comprises at least 10 contiguous nucleotides of a sequence as set forth in Table 3, or a complement thereof. In some embodiments, the nucleic acid amplification reaction contains less than

5 pg of starting nucleic acids from the bacterial contamination. In some embodiments, the nucleic acid amplification reaction is performed using a method selected from the group consisting of: polymerase chain reaction, real-time polymerase chain reaction, isothermal amplification, strand displacement amplification, rolling circle amplification, ligase chain reaction, transcription-mediated amplification, solid phase amplification, nucleic acid sequence-based amplification (NASBA), and linear amplification. In some embodiments, the nucleic acid amplification reaction is performed in a well, in a plate, in a tube, in a chamber, in a droplet, in a flow cell, in a slide, in a chip, attached to a solid substrate, attached to a bead, or in an emulsion. In some embodiments, the detectable signal has a linear range of detection across at least 5 logs. In some embodiments, the method further comprises determining the amount of bacterial contamination based on the probe signal.

[0010] In another aspect, the disclosure provides a method of detecting bacterial contamination by any of a plurality of bacterial species from different genera in a sample (e.g. a biological sample of a subject). In one embodiment, the method comprises performing a nucleic acid amplification reaction on the sample or a portion thereof with a single primer pair to yield a detectable amount of an amplicon of no more than about 800, 700, 600, 500, 400, 300, 200, 150, or 100 bases of a 16S rRNA polynucleotide, wherein amplification of about 1pg-5pg of DNA from any one of the species has a cycle threshold value (C_T) of less than 30; and detecting the amplicon with one or more detectable probes, wherein each of the one or more detectable probes specifically hybridizes to a conserved sequence, and the conserved sequence is identical among a plurality of bacterial species from different genera. In some embodiments, the sample is a blood sample or a buffy coat sample, and the contamination is predictive or diagnostic of sepsis in the subject. In some embodiments, the sample is a platelet sample. In some embodiments, the C_T for a negative control sample is at least 5 cycles higher than the C_T for a sample containing 1pg-5pg of DNA from any one of the at least 5 bacterial species. In some embodiments, the one or more detectable probes comprises no more than 5 different probes, or no more than 2 different probes. In some embodiments, the one or more detectable probes consists of one probe. In some embodiments, the detecting of bacterial contamination is completed prior to transfusion into a recipient. In some embodiments, the amplification reaction yields a detectable amount of amplicon of no more than 300 bases, or no more than 150 bases. In some embodiments, the amplification reaction yields a detectable amount of amplicon of 100-200 bases. In some embodiments, all of the bacterial species are Gram-positive bacteria, Gram-negative bacteria, or a combination of both detected in the same reaction with probes having different detectable labels. In some embodiments, the plurality of bacterial species comprise a plurality of Gram-positive bacterial species from different genera and a plurality of Gram-negative bacterial species from different genera. In some embodiments, the one or more detectable probes comprise a first probe that specifically hybridizes to a conserved sequence common among the Gram-positive bacterial species and absent in at least some of the Gram-negative species, and a second probe that specifically hybridizes to a conserved sequence common among the Gram-negative bacterial species and absent in at least some

of the Gram-positive species. In some embodiments, the bacterial species are selected from the group consisting of: *Staphylococcus aureus*, *Staphylococcus aureus* Mu3; *Staphylococcus epidermidis*, *Streptococcus agalactiae*, *Streptococcus pyogenes*, *Streptococcus pneumonia*, *Escherichia coli*, *Citrobacter koseri*, *Clostridium perfringens*, *Enterococcus faecalis*, *Klebsiella pneumonia*, *Lactobacillus acidophilus*, *Listeria monocytogenes*, *Propionibacterium granulosum*, *Pseudomonas aeruginosa*, *Serratia marcescens*, *Bacillus cereus*, *Staphylococcus aureus* Mu50 *Yersinia enterocolitica* *Staphylococcus simulans* *Micrococcus luteus* and *Enterobacter aerogenes*. In some embodiments, the method comprises detecting bacterial contamination by any of at least ten or fifteen bacterial species in a sample. In some embodiments, the single primer pair comprises a first primer comprising at least 10 contiguous nucleotides of a sequence as set forth in SEQ ID NO: 4, 7, or 9 and a second primer comprising at least 10 nucleotides of a sequence as set forth in SEQ ID NO: 5, 6, 8, or 10. In some embodiments, the probe comprises at least 10 contiguous nucleotides of a sequence as set forth in Table 3, or a complement thereof. In some embodiments, the nucleic acid amplification reaction contains less than 5 pg of starting nucleic acids from the bacterial contamination. In some embodiments, the nucleic acid amplification reaction is performed using a method selected from the group consisting of: polymerase chain reaction, real-time polymerase chain reaction, isothermal amplification, strand displacement amplification, rolling circle amplification, ligase chain reaction, transcription-mediated amplification, solid phase amplification, nucleic acid sequence-based amplification (NASBA), and linear amplification. In some embodiments, the nucleic acid amplification reaction is performed in a well, in a plate, in a tube, in a chamber, in a droplet, in a flow cell, in a slide, in a chip, attached to a solid substrate, attached to a bead, or in an emulsion. In some embodiments, the probe yields a signal that has a linear range of detection across at least 5 logs. In some embodiments, the method further comprises determining the abundance of the plurality of bacterial species based on the probe signal.

[0011] In one aspect, the disclosure provides a composition for amplification and detection of a portion of a 16S rRNA polynucleotide. In some embodiments, the portion is less than about 800, 700, 600, 500, 400, 300, 200, 150, or 100 nucleotides in length. In one embodiment, the composition comprises a first primer comprising at least 10 contiguous nucleotides of the sequence as set forth Table 2 or Table 15 including but not limited to SEQ ID NO: 9; a second primer comprising at least 10 contiguous nucleotides of the sequence as set forth in Table 2 or Table 15 including but not limited to SEQ ID NO: 10; and a probe comprising at least 10 contiguous nucleotides of the sequence as set forth in Table 3 including but not limited to SEQ ID NO: 16, or the complement thereof. In one embodiment, the composition comprises primers that, in an amplification reaction with a target 16S rRNA polynucleotide, amplify an amplicon of at least 50 nucleotides in length, the amplicon having 90 sequence identity with any of sequences listed in Table 1 including but not limited to SEQ ID NO: 1-3 when optimally aligned; and one or more probes that specifically hybridize to either strand of the amplicon. In some embodiments, the composition is in a container, such as a well, a plate, a tube,

a chamber, a flow cell, or a chip. In some embodiments, the composition is in a dehydrated form. In some embodiments, in an amplification reaction with a target 16S rRNA polynucleotide, amplification of about 1pg-5pg of DNA from any one of a plurality of target species by the primers and probes has a cycle threshold value (C_T) of less than 30.

[0012] In another aspect, the disclosure provides a method of detecting bacterial contamination of a platelet sample by any of at least five bacterial species. The method comprises: subjecting the sample or a portion thereof to a nucleic acid amplification reaction under conditions to yield a detectable amount of an amplicon of no more than about 800 bases in a reaction mixture, said reaction mixture comprising a first forward primer and a first reverse primer, wherein the first forward primer and the first reverse primer each hybridizes to a separate region that is conserved amongst at least 5 different bacterial genomes; detecting from said reaction mixture a signal indicative of the presence of said amount of an amplicon, thereby detecting bacterial contamination of a platelet sample by any of the at least five bacterial species. In one embodiment, the first forward and first reverse primer each hybridizes to a separate region that is conserved amongst at least 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25 or even more different bacterial genomes. The conserved region can encompass the region from 9 to 28, from 32 to 48, from 522 to 545, from 888 to 903, from 916 to 937, from 939 to 973, from 975 to 994, from 957 to 981, from 1093 to 1125, from 1184 to 1206, from 1231 to 1252, from 1378 to 1396, from 1398 to 1422, or from 1496 to 1516, of 16S rRNA of *Staphylococcus aureus* (GenBank accession Number NC_007622) or the corresponding regions in any one of the bacterial genomes: *Staphylococcus aureus* Mu3; *Staphylococcus epidermidis* *Streptococcus agalactiae* *Streptococcus pyogenes* *Streptococcus pneumonia* *Escherichia coli* *Citrobacter koseri* *Clostridium perfringens* *Enterococcus faecalis* *Klebsiella pneumonia* *Lactobacillus acidophilus* *Listeria monocytogenes* *Serratia marcescens* *Bacillus cereus* *Propionibacterium* sp. *Staphylococcus aureus* Mu50 *Yersinia enterocolitica* *Staphylococcus simulans* *Micrococcus luteus* and *Enterobacter aerogenes*. Any of the primers disclosed herein including the primer sets listed in Table 15 can be utilized for practice of this and other methods disclosed herein. In some embodiment, the first forward primer and the first reverse primer each exhibits at least 80 , 85 , 90 , 95 , 96 , 97 , 98 , 99 , or 100 sequence homology with the separate region of the target bacterial sequence when optimally aligned. In some embodiment, the reaction mixture further comprises a second forward primer exhibiting at least 80 , 85 , 90 , 95 , 96 , 97 , 98 , 99 , or 100 sequence homology when optimally aligned with any or all of the at least 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25 or more bacterial species. In some embodiment, the reaction mixture further comprises a second reverse primer exhibiting at least 80 , 85 , 90 , 95 , 96 , 97 , 98 , 99 , or 100 sequence homology when optimally aligned with any or all of the at least 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25 or more bacterial species. The region of homology can include but are not limited to any conserved regions disclosed herein, e.g., from 9 to 28, from 32 to 48, from 522 to 545, from

888 to 903, from 916 to 937, from 939 to 973, from 975 to 994, from 957 to 981, from 1093 to 1125, from 1184 to 1206, from 1231 to 1252, from 1378 to 1396, from 1398 to 1422, or from 1496 to 1516, of 16S rRNA of *Staphylococcus aureus* (GenBank accession Number NC_007622) or the corresponding regions in any one of the bacterial genomes referenced herein. Where desired, the reaction mixture further comprises a detectable label, including but not limited to a DNA-binding dye or other label molecules disclosed herein. In some embodiment, the nucleic acid amplification is performed under conditions such that about 1pg-5pg of DNA from any one of the at least 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25 or more bacterial species has a cycle threshold value (C_T) of less than 30.

[0013] In one aspect, the disclosure provides a reaction mixture for amplification and detection of a portion of a 16S rRNA polynucleotide. In some embodiments, the portion is less than about 800, 700, 600, 500, 400, 300, 200, 150, or 100 nucleotides in length. In some embodiments, the reaction mixture comprises sample nucleic acid; primers that, in an amplification reaction with a target 16S rRNA polynucleotide, amplify an amplicon of at least 50 nucleotides in length, the amplicon having 90 sequence identity with any of SEQ ID NO: 1-3 when optimally aligned; a probe that specifically hybridizes to either strand of the amplicon; and a polymerase; wherein the reaction mixture is in a reaction site. In some embodiments, the reaction site is a droplet, a well, a plate, a tube, a chamber, a flow cell, or a chip. In some embodiments, in an amplification reaction with a target 16S rRNA polynucleotide, amplification of about 1pg-5pg of DNA from any one of a plurality of target species by the primers and probes has a cycle threshold value (C_T) of less than 30.

[0014] In one aspect, the disclosure provides a kit for the detection of bacterial contamination in a sample, such as in a platelet sample. In one embodiment, the kit comprises a first primer comprising at least 10 contiguous nucleotides of a sequence as set forth in Table 2 or Table 15 including but not limited to SEQ ID NO: 9; a second primer comprising at least 10 contiguous nucleotides of a sequence as set forth in Table 2 or Table 15 including but not limited to SEQ ID NO: 10; a probe comprising at least 10 contiguous nucleotides of a sequence as set forth in Table 3 including but not limited to SEQ ID NO: 16, or the complement thereof.

[0015] In one aspect, the disclosure provides a method for using a kit of the disclosure. In one embodiment, the method comprises performing a nucleic acid amplification reaction on a sample or a portion thereof with a single primer pair to yield a detectable amount of an amplicon of no more than about 800, 700, 600, 500, 400, 300, 200, 150, or 100 bases of a 16S rRNA polynucleotide, wherein amplification of about 1pg-5pg of DNA from any one of a plurality of bacterial species from different genera has a cycle threshold value (C_T) of less than 30; and detecting the amplicon with one or more detectable probes, wherein each of the one or more detectable probes specifically hybridizes to a conserved sequence, and the conserved sequence is identical among a plurality of bacterial species from different genera.

[0016] In one aspect, the disclosure provides a system for detecting bacterial contamination of a sample (e.g. a platelet sample, a blood sample, or a buffy coat sample) by any of a plurality of bacterial species from different genera. In one embodiment, the system comprises a computer configured to receive a customer request to perform a detection reaction on a sample; an amplification system that performs a nucleic acid amplification reaction on the sample or a portion thereof in response to the customer request, wherein the amplification reaction yields a detectable amount of an amplicon of no more than about 800, 700, 600, 500, 400, 300, 200, 150, or 100 bases of a 16S rRNA polynucleotide using a single primer pair and single probe, and further wherein amplification of 1pg-5pg of DNA from any one of the at least five genera has a C_T of less than 30; and a report generator that sends a report to a recipient, wherein the report contains results for detection of a signal intensity produced by the probe. In some embodiments, the report generator identifies the sample as contaminated or not contaminated based on the signal intensity produced by the probe. In some embodiments, the recipient is the customer.

[0017] In one aspect, the disclosure provides a computer readable medium. In some embodiments, the computer readable medium comprises codes that, upon execution by one or more processors, implement a method of detecting bacterial contamination of a platelet sample by any of a plurality of bacterial species from different genera. In one embodiment, the method implemented upon execution of the codes comprises receiving a customer request to perform a detection reaction on a sample; performing a nucleic acid amplification reaction on the sample or a portion thereof in response to the customer request, wherein the amplification reaction yields a detectable amount of an amplicon of no more than about 800, 700, 600, 500, 400, 300, 200, 150, or 100 bases of 16S rRNA using a single primer pair and single probe, and further wherein amplification of 1pg-5pg of DNA from any one of the at least five genera has a C_T of less than 30; and generating a report that contains results for detection of a signal intensity produced by the probe.

[0018]

BRIEF DESCRIPTION OF THE DRAWINGS

[0019] The novel features of the invention are set forth with particularity in the appended claims. A better understanding of the features and advantages of the present invention will be obtained by reference to the following detailed description that sets forth illustrative embodiments, in which the principles of the invention are utilized, and the accompanying drawings of which:

[0020] FIG. 1 is a graph illustrating results of nucleic acid amplification reactions.

[0021] FIG. 2 is a graph illustrating the detection range of a nucleic acid amplification assay.

- [0022] FIGS. 3A and 3B are graphs illustrating results of nucleic acid amplification reactions.
- [0023] FIGS. 4A and 4B are graphs illustrating results of nucleic acid amplification reactions.
- [0024] FIG. 5 is an illustration depicting an example sample analysis system.
- [0025] FIGS. 6A and 6B illustrate results of a sample analysis of hybridization between primers and probes described by Liu et al.
- [0026] FIG. 7A is a graph illustrating results of nucleic acid amplification reactions.
- [0027] FIG. 7B is graph illustrating the detection range of a nucleic acid amplification assay.
- [0028] FIGS. 8A-G are graphs illustrating results of nucleic acid amplification reactions.
- [0029] FIG. 9 is a graph illustrating results of nucleic acid amplification reactions.
- [0030] FIG. 10A is a graph illustrating results of nucleic acid amplification reactions performed in triplets.
- [0031] FIG. 10B is a graph illustrating results of melting curve analysis of the resulting amplified nucleic acid.

DETAILED DESCRIPTION OF THE INVENTION

[0032] The practice of some embodiments disclosed herein employ, unless otherwise indicated, conventional techniques of immunology, biochemistry, chemistry, molecular biology, microbiology, cell biology, genomics and recombinant DNA, which are within the skill of the art. See for example Sambrook and Green, *Molecular Cloning: A Laboratory Manual*, 4th Edition (2012); the series *Current Protocols in Molecular Biology* (F. M. Ausubel, et al. eds.); the series *Methods In Enzymology* (Academic Press, Inc.), *PCR 2: A Practical Approach* (M.J. MacPherson, B.D. Hames and G.R. Taylor eds. (1995)), Harlow and Lane, eds. (1988) *Antibodies, A Laboratory Manual*, and *Culture of Animal Cells: A Manual of Basic Technique and Specialized Applications*, 6th Edition (R.I. Freshney, ed. (2010)).

[0033] As used in the specification and claims, the singular form “a”, “an” and “the” include plural references unless the context clearly dictates otherwise. For example, the term “a cell” includes a plurality of cells, including mixtures thereof.

[0034] The terms “polynucleotide”, “nucleotide”, “nucleotide sequence”, “nucleic acid” and “oligonucleotide” are used interchangeably. They refer to a polymeric form of nucleotides of any length, either deoxyribonucleotides or ribonucleotides, or analogs thereof. Polynucleotides may have any three dimensional structure, and may perform any function, known or unknown. The following are non limiting examples of polynucleotides: coding or non-coding regions of a gene or gene fragment, loci (locus) defined from linkage analysis, exons, introns, messenger RNA (mRNA), transfer RNA, ribosomal RNA, short interfering RNA (siRNA), short-hairpin RNA (shRNA), micro-RNA (miRNA), ribozymes, cDNA, recombinant polynucleotides, branched polynucleotides, plasmids, vectors, isolated DNA of any sequence, isolated RNA of any sequence, nucleic acid probes,

and primers. A polynucleotide may comprise one or more modified nucleotides, such as methylated nucleotides and nucleotide analogs. If present, modifications to the nucleotide structure may be imparted before or after assembly of the polymer. The sequence of nucleotides may be interrupted by non nucleotide components. A polynucleotide may be further modified after polymerization, such as by conjugation with a labeling component.

[0035] In general, the term “target polynucleotide” refers to a nucleic acid molecule or polynucleotide in a starting population of nucleic acid molecules having a target sequence whose presence, amount, and/or nucleotide sequence, or changes in one or more of these, are desired to be determined. In general, the term “target sequence” refers to a nucleic acid sequence on a single strand of nucleic acid. The target sequence may be a portion of a gene, a regulatory sequence, genomic DNA, cDNA, RNA including mRNA, miRNA, rRNA, or others. The target sequence may be a target sequence from a sample or a secondary target such as a product of an amplification reaction.

[0036] In general, a “nucleotide probe,” “probe,” or “tag oligonucleotide” refers to a polynucleotide used for detecting or identifying its corresponding target polynucleotide in a hybridization reaction by hybridization with a corresponding target sequence. Thus, a nucleotide probe is hybridizable to one or more target polynucleotides. Tag oligonucleotides can be perfectly complementary to one or more target polynucleotides in a sample, or contain one or more nucleotides that are not complemented by a corresponding nucleotide in the one or more target polynucleotides in a sample.

[0037] “Hybridization” refers to a reaction in which one or more polynucleotides react to form a complex that is stabilized via hydrogen bonding between the bases of the nucleotide residues. The hydrogen bonding may occur by Watson Crick base pairing, Hoogsteen binding, or in any other sequence specific manner. The complex may comprise two strands forming a duplex structure, three or more strands forming a multi stranded complex, a single self hybridizing strand, or any combination of these. A hybridization reaction may constitute a step in a more extensive process, such as the initiation of PCR, or the enzymatic cleavage of a polynucleotide by an endonuclease. A sequence capable of hybridizing with a given sequence is referred to as the “complement” of the given sequence.

[0038] The term “hybridizable” as applied to a polynucleotide refers to the ability of the polynucleotide to form a complex that is stabilized via hydrogen bonding between the bases of the nucleotide residues. The hydrogen bonding may occur by Watson Crick base pairing, Hoogsteen binding, or in any other sequence specific manner. The complex may comprise two strands forming a duplex structure, three or more strands forming a multi stranded complex, a single self hybridizing strand, or any combination of these. The hybridization reaction may constitute a step in a more extensive process, such as the initiation of a PCR reaction, or the enzymatic cleavage of a polynucleotide by a ribozyme. A sequence hybridized with a given sequence is referred to as the “complement” of the given sequence.

[0039] “Complementarity” refers to the ability of a nucleic acid to form hydrogen bond(s) with another nucleic acid sequence by either traditional Watson-Crick or other non-traditional types. A percent complementarity indicates the percentage of residues in a nucleic acid molecule which can form hydrogen bonds (e.g., Watson-Crick base pairing) with a second nucleic acid sequence (e.g., 5, 6, 7, 8, 9, 10 out of 10 being 50%, 60%, 70%, 80%, 90%, and 100% complementary). “Perfectly complementary” means that all the contiguous residues of a nucleic acid sequence will hydrogen bond with the same number of contiguous residues in a second nucleic acid sequence. “Substantially complementary” as used herein refers to a degree of complementarity that is at least 60%, 65%, 70%, 75%, 80%, 85%, 90%, 95%, 97%, 98%, 99%, or 100% over a region of 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 30, 35, 40, 45, 50, or more nucleotides, or refers to two nucleic acids that hybridize under stringent conditions.

[0040] As used herein, “stringent conditions” for hybridization refer to conditions under which a nucleic acid having complementarity to a target sequence predominantly hybridizes with a target sequence, and substantially does not hybridize to non-target sequences. Stringent conditions are generally sequence-dependent, and vary depending on a number of factors. In general, the longer the sequence, the higher the temperature at which the sequence specifically hybridizes to its target sequence. Non-limiting examples of stringent conditions are described in detail in Tijssen (1993), *Laboratory Techniques In Biochemistry And Molecular Biology-Hybridization With Nucleic Acid Probes Part I, Second Chapter “Overview of principles of hybridization and the strategy of nucleic acid probe assay”*, Elsevier, N.Y.

[0041] The terms “subject,” “individual,” and “patient” are used interchangeably herein to refer to a vertebrate, preferably a mammal, more preferably a human. Mammals include, but are not limited to, murines, simians, humans, farm animals, sport animals, and pets. Tissues, cells and their progeny of a biological entity obtained in vivo or cultured in vitro are also encompassed.

[0042] As used herein, “expression” refers to the process by which a polynucleotide is transcribed from a DNA template (such as into and mRNA or other RNA transcript) and/or the process by which a transcribed mRNA is subsequently translated into peptides, polypeptides, or proteins. Transcripts and encoded polypeptides may be collectively referred to as “gene product.” If the polynucleotide is derived from genomic DNA, expression may include splicing of the mRNA in a eukaryotic cell.

[0043] As used herein, “platelet sample” and “platelet concentrate” are used interchangeably to refer to a biological sample of a subject comprising platelets derived from a platelet purification process. Platelets can be purified away from one or more other blood components by a variety of methods, such as by centrifugation or aphaeresis. Such purified platelets may subsequently be combined, diluted, divided, or further purified, all of which produce samples comprising platelets derived from a platelet purification process.

[0044] In one aspect, the disclosure provides a method of detecting bacterial contamination of a platelet sample by any of a plurality of bacterial species, such as at least eight bacterial species. In

one embodiment, the method comprises subjecting the sample or a portion thereof to a nucleic acid amplification reaction under conditions to yield a detectable amount of an amplicon of no more than about 800, 700, 600, 500, 400, 300, 200, 150, or 100 bases in a single reaction mixture, said reaction mixture comprising a single primer pair and a single detectable probe, wherein the primer pair flanks the amplicon, the amplicon comprises a conserved sequence to which the detectable probe hybridizes, and the conserved sequence is identical among the at least eight bacterial species; and detecting hybridization to the amplicon by the probe, wherein the hybridization by the probe yields a detectable signal indicative of bacterial contamination of the platelet sample by any of the at least eight bacterial species.

[0045] In another aspect, the disclosure provides a method of detecting bacterial contamination of a platelet sample. In one embodiment, the method comprises subjecting the sample or a portion thereof to a nucleic acid amplification reaction under conditions to yield a detectable amount of an amplicon of no more than about 800, 700, 600, 500, 400, 300, 200, 150, or 100 bases in a single reaction mixture, said reaction mixture comprising a single primer pair and a single detectable probe, wherein the primer pair flanks the amplicon, the amplicon comprises a conserved sequence to which the detectable probe hybridizes, and the sample or portion thereof has not been cultured at a temperature above 35 °C prior to amplification; and detecting hybridization to the amplicon by the probe, wherein the hybridization by the probe yields a detectable signal indicative of bacterial contamination of the platelet sample.

[0046] In one aspect, the disclosure provides a method of rapidly detecting bacterial contamination in a platelet sample within 24 hours after obtaining the sample. In one embodiment, the method comprises subjecting the sample or a portion thereof to a nucleic acid amplification reaction with a single primer pair and a single detectable probe in a single reaction mixture under conditions to yield a detectable amount of an amplicon of no more than about 800, 700, 600, 500, 400, 300, 200, 150, or 100 bases, wherein the primer pair flanks the amplicon, the amplicon comprises a conserved sequence to which the detectable probe hybridizes, and amplification of about 1pg-5pg of DNA from any one of the species has a cycle threshold value (C_T) of less than 30; and within about 24 hours after obtaining said sample, detecting hybridization to said amplicon by said probe, wherein said hybridization by said probe yields a detectable signal indicative of bacterial contamination of the platelet sample, thereby detecting the contamination within about 24 hours from obtaining said sample.

[0047] In another aspect, the disclosure provides a method of detecting bacterial contamination by any of a plurality of bacterial species from different genera in a biological sample of a subject. In one embodiment, the method comprises performing a nucleic acid amplification reaction on the sample or a portion thereof with a single primer pair to yield a detectable amount of an amplicon of no more than about 800, 700, 600, 500, 400, 300, 200, 150, or 100 bases of a 16S rRNA polynucleotide, wherein amplification of about 1pg-5pg of DNA from any one of the species has a cycle threshold value (C_T) of less than 30; and detecting the amplicon with one or more detectable probes, wherein

each of the one or more detectable probes specifically hybridizes to a conserved sequence, and the conserved sequence is identical among a plurality of bacterial species from different genera.

[0048] In any of the various aspects, nucleic acids may be derived from a variety of sample sources. Nucleic acids may optionally, but not necessarily, be isolated and/or purified before further manipulation, such as in a nucleic acid amplification reaction. For example, a biological sample may be subjected to a polymerase chain reaction (PCR) procedure without a separate extraction step, such that cell-free nucleic acids are amplified from an unpurified sample. As a further example, a sample may be subjected to cell lysis conditions, either immediately before or during a nucleic acid amplification reaction, without purifying the nucleic acids away from other cellular components. In some embodiments, nucleic acids (e.g. DNA, RNA, or both) are purified from a biological sample before subjecting the nucleic acid to an amplification reaction. Various methods of nucleic acid purification are known in the art, and may vary with the type of biological sample. For example, biological samples may include tissue and/or fluid from a subject. In general, a biological fluid includes any treated or untreated fluid associated with living organisms, including, but not limited to, blood, including whole blood, warm or cold blood, and stored or fresh blood; treated blood, such as blood diluted with at least one physiological solution, including but not limited to saline, nutrient, and/or anticoagulant solutions; blood components, such as platelet concentrate (PC), platelet-rich plasma (PRP), platelet-poor plasma (PPP), platelet-free plasma, plasma, fresh frozen plasma (FFP), components obtained from plasma, packed red cells (PRC), transition zone material or buffy coat (BC); analogous blood products derived from blood or a blood component or derived from bone marrow; red cells separated from plasma and resuspended in physiological fluid or a cryoprotective fluid; and platelets separated from plasma and resuspended in physiological fluid or a cryoprotective fluid. Other non-limiting examples of biological samples include skin, heart, lung, kidney, bone marrow, breast, pancreas, liver, muscle, smooth muscle, bladder, gall bladder, colon, intestine, brain, prostate, esophagus, thyroid, serum, saliva, urine, gastric and digestive fluid, tears, stool, semen, vaginal fluid, interstitial fluids derived from tumorous tissue, ocular fluids, sweat, mucus, earwax, oil, glandular secretions, spinal fluid, hair, fingernails, skin cells, plasma, nasal swab or nasopharyngeal wash, spinal fluid, cerebral spinal fluid, tissue, throat swab, biopsy, placental fluid, amniotic fluid, cord blood, emphyatic fluids, cavity fluids, sputum, pus, micropiota, meconium, breast milk, and/or other excretions or body tissues. In some embodiments, the sample to be tested is whole blood. In some embodiments, the sample to be tested is buffy coat. In some embodiments, the tissue analyzed is a portion of a tissue to be transplanted or surgically grafted, such as an organ (e.g. heart, kidney, liver, lung, etc.), skin, bone, nervous tissue, tendons, blood vessels, fat, cornea, blood, or a blood component. In some embodiments, the sample is from a subject, such as a mammal, including but not limited to murines, simians, humans, farm animals, sport animals, or pets. In some embodiments, detection of contamination in the sample is the basis for medical action, such as making a diagnosis or

treating the subject. For example, contamination may be diagnostic or predictive of sepsis in the subject. Corrective medical intervention, such as administering a therapeutic agent, may be taken.

[0049] In some embodiments, the sample to be tested is a platelet sample. Methods for purifying platelets away from other components of whole blood are known in the art, including methods utilizing centrifugation and/or filtration (e.g. apheresis). When separated as a component of whole blood, platelets can be concentrated, re-suspended in plasma and/or platelet additive solutions, leukoreduced by passage through a filtration device, and/or stored in platelet storage bags kept on flatbed at a temperature of about 22° C. A platelet sample may comprise a pool of platelet samples from separate purification procedures, or portions thereof. In some embodiments, a platelet sample is a portion of a sample of purified platelets from which platelets have been removed, such as by centrifugation.

[0050] Nucleic acids may be extracted from a biological sample using any suitable method known in the art. For example, nucleic acids can be purified by organic extraction with phenol, phenol/chloroform/isoamyl alcohol, or similar formulations, including TRIzol and TriReagent. Other non-limiting examples of extraction techniques include: (1) organic extraction followed by ethanol precipitation, e.g., using a phenol/chloroform organic reagent (Ausubel et al., 1993), with or without the use of an automated nucleic acid extractor, e.g., the Model 341 DNA Extractor available from Applied Biosystems (Foster City, Calif.); (2) stationary phase adsorption methods (U.S. Pat. No. 5,234,809; Walsh et al., 1991); and (3) salt-induced nucleic acid precipitation methods (Miller et al., (1988), such precipitation methods being typically referred to as “salting-out” methods. Another example of nucleic acid isolation and/or purification includes the use of magnetic particles (e.g. beads) to which nucleic acids can specifically or non-specifically bind, followed by isolation of the particles using a magnet, and washing and eluting the nucleic acids from the particles (see e.g. U.S. Pat. No. 5,705,628). In some embodiments, the above isolation methods may be preceded by an enzyme digestion step to help eliminate unwanted protein from the sample, e.g., digestion with proteinase K, or other like proteases. See, e.g., U.S. Pat. No. 7,001,724. If desired, RNase inhibitors may be added to the lysis buffer. For certain cell or sample types, it may be desirable to add a protein denaturation/digestion step to the protocol. Purification methods may be directed to isolate DNA, RNA (including but not limited to mRNA, rRNA, tRNA), or both. When both DNA and RNA are isolated together during or subsequent to an extraction procedure, further steps may be employed to purify one or both separately from the other. Sub-fractions of extracted nucleic acids can also be generated, for example, purification by size, sequence, or other physical or chemical characteristic. In addition to an initial nucleic acid isolation step, purification of nucleic acids can be performed after subsequent manipulation, such as to remove excess or unwanted reagents, reactants, or products.

[0051] In any of the various aspects, a nucleic acid amplification reaction can involve any of a variety of methods for nucleic acid amplification. In general, “amplification” refers to any process by which the copy number of a target sequence is increased. Numerous amplification-based methods for

the detection and quantification of target nucleic acids are known in the art. The polymerase chain reaction (PCR) uses multiple cycles of denaturation, annealing of primer pairs to opposite strands, and primer extension to exponentially increase copy numbers of the target sequence. In a variation called RT-PCR, reverse transcriptase (RT) is used to make a complementary DNA (cDNA) from RNA, and the cDNA is then amplified by PCR to produce multiple copies of DNA (see e.g. U.S. Pat. Nos. 5,322,770 and 5,310,652).

[0052] Amplification methods may involve changes in temperature (such as in a heat denaturation step), or may be isothermal processes that do not include a heat denaturation step. An example of an isothermal amplification method is strand displacement amplification, commonly referred to as SDA, which uses cycles of annealing pairs of primer sequences to opposite strands of a target sequence, primer extension in the presence of a dNTP to produce a duplex hemiphosphorothioated primer extension product, endonuclease-mediated nicking of a hemi-modified restriction endonuclease recognition site, and polymerase-mediated primer extension from the 3'-end of the nick to displace an existing strand and produce a strand for the next round of primer annealing, nicking, and strand displacement, resulting in geometric amplification of product (see e.g., U.S. Pat. No. 5,270,184 and U.S. Pat. No. 5,455,166). Thermophilic SDA (tSDA) uses thermophilic endonucleases and polymerases at higher temperatures in essentially the same method (European Pat. No. 0684315).

[0053] Other examples of amplification methods include rolling circle amplification (RCA) (e.g., Lizardi, "Rolling Circle Replication Reporter Systems," U.S. Pat. No. 5,854,033); helicase dependent amplification (HDA) (e.g. U.S. Pat. Appl. US 20040058378), and loop-mediated isothermal amplification (LAMP) (e.g., Notomi et al., "Process for Synthesizing Nucleic Acid," U.S. Pat. No. 6,410,278).

[0054] Further examples of nucleic acid amplification reactions include transcription-based amplification methods such as nucleic acid sequence based amplification, also referred to as NASBA (e.g., Malek et al., U.S. Pat. No. 5,130,238); methods which rely on the use of an RNA replicase to amplify the probe molecule itself, commonly referred to as Q β replicase (e.g., Lizardi, P. et al. (1988) *BioTechnol.* 6, 1197-1202); and self-sustained sequence replication (e.g., Guatelli, J. et al. (1990) *Proc. Natl. Acad. Sci. USA* 87, 1874-1878; Landgren (1993) *Trends in Genetics* 9, 199-202; and HELEN H. LEE et al. NUCLEIC ACID AMPLIFICATION TECHNOLOGIES (1997)). Another transcription-based amplification method is transcription-mediated amplification, commonly referred to as TMA, which synthesizes multiple copies of a target nucleic acid sequence autocatalytically under conditions of substantially constant temperature, ionic strength, and pH, in which multiple RNA copies of the target sequence autocatalytically generate additional copies (see e.g., U.S. Pat. No. 5,480,784; and U.S. Pat. No. 5,399,491). Additional examples of nucleic acid amplification methods include ligase chain reaction (see e.g. U.S. Pat. Nos. 5,494,810 and 5,830,711), and solid-phase amplification methods (e.g. bridge amplification with primers attached to a solid surface, such as a slide or a bead; see e.g. U.S. Pat. Nos. 5,641,658 and 7,985,565).

[0055] In general, SDA may be described as follows. A single stranded target nucleic acid, usually a DNA target sequence, is contacted with an SDA primer. An "SDA primer" generally has a length of 25-100 nucleotides, with SDA primers of approximately 35 nucleotides being preferred. An SDA primer is substantially complementary to a region at the 3' end of the target sequence, and the primer has a sequence at its 5' end (outside of the region that is complementary to the target) that is a recognition sequence for a restriction endonuclease, sometimes referred to as a "nicking enzyme" or a "nicking endonuclease." The SDA primer then hybridizes to the target sequence. The SDA reaction mixture also contains a polymerase (an "SDA polymerase") and a mixture of all four deoxynucleoside-triphosphates (also called deoxynucleotides or dNTPs, i.e. dATP, dTTP, dCTP and dGTP, commonly used in primer extension reactions), at least one species of which is a substituted or modified dNTP; thus, the SDA primer is extended, to form a modified primer, sometimes referred to as a "newly synthesized strand." The substituted dNTP is modified such that it will inhibit cleavage in the strand containing the substituted dNTP but will not inhibit cleavage on the other strand. Examples of suitable substituted dNTPs include, but are not limited, 2'-deoxyadenosine 5'-O-(1-thiotriphosphate), 5-methyldeoxycytidine 5'-triphosphate, 2'-deoxyuridine 5'-triphosphate, and 7-deaza-2'-deoxyguanosine 5'-triphosphate. In addition, the substitution of the dNTP may occur after incorporation into a newly synthesized strand; for example, a methylase may be used to add methyl groups to the synthesized strand. In addition, if all the nucleotides are substituted, the polymerase may have 5' 3' exonuclease activity. However, if less than all the nucleotides are substituted, the polymerase preferably lacks 5' 3' exonuclease activity. As will be appreciated by those in the art, the recognition site/endonuclease pair can be any of a wide variety of known combinations. The endonuclease is chosen to cleave a strand either at the recognition site, or either 3' or 5' to it, without cleaving the complementary sequence, either because the enzyme only cleaves one strand or because of the incorporation of the substituted nucleotides. Suitable recognition site/endonuclease pairs are known in the art including but not limited to HincII, HindII, AvaI, Fnu4HI, TthIII, NciI, BstXI, BamHI, etc. A chart depicting suitable enzymes, and their corresponding recognition sites and the modified dNTP to use is found in U.S. Pat. No. 5,455,166. Once nicked, a polymerase (an "SDA polymerase") is used to extend the newly nicked strand, 5' 3', thereby creating another newly synthesized strand. The polymerase chosen should be able to initiate 5' 3' polymerization at a nick site, should also displace the polymerized strand downstream from the nick, and should lack 5' 3' exonuclease activity (this may be additionally accomplished by the addition of a blocking agent). Suitable polymerases in SDA include, but are not limited to, the Klenow fragment of DNA polymerase I, SEQUENASE 1.0 and SEQUENASE 2.0 (U.S. Biochemical), T5 DNA polymerase and Phi29 DNA polymerase. In general, SDA does not require thermocycling. The temperature of the reaction is generally set to be high enough to prevent non-specific hybridization but low enough to allow specific hybridization; this is typically from about 37 C. to about 42 C., depending on the enzymes. In some embodiment, as for other amplification

techniques described herein, a second primer extension reaction can be done using the complementary target sequence, resulting in a substantial increase in amplification during a set period of time. That is, a second primer nucleic acid is hybridized to a second target sequence, that is substantially complementary to the first target sequence, to form a second hybridization complex. The addition of the enzyme, followed by disassociation of the second hybridization complex, results in the generation of a number of newly synthesized second strands. Accordingly, amplification may be linear or non-linear (e.g. exponential).

[0056] NASBA is generally described in U.S. Pat. No. 5,409,818; Sooknanan et al., Nucleic Acid Sequence-Based Amplification, Ch. 12 (pp. 261-285) of Molecular Methods for Virus Detection, Academic Press, 1995; and "Profiting from Gene-based Diagnostics", CTB International Publishing Inc., N.J., 1996.

NASBA is very similar to both TMA and QBR. Transcription mediated amplification (TMA) is generally described in U.S. Pat. Nos. 5,399,491, 5,888,779, 5,705,365, 5,710,029.

A main difference between NASBA and TMA is that NASBA utilizes the addition of RNase H to effect RNA degradation, and TMA relies on inherent RNase H activity of a reverse transcriptase. In general, these techniques may be described as follows. A single stranded target nucleic acid, usually an RNA target sequence (sometimes referred to as "the first target sequence" or "the first template"), is contacted with a first primer, generally referred to herein as a "NASBA primer" (although "TMA primer" is also suitable). Starting with a DNA target sequence is described below. These primers generally have a length of 25-100 nucleotides, with NASBA primers of approximately 50-75 nucleotides being preferred. The first primer is preferably a DNA primer that has at its 3' end a sequence that is substantially complementary to the 3' end of the first template. The first primer also has an RNA polymerase promoter at its 5' end (or its complement (antisense), depending on the configuration of the system). The first primer is then hybridized to the first template to form a first hybridization complex. The reaction mixture also includes a reverse transcriptase enzyme (a "NASBA reverse transcriptase") and a mixture of the four dNTPs, such that the first NASBA primer is extended, to form a modified first primer, comprising a hybridization complex of RNA (the first template) and DNA (the newly synthesized strand). By "reverse transcriptase" or "RNA-directed DNA polymerase" herein is meant an enzyme capable of synthesizing DNA from a DNA primer and an RNA template. Suitable RNA-directed DNA polymerases include, but are not limited to, avian myeloblastosis virus reverse transcriptase ("AMV RT") and the Moloney murine leukemia virus RT. When the amplification reaction is TMA, the reverse transcriptase enzyme further comprises a RNA degrading activity. In addition to the components listed above, the NASBA reaction also includes an RNA degrading enzyme, also sometimes referred to herein as a ribonuclease, that will hydrolyze RNA of an RNA:DNA hybrid without hydrolyzing single- or double-stranded RNA or DNA. Suitable ribonucleases include, but are not limited to, RNase H from *E. coli* and calf thymus. The ribonuclease activity degrades the first RNA template in the hybridization complex, resulting in a

disassociation of the hybridization complex leaving a first single stranded newly synthesized DNA strand, sometimes referred to as "the second template." In addition, the NASBA reaction also includes a second NASBA primer, generally comprising DNA (although as for all the probes and primers herein, nucleic acid analogs may also be used). This second NASBA primer has a sequence at its 3' end that is substantially complementary to the 3' end of the second template, and also contains an antisense sequence for a functional promoter and the antisense sequence of a transcription initiation site. Thus, this primer sequence, when used as a template for synthesis of the third DNA template, contains sufficient information to allow specific and efficient binding of an RNA polymerase and initiation of transcription at the desired site. The antisense promoter and transcription initiation site can be that of the T7 RNA polymerase, although other RNA polymerase promoters and initiation sites can be used as well. The second primer hybridizes to the second template, and a DNA polymerase, also termed a "DNA-directed DNA polymerase," also present in the reaction, synthesizes a third template (a second newly synthesized DNA strand), resulting in second hybridization complex comprising two newly synthesized DNA strands. Finally, the inclusion of an RNA polymerase and the required four ribonucleoside triphosphates (ribonucleotides or NTPs) results in the synthesis of an RNA strand (a third newly synthesized strand that is essentially the same as the first template). The RNA polymerase, sometimes referred to herein as a "DNA-directed RNA polymerase", recognizes the promoter and specifically initiates RNA synthesis at the initiation site. In addition, the RNA polymerase preferably synthesizes several copies of RNA per DNA duplex. Preferred RNA polymerases include, but are not limited to, T7 RNA polymerase, and other bacteriophage RNA polymerases including those of phage T3, phage ϕ II, Salmonella phage sp6, or Pseudomonas phage gh-1. In some embodiments, TMA and NASBA are used with starting DNA target sequences, a first primer comprising the RNA polymerase promoter, and a DNA polymerase enzyme to generate a double stranded DNA hybrid with the newly synthesized strand comprising the promoter sequence. The hybrid is then denatured and the second primer added.

[0057] Another example of an isothermal amplification reaction is Single Primer Isothermal Amplification (SPIA). This amplification technique is disclosed in WO2001020035 and U.S. Pat. No. 6,251,639.

Generally, the method includes hybridizing chimeric RNA/DNA amplification primers to the probes or target. Preferably the DNA portion of the probe is 3' to the RNA. Optionally, the method includes hybridizing a polynucleotide comprising a termination polynucleotide sequence to a region of the template that is 5' with respect to hybridization of the composite primer to the template. Following hybridization of the primer to the template, the primer is extended with DNA polymerase. Subsequently, the RNA is cleaved from the composite primer with an enzyme that cleaves RNA from an RNA/DNA hybrid. Subsequently, an additional RNA/DNA chimeric primer is hybridized to the template such that the first extended primer is displaced from the target probe. The extension reaction is repeated, whereby multiple copies of the probe sequence are generated. When only one SPIA primer is used, the amplification reaction

proceeds linearly. When a reverse SPIA primer with complementarity to the first primer extension product is also used, the amplification reaction is non-linear.

[0058] In some embodiments, the nucleic acid amplification reaction is a PCR reaction. Conditions favorable to the amplification of target sequences by PCR can be determined by methods known in the art, can be optimized at a variety of steps in the process, and depend on characteristics of elements in the reaction, such as target type, target concentration, sequence length to be amplified, sequence of the target and/or one or more primers, primer length, primer concentration, polymerase used, reaction volume, ratio of one or more elements to one or more other elements, and others, some or all of which can be altered. In general, PCR involves the steps of denaturation of the target to be amplified (if double stranded), hybridization of one or more primers to the target, and extension of the primers by a DNA polymerase, with the steps repeated (or “cycled”) in order to amplify the target sequence. Steps in this process can be optimized for various outcomes, such as to enhance yield, decrease the formation of spurious products, and/or increase or decrease specificity of primer annealing. Methods of optimization are known in the art and include adjustments to the type or amount of elements in the amplification reaction and/or to the conditions of a given step in the process, such as temperature at a particular step, duration of a particular step, and/or number of cycles. In some embodiments, an amplification reaction comprises at least 5, 10, 15, 20, 25, 30, 35, 50, or more cycles. In some embodiments, an amplification reaction comprises no more than 5, 10, 15, 20, 25, 35, 50, or more cycles. Cycles can contain any number of steps, such as 2, 3, 4, 5, 6, 7, 8, 9, 10 or more steps, and cycled steps may be preceded and/or followed by one or more steps not included in those steps that are cycled (e.g. an initial melting step or a final incubation step). Steps can comprise any temperature or gradient of temperatures, suitable for achieving the purpose of the given step, including but not limited to, primer annealing, primer extension, and strand denaturation. Steps can be of any duration, including but not limited to about, less than about, or more than about 1, 5, 10, 15, 20, 25, 30, 35, 40, 45, 50, 55, 60, 70, 80, 90, 100, 120, 180, 240, 300, 360, 420, 480, 540, 600, or more seconds, including indefinitely until manually interrupted. Cycles of any number comprising different steps can be combined in any order. In some embodiments, different cycles comprising different steps are combined such that the total number of cycles in the combination is about, less than about, or more than about 5, 10, 15, 20, 25, 30, 35, 50, or more cycles.

[0059] In some embodiments of any of the various aspects, the nucleic acid amplification reaction comprises 3'-end extension of one or more primers, e.g. about, more than about, or less than about 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, or more primers. In some embodiments, primer extension in the nucleic acid amplification reaction involves only one pair of primers. In other embodiments, primer extension in the nucleic acid amplification reaction involves multiple pairs of primers, such as 2, 3, 4, 5, or more primer pairs. In some embodiments, a pair of primers consists of a first primer and a second primer, wherein the first primer comprises a sequence that is hybridizable to at least a portion of one or more target polynucleotides, and further wherein the second primer comprises a sequence that is

hybridizable to at least a portion of the complement of a first primer extension product. When the target polynucleotide is double-stranded, the sequence of the second primer that is hybridizable to at least a portion of the complement of a first primer extension product may also be hybridizable to at least a portion of the complementary strand of the target polynucleotide. When an amplification reaction contains a plurality of primer pairs, the plurality of primer pairs may be distinct (as in two different primers for each pair), overlapping (such as one forward primer paired with two or more different reverse primers), or combinations of distinct pairs and overlapping pairs. An amplification primer can be of any suitable length, such as about, less than about, or more than about 10, 15, 20, 25, 30, 35, 40, 45, 50, 55, 60, 65, 70, 75, 80, 90, 100, or more nucleotides, any portion or all of which may be complementary to the corresponding target sequence (e.g. about, less than about, or more than about 5, 10, 15, 20, 25, 30, 35, 40, 45, 50, or more nucleotides). Typically, when a primer comprises a complementary portion and a non-complementary portion, the portion that is complementary to a target sequence is located at the 3'-end of the primer. Primer pairs can be designed to amplify a target sequence of any desired length. As used herein, "amplicon" refers to the target sequence that is amplified from the target polynucleotide in the nucleic acid amplification reaction, in single- or double-stranded form. When an amplicon is amplified by a pair of primers, the amplicon is generally flanked by the pair of primers, such that one primer hybridizes at the 5' end of the target sequence and the other primer hybridizes to the complement of the 3' end of the target sequence. In some embodiments, the amplicon is about, or less than about 1000, 900, 800, 700, 600, 500, 400, 300, 250, 200, 175, 150, 125, 100, 90, 80, 70, 60, 50, 40, 30, 25, or fewer nucleotides in length. In some embodiments, the amplicon is about, or more than about, 50, 100, 200, 300, 400, 500, 750, 1000, or more nucleotides in length. In some embodiments, amplicon length is between any two of these endpoints, such as 25-1000, 30-500, 50-400, 50-250, 50-150, or 100-200 nucleotides in length. Primers may be selected based on conformance to any of a variety of design considerations, which may be used alone or in combination with any other design consideration disclosed herein or known in the art. Additional non-limiting examples of optional design considerations for primers include: avoiding runs of the same nucleotide (e.g. 3, 4, 5, or more of the same nucleotide in a row); proximity to the probe without overlapping probe hybridization site (e.g. about or less than about 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 15, 25, 30, 40, 50, 75, 100, or more nucleotides between the 3' end of a primer and the 5' end of a probe along the same strand); G-C content within about 20 -80 %, melting temperature (T_m) within a selected range (e.g. about 55-65 °C, 58-62 °C, or 58-60 °C); having no more than two G and/or C bases within the last five nucleotides at the 3' end; primers in a pair having similar T_m (e.g. the same T_m , or T_m 's within about 1-2 °C of each other); minimal secondary structure (e.g. about or fewer than about 5, 4, 3, 2, or 1 Watson-Crick paired bases when optimally folded, such as by analysis with mFold (see e.g. Zuker et al., Nucl. Acid Res, 2003, 31: 3406-3415)); minimal hybridization between primers in a reaction as homodimers or heterodimers (e.g. about or fewer than about 10, 9, 8, 7, 6, 5, 4, 3, 2, or 1 Watson-Crick paired bases when optimally aligned); and minimal hybridization

between a primer and corresponding probe (e.g. about or fewer than about 10, 9, 8, 7, 6, 5, 4, 3, 2, or 1 Watson-Crick paired bases when optimally aligned). In some embodiments, primers specifically amplify amplicons that are about or at least about 25, 50, 75, 100, 125, 150, or 175 nucleotides in length, and have about or at least about 80 , 85 , 90 , 95 , 97.5 , 99 , 99.5 , or more sequence identity with a sequence in Table 1 (or a complement thereof) when optimally aligned. Methods and algorithms for determining optimal sequence alignment are known in the art, any of which may be used to determine percent sequence identity. One example of an algorithm for determining sequence identity between two sequences includes the Basic Local Alignment Search Tool (BLAST), as maintained by the National Center for Biotechnology Information at blast.ncbi.nlm.nih.gov.

[0060] In some embodiments, primer pairs are immobilized on a solid support. Examples of solid supports include, but are not limited to, inorganic materials such as silica based substrates (e.g. glass, quartz, fused silica, silicon, or the like), other semiconductor materials, and organic materials such as polymer materials (e.g. polymethylmethacrylate, polyethylene, polypropylene, polystyrene, cellulose, agarose, or any of a variety of organic substrate materials conventionally used as supports for reactive media). In addition to the variety of materials useful as solid supports, solid support structures may be in any of a variety of physical configurations, including but not limited to microparticles, beads, nanoparticles, nanocrystals, fibers, microfibers, nanofibers, nanowires, nanotubes, mats, planar sheets, planar wafers or slides, multiwell plates, optical slides including additional structures, capillaries, microfluidic channels, and the like. In some embodiments, amplification on a solid support comprises bridge amplification. General methods of bridge amplification are known in the art. See for example WO/1998/044151 and WO/2000/018957.

[0061] Of particular interest are primer sequences capable of specific hybridization to regions conserved amongst at least 5, 10, 15, 20 or more different bacterial genomes. For example, a forward and a reverse primer each hybridizes to a separate region that is conserved amongst at least 5, 10, 15, 20 or more different bacterial genomes are selected. These conserved regions include but not limited to from 9 to 28, from 32 to 48, from 522 to 545, from 888 to 903, from 916 to 937, from 939 to 973, from 975 to 994, from 957 to 981, from 1093 to 1125, from 1184 to 1206, from 1231 to 1252, from 1378 to 1396, from 1398 to 1422, or from 1496 to 1516 of 16S rRNA of *Staphylococcus aureus* (GenBank accession Number NC_007622) or the corresponding regions in any one of the bacterial genomes: *Staphylococcus aureus* Mu3; *Staphylococcus epidermidis* *Streptococcus agalactiae* *Streptococcus pyogenes* *Streptococcus pneumonia* *Escherichia coli* *Citrobacter koseri* *Clostridium perfringens* *Enterococcus faecalis* *Klebsiella pneumonia* *Lactobacillus acidophilus* *Listeria monocytogenes* *Serratia marcescens* *Bacillus cereus* *Propionibacterium* sp. *Staphylococcus aureus* Mu50 *Yersinia enterocolitica* *Staphylococcus simulans* *Micrococcus luteus* and *Enterobacter aerogenes*.

[0062] In some embodiments, the subject primers are capable of specific hybridization to conserved regions of at least 5, 10, 15, 20 or more different bacterial genomes, and hence allow specific

amplification and detection of any type of the at least 5, 10, 15, 20 or more different bacterial genomes. The design of such primers and sets thereof allows for simultaneous determination of bacterial infection across a wide set of bacterial strains. In some embodiment, such detection occurs in a single amplification reaction with a single pair of primers, and optionally with one or more optional primers to provide additional bacterial coverage. These primers and sets thereof can be used in conjunction with probes disclosed herein or other labeling molecules such as DNA-binding dyes (e.g., SYBR[®] Green) and the like.

[0063] Primer extension in a nucleic acid amplification reaction can be carried out by any suitable polymerase known in the art, such as a DNA polymerase, many of which are commercially available. DNA polymerases can comprise DNA-dependent DNA polymerase activity, RNA-dependent DNA polymerase activity, or DNA-dependent and RNA-dependent DNA polymerase activity. DNA polymerases can be thermostable or non-thermostable. Examples of DNA polymerases include, but are not limited to, Taq polymerase, Tth polymerase, Tli polymerase, Pfu polymerase, PfuTubo polymerase, Pyrobest polymerase, Pwo polymerase, KOD polymerase, Bst polymerase, Sac polymerase, Sso polymerase, Poc polymerase, Pab polymerase, Mth polymerase, Pho polymerase, ES4 polymerase, VENT polymerase, DEEPVENT polymerase, EX-Taq polymerase, LA-Taq polymerase, Expand polymerases, Platinum Taq polymerases, Hi-Fi polymerase, Tbr polymerase, Tfi polymerase, Tru polymerase, Tac polymerase, Tne polymerase, Tma polymerase, Tih polymerase, Tfi polymerase, Klenow fragment, and variants, modified products and derivatives thereof. In some embodiments, enzymes produced using bacteria are highly purified, such that a no-template control amplification reaction does not produce an amplification signal above background levels after about, or more than about 25, 30, 35, 40, 45, or more cycles of a PCR reaction.

[0064] In some embodiments of any of the various aspects, nucleic acid amplification products are detected during and/or at the completion of the amplification process. Amplification product detection can be conducted in real time in an amplification assay. In some embodiments, the amplified products can be directly visualized with fluorescent DNA-binding agents including but not limited to DNA intercalators and DNA groove binders. Because the amount of the intercalators incorporated into the double-stranded DNA molecules is typically proportional to the amount of the amplified DNA products, one can conveniently determine the amount of the amplified products by quantifying the fluorescence of the intercalated dye using conventional optical systems. Non-limiting examples of DNA-binding dyes include SYBR[®] green, SYBR blue, DAPI, propidium iodine, Hoechst, SYBR gold, ethidium bromide, acridines, proflavine, acridine orange, acriflavine, fluorcoumanin, ellipticine, daunomycin, chloroquine, distamycin D, chromomycin, homidium, mithramycin, ruthenium polypyridyls, anthramycin, and the like.

[0065] In some embodiments, sequence specific oligonucleotide probes are employed in the nucleic acid amplification reaction to facilitate the detection and/or quantification of the amplified products. Probe-based quantitative amplification relies on the sequence-specific detection of a desired amplified

product, such as by specific hybridization between a probe and a target sequence within an amplification product. Examples of target-specific probes include, without limitation, TaqMan® probes and molecular beacons. Generic methods for performing probe-based quantitative amplification are known in the art (see e.g. U.S. Pat. No. 5,210,015). Hybridization can be performed under various stringencies. Suitable hybridization conditions are generally such that the recognition interaction between the probe and target polynucleotide is both sufficiently specific and sufficiently stable as to provide preferential hybridization between an oligonucleotide probe and/or primer and the intended target sequence. Conditions that increase the stringency of a hybridization reaction are known in the art, and include optimization of annealing temperature and/or salt concentration. An oligonucleotide probe can be of any suitable length, such as about, less than about, or more than about 10, 15, 20, 25, 30, 35, 40, 45, 50, 55, 60, 65, 70, 75, 80, 90, 100, or more nucleotides, any portion or all of which may be complementary to the corresponding target sequence (e.g. about, less than about, or more than about 5, 10, 15, 20, 25, 30, 35, 40, 45, 50, or more nucleotides). In some embodiments, a plurality of probes are used in a single nucleic acid amplification reaction, such as about or less than about 2, 3, 4, 5, 6, 7, 8, 9, 10, 15, 20, 25, or more probes. In some embodiments, a single nucleic acid amplification reaction contains only two probes, such as one that specifically hybridizes to a sequence from one or more Gram-positive bacteria (e.g. about or more than about 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, or more) and a second that specifically hybridizes to a sequence from one or more Gram-negative bacteria (e.g. about or more than about 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, or more). In some embodiments, a single nucleic acid amplification reaction contains only one probe, such as a probe that specifically hybridizes to a sequence that is identical among a plurality of different bacterial species (e.g. about or more than about 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 25, 30, 40, 50, or more species) and/or identical among bacteria from a plurality of different genera (e.g. about or more than about 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 25, 30, 40, 50, or more genera). Probes may be selected based on conformance to any of a variety of design considerations, which may be used alone or in combination with any other design consideration disclosed herein or known in the art. Additional non-limiting examples of optional design considerations for probes include: avoiding runs of the same nucleotide (e.g. 3, 4, 5, or more of the same nucleotide in a row); proximity to an amplification primer hybridization site without overlapping (e.g. about or less than about 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 15, 25, 30, 40, 50, 75, 100, or more nucleotides between the 3' end of a primer and the 5' end of a probe along the same strand); G-C content within about 20 % -80 %, melting temperature (T_m) within a selected range (e.g. about 8-10 °C higher than a corresponding primer T_m); and having more C's than G's; no G on the 5' end. In some embodiments, a probe specifically hybridizes to amplicons that are about or at least about 25, 50, 75, 100, 125, 150, or 175 nucleotides in length, and have about or at least about 80 %, 85 %, 90 %, 95 %, 97.5 %, 99 %, 99.5 %, or more sequence identity with a sequence in Table 1 when optimally aligned. Methods and algorithms for determining optimal sequence alignment are known in the art, any of which may be used to determine percent

sequence identity. One example of an algorithm for determining sequence identity between two sequences includes the Basic Local Alignment Search Tool (BLAST), as maintained by the National Center for Biotechnology Information at blast.ncbi.nlm.nih.gov.

[0066] For a convenient detection of the probe-target complexes formed during the hybridization assay, the nucleotide probes can be conjugated to a detectable label. Suitable detectable labels can include any composition detectable by photochemical, biochemical, spectroscopic, immunochemical, electrical, optical, or chemical means. A wide variety of appropriate detectable labels are known in the art, which include fluorescent labels, chemiluminescent labels, radioactive isotope labels, enzymatic labels, and ligands. The detection methods used to detect or quantify the hybridization intensity will typically depend upon the label selected above. For example, radiolabels may be detected using photographic film or a phosphorimager. Fluorescent markers may be detected and quantified using a photodetector to detect emitted light. In some embodiments, each of a plurality of probes in a single reaction is conjugated to a different detectable label (e.g. fluorescent dyes with different emission spectra), such that signal corresponding to amplification of different targets can be differentiated. Enzymatic labels are typically detected by providing the enzyme with a substrate and measuring the reaction product produced by the action of the enzyme on the substrate; and finally colorimetric labels are detected by simply visualizing the colored label.

[0067] In some embodiments, hybridization of a bound probe is detected using a TaqMan assay (PE Biosystems, Foster City, Calif.; See e.g., U.S. Pat. Nos. 5,962,233 and 5,538,848).

The assay is performed during a PCR reaction. The TaqMan assay exploits the 5'-3' exonuclease activity of DNA polymerases such as AMPLITAQ DNA polymerase. A sequence-specific probe is included in the PCR reaction. A typical TaqMan probe is an oligonucleotide with a 5'-reporter dye (e.g., a fluorescent dye) and a 3'-quencher dye. During PCR, if the probe is bound to its target, the 5'-3' nucleolytic activity of the AMPLITAQ polymerase cleaves the probe between the reporter and the quencher dye. The separation of the reporter dye from the quencher dye results in an increase of fluorescence. The signal accumulates with each cycle of PCR and can be monitored with a fluorimeter. A variety of reporter-quencher pairs are known in the art. Some pairs interact through fluorescence resonance energy transfer (FRET). Molecules commonly used in FRET as reporters or quenchers include, but are not limited to, fluorescein dyes (e.g., FAM, JOE, and HEX), rhodamine dyes (e.g. R6G, TAMRA, ROX), cyanine dyes (e.g. Cy3, Cy3.5, Cy5, Cy5.5, and Cy7), DABCYL, and EDANS. Whether a fluorescent dye acts as a reporter or a quencher is defined by its excitation and emission spectra, and by the fluorescent dye with which it is paired. For example, FAM is most efficiently excited by light with a wavelength of 488 nm, and emits light with a spectrum of 500 to 650 nm, and an emission maximum of 525 nm. FAM is a suitable reporter label for use with, e.g., TAMRA as a quencher, which has its excitation maximum at 514 nm. Examples of non-fluorescent or dark quenchers that dissipate energy absorbed from a fluorescent dye include the Black Hole Quenchers™ marketed by Bioscience Technologies, Inc. (Novato, Calif.,

USA). The Black Hole Quenchers™ are structures comprising at least three radicals selected from substituted or unsubstituted aryl or heteroaryl compounds, or combinations thereof, wherein at least two of the residues are linked via an exocyclic diazo bond (see, e.g., International Publication No. WO2001086001). Other dark quenchers include Iowa Black quenchers (e.g., Iowa Black FQ™ and Iowa Black RQ™), Eclipse® Dark Quenchers (Epoch Biosciences, Inc, Bothell, Wash.), and Zen™ quenchers (Integrated DNA Technologies, Inc.; Coralville, IA). Additional non-limiting examples of quenchers are also provided in U.S. Pat. No. 6,465,175.

[0068] In some embodiments, hybridization of a bound probe is detected using a molecular beacon oligonucleotide probe, such as described in U.S. Pat. No. 5,925,517, PCT Application No. WO1995013399, and U.S. Pat. No. 6,150,097. In a typical molecular beacon, a central target-recognition sequence is flanked by arms that hybridize to one another when the probe is not hybridized to a target strand, forming a hairpin structure, in which the target-recognition sequence is in the single-stranded loop of the hairpin structure, and the arm sequences form a double-stranded stem hybrid. When the probe hybridizes to a target, a relatively rigid helix is formed, causing the stem hybrid to unwind and forcing the arms apart. A FRET pair, such as the fluorophore EDANS and the quencher DABCYL (or other pairs described herein or known in the art), may be attached to the arms by alkyl spacers. When the molecular beacon is not hybridized to a target strand, the fluorophore's emission is quenched. When the Molecular Beacon is hybridized to a target strand, the FRET pair is separated, and the fluorophore's emission is not quenched. Emitted fluorescence signals the presence of target strands. Signal can be detected during a nucleic acid amplification reaction, such as with a fluorimeter at the end of each cycle in a PCR reaction. Signal intensity increases with an increasing amount of target sequence.

[0069] As disclosed in Whitcombe et al., Detection Of PCR Products Using Self-probing Amplicons and Fluorescence, *Nature Biotechnology* 17: 804-807 (August 1999), detection of PCR products may be accomplished with self-probing amplicons. A Scorpion Primer carries a 5' extension comprising a probe element, a pair of self-complimentary stem sequences, and a fluorophore/quencher pair. The extension is "protected" from being copied by the inclusion of a blocking hexethylene glycol (HEG) monomer. After a round of PCR extension from a primer, a newly synthesized target region is now attached to the same strand as the probe. Following a second round of denaturation and annealing, the probe and target hybridize, the probe subsequently fluorescing. Accordingly, a "probe" as described herein, may be present as a portion of a primer.

[0070] In some embodiments of any of the various aspects, a target sequence amplified in the nucleic acid amplification reaction is the sequence of a portion of a conserved bacterial polynucleotide. In some embodiments, an amplified portion of a conserved polynucleotide exhibits about or more than about 80%, 85%, 90%, 95%, 97.5%, or higher homology across different bacterial genera. Examples of conserved polynucleotide sequences include, but are not limited to, nucleotide sequences found in the 16S rRNA gene, 23S rRNA gene, 5S rRNA gene, 5.8S rRNA gene, 12S rRNA gene, 18S rRNA

gene, 28S rRNA gene, gyrB gene, rpoB gene, fusA gene, recA gene, cox1 gene and nifD gene. In some embodiments, the conserved polynucleotide is a portion of a 16S rRNA polynucleotide (e.g. rRNA, rDNA, amplification product, or combination of these). A listing of almost 40,000 aligned 16S rDNA sequences greater than 1250 nucleotides in length can be found on the Greengenes web application, a publicly accessible database run by Lawrence Berkeley National Laboratory. Other publicly accessible databases include GenBank, Michigan State University's ribosomal database project, the Max Planck Institute for Marine Microbiology's Silva database, and the National Institute of Health's NCBI. Non-limiting examples of amplification target sequences are shown in Table 1. In some embodiments, an amplicon is about or at least about 25, 50, 75, 100, 125, 150, or 175 nucleotides in length, and has about or at least about 80 , 85 , 90 , 95 , 97.5 , 99 , 99.5 , or more sequence identity with a sequence in Table 1 when optimally aligned. Methods and algorithms for determining optimal sequence alignment are known in the art, any of which may be used to determine percent sequence identity. One example of an algorithm for determining sequence identity between two sequences includes the Basic Local Alignment Search Tool (BLAST), as maintained by the National Center for Biotechnology Information at blast.ncbi.nlm.nih.gov.

[0071] In some embodiments, a portion of a conserved polynucleotide is specifically amplified by a pair of primers consisting of a first primer and a second primer that are specifically hybridizable to a sequence that is identical among a plurality of different bacterial species (e.g. about or more than about 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 25, 30, 40, 50, or more) and/or identical among bacteria from a plurality of different genera (e.g. about or more than about 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 25, 30, 40, 50, or more). Amplification with a single pair of universal primers can thus amplify polynucleotides from a plurality of different organisms in a single reaction. In some embodiments, a primer pair comprises a first primer comprising at least about 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 25, or more contiguous nucleotides from a sequence in Table 1 at its 3'-end, and a second primer comprising the complement of least about 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 25, or more contiguous nucleotides from the same Table 1 sequence at its 3'-end. In some embodiments, one or more primers in a nucleic acid amplification reaction comprise at least about 10, 11, 12, 13, 14, 15, or all nucleotides of a sequence selected from Table 2 at their 3'-ends. In some embodiments, a first primer comprising at least about 10 nucleotides from SEQ ID NO: 4 at its 3' end is used in combination with a second primer comprising at least about 10 nucleotides from SEQ ID NO: 5 or 6 at its 3' end. In some embodiments, a first primer comprising at least about 10 nucleotides from SEQ ID NO: 7 at its 3' end is used in combination with a second primer comprising at least about 10 nucleotides from SEQ ID NO: 8 at its 3' end. In some embodiments, a first primer comprising at least about 10 nucleotides from SEQ ID NO: 9 at its 3' end is used in combination with a second primer comprising at least about 10 nucleotides from SEQ ID NO: 10 at its 3' end.

[0072] In some embodiments of the various aspects, the presence, absence, and/or quantity of a plurality of organisms are detected in a single reaction. In some embodiments, the organisms detected are microorganisms, non-limiting examples of which include viruses, viroids, bacteria, archaea, fungi, and protozoa. In some embodiments, the microorganisms are bacteria. The bacteria detected may be Gram-positive, Gram-negative, or combinations of Gram-positive and Gram-negative bacteria. Non-limiting examples of bacteria that may be detected in a single reaction include two or more (e.g. 2, 3, 4, 5, 6, 7, 8, 9, 10, or more) of *Staphylococcus aureus*, *Staphylococcus aureus* Mu3; *Staphylococcus epidermidis*, *Streptococcus agalactiae*, *Streptococcus pyogenes*, *Streptococcus pneumoniae*, *Escherichia coli*, *Citrobacter koseri*, *Clostridium perfringens*, *Enterococcus faecalis*, *Klebsiella pneumoniae*, *Lactobacillus acidophilus*, *Listeria monocytogenes*, *Propionibacterium granulosum*, *Pseudomonas aeruginosa*, *Serratia marcescens*, *Bacillus cereus* *Staphylococcus aureus* Mu50 *Yersinia enterocolitica* *Staphylococcus simulans* *Micrococcus luteus* and *Enterobacter aerogenes*. In some embodiments, all bacteria detected are detected with a single probe complementary to a sequence shared among all bacteria to be detected. The target sequence flanked and amplified by a pair of universal primers may be different among a plurality of different organisms having the conserved polynucleotide (e.g. have one or more insertion, deletion, substitution, or combinations thereof), identical among a plurality of different organisms having the conserved polynucleotide, or combinations of these. Typically, the target sequence flanked and amplified by a pair of universal primers comprises one or more conserved internal regions of nucleotide sequence that are identical among a plurality of different bacterial species (e.g. about or more than about 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 25, 30, 40, 50, or more) and/or identical among bacteria from a plurality of different genera (e.g. about or more than about 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 25, 30, 40, 50, or more), which conserved internal region may be used as a probe target. In some embodiments, a conserved internal region is identical among a plurality of Gram-positive bacteria and not among Gram-negative bacteria, or vice versa. In some embodiments, a conserved internal region is about, or at least about 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 25, 30, 40, 50, 75, 100, or more nucleotides in length. In some embodiments, primers are selected such that the amplicon sequence among the species and/or genera to be detected is about or at least about 80 , 85 , 90 , 95 , 97.5 , 98 , 99 , 99.5 , or higher sequence identity across the species and/or genera to be detected. In some embodiments, primers are selected to produce an amplicon within a target length across the species and/or genera to be detected, such as any amplicon length described herein.

[0073] In some embodiments, a plurality of bacterial species and/or genera are detected (and optionally quantified) by hybridization between an amplified conserved internal region and a probe oligonucleotide. In general, a positive signal from a probe that specifically hybridizes to a conserved internal region is indicative of the presence of the target sequence, indicating that at least one organism having that target sequence was present in the sample from which the nucleic acids were

derived. In this way, the presence, absence, and/or quantity of a plurality of species and/or genera can be detected with a common probe. In some embodiments, the probe comprises at least about 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 25, or more contiguous nucleotides from a sequence in Table 1, or a sequence complementary thereto. In some embodiments, one or more probes in a nucleic acid amplification reaction comprise at least about 10, 11, 12, 13, 14, 15, or all nucleotides of a sequence selected from Table 3, or a complement thereof. In some embodiments, one or more probes comprising at least 10 nucleotides from SEQ ID NO: 11, 12, or 13 (or complements thereof) are used to detect amplification products amplified by primers based on SEQ ID NO: 4-6. In some embodiments, one or more probes comprising at least 10 nucleotides from SEQ ID NO: 14 or 15 (or complements thereof) are used to detect amplification products amplified by primers based on SEQ ID NO: 7-8. In some embodiments, a probe comprising at least 10 nucleotides from SEQ ID NO: 16 (or a complement thereof) is used to detect amplification products amplified by primers based on SEQ ID NO: 9-10.

[0074] In some embodiments of any of the various aspects, primers and probes are selected to maximize sensitivity of target polynucleotide detection. In some embodiments, sensitivity is measured in terms of cycle threshold (C_T) value. In the initial cycles of PCR, there is little change in fluorescence signal. This defines the baseline for an amplification plot (a plot of fluorescence intensity over cycle number). An increase in fluorescence above the baseline indicates the detection of accumulated PCR product. A fixed fluorescence threshold can be set above the baseline. The parameter C_T is defined as the fractional cycle number at which the fluorescence passes the fixed threshold, typically an intensity that is statistically significant above the baseline or background and in the log-linear phase of amplification. Software for calculating the threshold level of fluorescence in a given reaction or set of reactions are typically included in real-time PCR analysis software packages. One common method for setting the threshold is determining the baseline (background) average signal and setting a threshold 10-fold higher than the baseline average signal. Alternatively, a threshold value may be set at about 10 times the standard deviation of baseline emission. A plot of the log of initial target copy number for a set of standards versus C_T is typically a straight line. Quantification of the amount of target in unknown samples is accomplished by measuring C_T and using the standard curve to determine starting copy number. In some embodiments, detection has a linear range of detection over about or more than about 3, 4, 5, 6, 7, 8, or more logs. In some embodiments, amplification of about or less than about 10pg, 5pg, 4pg, 3pg, 2pg, 1pg, 0.5pg, 0.1pg, or range between any of these (e.g. 0.5-4pg, 1pg-5pg, 1pg-3pg, etc) of genomic DNA from any one of the bacterial species detectable by a probe in the amplification reaction has a C_T of less than 30. In some embodiments, amplification of about or less than about 15000, 10000, 5000, 2500, 1500, 1000, 500, 200, 100, 50, or fewer starting copies of a target sequence detectable by a probe in the amplification reaction has a C_T of less than 30. In some embodiments, amplification of about 1pg of genomic DNA from any one of the bacterial species detectable by a probe in the amplification

reaction has a C_T of about or less than about 30, 29, 28, 27, 26, 25, or lower. In some embodiments, the C_T for a negative control sample is at least 2 cycles (e.g. at least 2, 3, 4, 5, 6, 7, 8, 9, 10, or more cycles) higher than the C_T for a sample containing about 100pg, 10pg, 5pg, 4pg, 3pg, 2pg, 1pg, 0.5pg, 0.1pg, or range between any of these (e.g. 0.5-4pg, 1pg-5pg, 1pg-3pg, 5pg-10pg, etc) of genomic DNA from any one of the bacterial species detectable by a probe in the amplification reaction. Typically, a negative control is an amplification reaction that has all reaction reagents, but no template is added (e.g. add water instead of template, or polynucleotides known to lack a target amplicon, such as human genomic DNA in the case of a bacteria-specific amplicon). In some embodiments, bacterial contamination is detected in nucleic acid from about or less than about 25mL, 20mL, 15mL, 10mL, 5mL, 4mL, 3mL, 2mL, 1mL, 0.1mL or less of a platelet concentrate. In some embodiments, amplification is performed on a platelet sample or portion thereof without first incubating the sample to promote bacterial growth, such as at a temperature above about 30 °C, 35 °C, or 37 °C. In some embodiments, detection yields a detectable signal indicative of bacterial contamination of a platelet sample having a bacterial load of about or less than about 50, 25, 10, 5, 4, 3, 2, 1, 0.1 or fewer colony forming units per mL (CFU/mL) in a platelet sample. In some embodiments, detection yields a detectable signal indicative of bacterial contamination of a platelet sample when nucleic acids derived from fewer than 50000, 40000, 30000, 25000, 20000, 15000, 10000, 7500, 5000, 2500, 1250, 1000, 750, 500, 250, 100, 50, 25, 10, 5, or fewer CFU are present in the detection reaction. In some embodiments, a detectable signal is obtained for a reaction containing nucleic acids derived from 5 to 50000 CFU, 500 to 25000 CFU, 1000 to 10000 CFU, or 25 to 2500 CFU. In some embodiments, detection is completed prior to transfusion of a donated platelet sample, and if a positive signal is detected (indicating bacterial contamination), the donated platelets are not transfused into a recipient. In some embodiments, a positive signal for a sample having contamination at or above any of the disclosed detection thresholds is detected within about 48, 24, 12, 6, 4, 2, or fewer hours from obtaining the sample from a subject (e.g. from withdrawing blood from a subject).

[0075] In some embodiments of any of the aspects described herein, a detection procedure is initiated at a time just prior to use of the biological sample (e.g. prior to administering a blood sample or blood-derived sample, such as a platelet sample, to a subject), and yields a result prior to such use, regardless of when the sample was collected. For example, a biological sample may be tested for contamination about or less than about 12, 11, 10, 9, 8, 7, 6, 5, 4, 3, 2, or 1 hour before a planned use of the biological sample, and a detection result is obtained before the time of such planned use (e.g. 1, 2, 3, 4, 5, or more hours before use). In some embodiments, a sample is tested within about 5 hours of planned use, and a result is obtained prior to such planned use. In some embodiments, a sample is tested within about 2 hours of planned use, and a result is obtained prior to such planned use. In some embodiments, a sample is tested within about 1 hour of planned use, and a result is obtained prior to such planned use. In some embodiments, the biological sample is discarded without using it if bacterial contamination is detected by the detection method. In some embodiments, the planned use

of the biological sample proceeds if bacterial contamination is not detected. In some embodiments, the sample that is tested prior to use was collected about or more than about 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, or more days prior to the planned use. In some embodiments, the sample that is tested prior to use was collected about or more than about 5 days prior to the planned use.

[0076] In one aspect, the disclosure provides a system for use in any of the methods disclosed herein. In some embodiments, the system is used for detecting bacterial contamination of a sample, such as a platelet sample, by any of a plurality of bacterial species from different genera. In one embodiment, the system comprises: a computer configured to receive a customer request to perform a detection reaction on a sample; an amplification system that performs a nucleic acid amplification reaction on the sample or a portion thereof in response to the customer request, wherein the amplification reaction yields a detectable amount of an amplicon of no more than about 500 bases of a 16S rRNA polynucleotide using a single primer pair and single probe, and further wherein amplification of 1pg-5pg of DNA from any one of the at least five genera has a C_T of less than 30; and a report generator that sends a report to a recipient, wherein the report contains results for detection of a signal intensity produced by the probe.

[0077] In some embodiments, the computer comprises one or more processors. Processors may be associated with one or more controllers, calculation units, and/or other units of a computer system, or implanted in firmware as desired. If implemented in software, the routines may be stored in any computer readable memory such as in RAM, ROM, flash memory, a magnetic disk, a laser disk, or other storage medium. Likewise, this software may be delivered to a computing device via any known delivery method including, for example, over a communication channel such as a telephone line, the internet, a wireless connection, etc., or via a transportable medium, such as a computer readable disk, flash drive, etc. The various steps may be implemented as various blocks, operations, tools, modules or techniques which, in turn, may be implemented in hardware, firmware, software, or any combination thereof. When implemented in hardware, some or all of the blocks, operations, techniques, etc. may be implemented in, for example, a custom integrated circuit (IC), an application specific integrated circuit (ASIC), a field programmable logic array (FPGA), a programmable logic array (PLA), etc. In some embodiments, the computer is configured to receive a customer request to perform a detection reaction on a sample. The computer may receive the customer request directly (e.g. by way of an input device such as a keyboard, mouse, or touch screen operated by the customer or a user entering a customer request) or indirectly (e.g. through a wired or wireless connection, including over the internet). Non-limiting examples of customers include the subject providing the sample, medical personnel, clinicians, laboratory personnel, insurance company personnel, or others in the health care industry.

[0078] In some embodiments, the system comprises an amplification system for performing a nucleic acid amplification reaction on a sample or a portion thereof, responsive to receipt of a customer request by the computer. The amplification system may include a liquid handler, a thermocycler, an

optical detector, and/or processor for analyzing detection data. In some embodiments, one or more steps in sample processing, nucleic acid isolation, amplification, and/or analysis are automated by the amplification system. In some embodiments, automation may comprise the use of one or more liquid handlers and associated software. Several commercially available liquid handling systems can be utilized to run the automation of such processes (see for example liquid handlers from Perkin-Elmer, Caliper Life Sciences, Tecan, Eppendorf, Apricot Design, Velocity 11). In some embodiments, detecting comprises a real-time detection instrument. Exemplary real-time instruments include, but are not limited to, the ABI PRISM® 7000 Sequence Detection System, the ABI PRISM® 7700 Sequence Detection System, the Applied Biosystems 7300 Real-Time PCR System, the Applied Biosystems 7500 Real-Time PCR System, the Applied Biosystems 7900 HT Fast Real-Time PCR System (all from Applied Biosystems); the LightCycler™ System (Roche Diagnostics GmbH); the Mx3000P™ Real-Time PCR System, the Mx3005P™ Real-Time PCR System, and the Mx4000® Multiplex Quantitative PCR System (Stratagene, La Jolla, Calif.); and the Smart Cycler System (Cepheid, distributed by Fisher Scientific). Additional non-limiting examples of automated systems for processing and/or assaying samples include COBAS® AmpliPrep/COBAS® TaqMan® systems (Roche Molecular Systems), TIGRIS DTS systems (Hologic Gen-Probe, San Diego, CA), PANTHER systems (Hologic Gen-Probe, San Diego, CA), BD MAX™ system (Becton Dickinson), GeneXpert System (Cepheid), Filmarray® (BioFire Diagnostics), iCubate systems, IDBox systems (Luminex), EncompassMDx™ (Rheonix), Liat™ Analyzer (IQuum), Biocartis' Molecular Diagnostic Platform, Enigma® ML systems (Enigma Diagnostics), T2Dx® systems (T2 Biosystems), Verigene® system (NanoSphere), Great Basin's Diagnostic System, Unyvero™ System (Curetis), PanNAT systems (Micronics), Spartan™ RX systems (Spartan Bioscience), Atlas io system (Atlas Genetics), Idylla platform (Biocartis), ARIES (Luminex), GenMark's automated PCR platform (e.g. eSensor systems), 3M Integrated Cycler (Focus Diagnostics), and Alere i automated PCR platform (Alere). Descriptions of real-time instruments can be found in, among other places, their respective manufacturer's users manuals; McPherson; DNA Amplification: Current Technologies and Applications, Demidov and Broude, eds., Horizon Bioscience, 2004; and U.S. Pat. No. 6,814,934.

[0079] In some embodiments, the system comprises a report generator that sends a report to a recipient, wherein the report contains results for detection of a signal intensity produced by the probe. The report generator may send a report automatically in response to production of fluorescence intensity data by the amplification system, such as in the form of data analysis performed by real-time PCR analysis software. Alternatively, the report generator may send a report in response to instructions from an operator. A report may contain raw signal intensity data, processed signal intensity data (e.g. graphical displays, identification of C_T values, calculation of starting amount of template polynucleotide), a conclusion that bacterial contamination was or was not detected, and/or quantification of an amount of contamination in the source sample (such as in CFU/mL). The report may be transmitted to a recipient at a local or remote location using any suitable communication

medium. For example, the communication medium can be a network connection, a wireless connection, or an internet connection. A report can be transmitted over such networks or connections (or any other suitable means for transmitting information, including but not limited to mailing a physical report, such as a print-out) for reception and/or for review by a recipient. The recipient can be but is not limited to the customer, an individual, a health care provider, a health care manager, or electronic system (e.g. one or more computers, and/or one or more servers). In some embodiments, the report generator sends the report to a recipient's device, such as a personal computer, phone, tablet, or other device. The report may be viewed online, saved on the recipient's device, or printed.

[0080] Figure 5 illustrates an example system for detecting bacterial contamination of a sample. The system may be understood as a logical apparatus that can read instructions from media (e.g. software) and/or network port (e.g. from the internet), which can optionally be connected to a server having fixed media. A computer system may comprise one or more of a CPU, disk drives, input devices such as keyboard and/or mouse, and a display (e.g. a monitor). Data communication, such as transmission of instructions or reports, can be achieved through a communication medium to a server at a local or a remote location. The communication medium can include any means of transmitting and/or receiving data. For example, the communication medium can be a network connection, a wireless connection, or an internet connection. Such a connection can provide for communication over the World Wide Web.

[0081] In one aspect, the disclosure provides a computer-readable medium comprising codes that, upon execution by one or more processors, implements a method according to any of the methods disclosed herein. In some embodiments, execution of the computer readable medium implements a method of detecting bacterial contamination of a biological sample, such as a platelet sample, by any of a plurality of bacterial species from different genera. In one embodiment, execution of the computer readable medium implements a method comprising: responsive to a customer request to perform a detection reaction on a sample, performing a nucleic acid amplification reaction on the sample or a portion thereof in response to the customer request, wherein the amplification reaction yields a detectable amount of an amplicon of no more than about 500 bases of 16S rRNA using a single primer pair and single probe, and further wherein amplification of 1pg-5pg of DNA from any one of the at least five genera has a C_T of less than 30; and generating a report that contains results for detection of a signal intensity produced by the probe.

[0082] Computer readable medium may take many forms, including but not limited to, a tangible storage medium, a carrier wave medium, or physical transmission medium. Non-volatile storage media include, for example, optical or magnetic disks, such as any of the storage devices in any computer(s) or the like, such as may be used to implement the calculation steps, processing steps, etc. Volatile storage media include dynamic memory, such as main memory of a computer. Tangible transmission media include coaxial cables; copper wire and fiber optics, including the wires that comprise a bus within a computer system. Carrier-wave transmission media can take the form of

electric or electromagnetic signals, or acoustic or light waves such as those generated during radio frequency (RF) and infrared (IR) data communications. Common forms of computer-readable media therefore include for example: a floppy disk, a flexible disk, hard disk, magnetic tape, any other magnetic medium, a CD-ROM, DVD or DVD-ROM, any other optical medium, punch cards paper tape, any other physical storage medium with patterns of holes, a RAM, a PROM and EPROM, a FLASH-EPROM, any other memory chip or cartridge, a carrier wave transporting data or instructions, cables or links transporting such a carrier wave, or any other medium from which a computer can read programming code and/or data. Many of these forms of computer readable media may be involved in carrying one or more sequences of one or more instructions to a processor for execution.

[0083] In one aspect, the disclosure provides compositions for amplifying and detecting at least a portion of a conserved polynucleotide. Compositions can comprise one or more elements disclosed herein in relation to any of the various aspects, in any combination. In some embodiments, the conserved polynucleotide is a 16S rRNA polynucleotide (e.g. 16S rRNA, DNA containing a 16S rRNA gene, 16S rRNA and/or rDNA amplification products, or combinations of these). In some embodiments the portion of the 16S rRNA polynucleotide amplified is about or less than about 1000, 900, 800, 700, 600, 500, 400, 300, 250, 200, 175, 150, 125, 100, 90, 80, 70, 60, 50, or fewer nucleotides in length. In some embodiments, the composition comprises: a first primer comprising at least about 10, 11, 12, 13, 14, 15, or all nucleotides of SEQ ID NO: 9; a second primer comprising at least about 10, 11, 12, 13, 14, 15, or all nucleotides of SEQ ID NO: 10; and a probe comprising at least about 10, 11, 12, 13, 14, 15, or all nucleotides of SEQ ID NO: 16. In some embodiments, the composition comprises primers that, in an amplification reaction with a target 16S rRNA polynucleotide, amplify an amplicon of at least 50 nucleotides in length, the amplicon having 90 sequence identity with any of SEQ ID NO: 1-3 when optimally aligned; and a probe that specifically hybridizes to either strand of the amplicon. In some embodiments, the primers and probes are selected in accordance with one or more parameters disclosed herein. For example, primers and probes may be selected such that amplification of about 1pg-5pg of DNA from any one of a plurality of target species has a cycle threshold value (C_T) of less than 30. Compositions may be contained in any suitable container, such as a well of a multi-well plate, a plate, a tube, a chamber, a flow cell, a chamber or channel of a micro-fluidic device, or a chip. In some embodiments, the composition is in a dehydrated form, such as a bead or film adhered to a surface of a container.

[0084] In one aspect, the disclosure provides a reaction mixture for amplification and detection of a conserved polynucleotide. Reaction mixtures can comprise one or more elements disclosed herein in relation to any of the various aspects, in any combination. In some embodiments, the conserved polynucleotide is a 16S rRNA polynucleotide (e.g. 16S rRNA, DNA containing a 16S rRNA gene, 16S rRNA and/or rDNA amplification products, or combinations of these). In some embodiments the portion of the 16S rRNA polynucleotide amplified is about or less than about 1000, 900, 800, 700,

600, 500, 400, 300, 250, 200, 175, 150, 125, 100, 90, 80, 70, 60, 50, or fewer nucleotides in length. In some embodiments, the reaction mixture comprises: a first primer comprising at least about 10, 11, 12, 13, 14, 15, or all nucleotides of SEQ ID NO: 9; a second primer comprising at least about 10, 11, 12, 13, 14, 15, or all nucleotides of SEQ ID NO: 10; and a probe comprising at least about 10, 11, 12, 13, 14, 15, or all nucleotides of SEQ ID NO: 16. In some embodiments, the reaction mixture comprises primers that, in an amplification reaction with a target 16S rRNA polynucleotide, amplify an amplicon of at least 50 nucleotides in length, the amplicon having 90% sequence identity with any of SEQ ID NO: 1-3 when optimally aligned; and a probe that specifically hybridizes to either strand of the amplicon. In some embodiments, the primers and probes are selected in accordance with one or more parameters disclosed herein. For example, primers and probes may be selected such that amplification of about 1pg-5pg of DNA from any one of a plurality of target species has a cycle threshold value (C_T) of less than 30. Reaction mixtures may be contained in any suitable reaction site. The reaction site may be a container, such as a well of a multi-well plate, a plate, a tube, a chamber, a flow cell, a chamber or channel of a micro-fluidic device, or a chip. The reaction site may be a partition within a solution, such as a droplet (e.g. within an emulsion mixture). In some embodiments, the composition is in a dehydrated form, such as a bead or film adhered to a surface of a container.

[0085] In one aspect, the disclosure provides kits for detection of bacterial contamination of a biological sample, such as a platelet sample. Kits can comprise one or more elements disclosed herein in relation to any of the various aspects, in any combination. In some embodiments, the kit comprises: a first primer comprising at least about 10, 11, 12, 13, 14, 15, or all nucleotides of SEQ ID NO: 9; a second primer comprising at least about 10, 11, 12, 13, 14, 15, or all nucleotides of SEQ ID NO: 10; and a probe comprising at least about 10, 11, 12, 13, 14, 15, or all nucleotides of SEQ ID NO: 16. Reagents and other materials in a kit may be contained in any suitable container, and may be in an immediately usable form or require combination with other reagents in the kit or reagents supplied by a user (e.g. dilution of a concentrated composition or reconstitution of a lyophilized composition). A kit may provide buffers, non-limiting examples of which include sodium carbonate buffer, a sodium bicarbonate buffer, a borate buffer, a Tris buffer, a MOPS buffer, a HEPES buffer, and combinations thereof. A kit may comprise a control sample, e.g., a known bacterium for control of DNA extraction procedures and/or purified DNA for use as a positive control or quantification standard. In some embodiments, the kit comprises instructions for use of the kit in accordance with one or more methods disclosed herein. In some embodiments, a method for using the kit comprises performing a nucleic acid amplification reaction on a sample or a portion thereof with a single primer pair to yield a detectable amount of an amplicon of no more than about 500 bases of a 16S rRNA polynucleotide, wherein amplification of about 1pg-5pg of DNA from any one of a plurality of bacterial species from different genera has a cycle threshold value (C_T) of less than 30; and detecting the amplicon with one or more detectable probes, wherein each of the one or more detectable probes

specifically hybridizes to a conserved sequence, and the conserved sequence is identical among a plurality of bacterial species from different genera.

[0086] Table 1: Exemplary Amplification Target Sequences

SEQ ID NO: 1	CAAGGTTGAAACTCAAAGGAATTGACGGGGACCCGCACAAGCGGTGGAGCATGTGGTTTAATTC GAAGCAACGCGAAGAACCTTACC
SEQ ID NO: 2	GCAACGCGAAGAACCTTACCAAATCTTGACATCCTTTGACAACTCTAGAGATAGAGCCTTCCCCTT CGGGGGACAAAGTGACAGGTGGTGCATGGTTGTCGTCAGCTCGTGTCGTGAGATGTTGGGTAA GTCCCGCA
SEQ ID NO: 3	GCAACGAGCGCAACCCTTAAGCTTAGTTGCCATCATTAAAGTTGGGCACTCTAAGTTGACTGCCGG TGACAAACCGGAGGAAGGTGGGGATGACGTCAAATCATCATGCCCTTATGATTGGGCTACAC ACGTGCTACAATGG
SEQ ID NO: 20	CTTGCATGTATTAGGCACGCCGCGCAGCGTTCATCCTGAGCCAGGATCAAACCTCT
SEQ ID NO: 21	AGAGTTTGATCCTGGCTCAGGATGAACGCTGGCGGCGTGCCTAATACATGCAAGT
SEQ ID NO: 22	GGCGTGCCTAATACATGCAAGTCGAGCGAACGGACGAGAAGCTTGCTTCTCTGATGTTAGCGGC GGACGGGTGAGTAA
SEQ ID NO: 23	CGTGCCTAATACATGCAAGTCGAGCGAACGGACGAGAAGCTTGCTTCTCTGATGTTAGCGGCGG ACGGGTGAGTAA
SEQ ID NO: 24	GGCGTGCCTAATACATGCAAGTCGAGCGAACGGACGAGAAGCTTGCTTCTCTGATGTTAGCGGC GGACGGGTGAGTAACACGTGGATAACCTACCTATAAGACTGGGATAACTTCGGGAAACCGGAGC TAATACCGGATAATATTTTGAACCGCATGGTTCAAAAGTGAAAGACGGTCTTGCTGTCACTTATA GATGGATCCGCGCTGCATTAGCTAGTTGGTAAGGTAACGGCTTACCAAGGCAACGATGCATAGC CGACCTGAGAGGGTGATCGGCCACACTGGAAGTGAACACGGTCCAGACTCCTACGGGAGGCA GCAGTAGGGAATCTTCCGCAATGGGCGAAAGCCTGACGGAGCAACGCCGCGTGAGTGATGAAG GTCTTCGGATCGTAAACTCTGTTATTAGGGAAGAACATATGTGTAAGTAACTGTGCACATCTTG ACGGTACCTAATCAGAAAGCCACGGCTAACTACGTGCCAGCAGCCGCGGTAATACGTAGGTGGC AAGCGTTATCCGGAATTATTGGGCGTAAAG
SEQ ID NO: 25	CGTGCCTAATACATGCAAGTCGAGCGAACGGACGAGAAGCTTGCTTCTCTGATGTTAGCGGCGG ACGGGTGAGTAACACGTGGATAACCTACCTATAAGACTGGGATAACTTCGGGAAACCGGAGCTA ATACCGGATAATATTTTGAACCGCATGGTTCAAAAGTGAAAGACGGTCTTGCTGTCACTTATAGA TGGATCCGCGCTGCATTAGCTAGTTGGTAAGGTAACGGCTTACCAAGGCAACGATGCATAGCCG ACCTGAGAGGGTGATCGGCCACACTGGAAGTGAACACGGTCCAGACTCCTACGGGAGGCAGCA GTAGGGAATCTTCCGCAATGGGCGAAAGCCTGACGGAGCAACGCCGCGTGAGTGATGAAGGTC TTCGGATCGTAAACTCTGTTATTAGGGAAGAACATATGTGTAAGTAACTGTGCACATCTTGACG

	GTACCTAATCAGAAAGCCACGGCTAACTACGTGCCAGCAGCCGCGGTAATACGTAGGTGGCAAG CGTTATCCGGAATTATTGGGCGTAAAG
SEQ ID NO: 26	TTACTACCCGTCCGCCGCTAACATCAGAGAAGCAAGCTTCTCGTCCGTTGCTCGACTTGCATGT ATTAGGCACGCCGCCAGCGTTCATCCTGAGCCAGGATCAAACCTCT
SEQ ID NO: 27	AGTCTGGACCGTGTCTCAGTTCAGTGTGGCCGATCACCTCTCAGGTGGCTATGCATCGTTGCC TTGGTAAGCCGTTACCTTACCAACTAGCTAATGCAGCGCGGATCCATCTATAAGTGACAGCAAGA CCGTCTTTCACTTTTGAACCATGCGGTTCAAATATTATCCGGTATTAGCTCCGGTTTCCGAAGTT ATCCAGTCTTATAGGTAGGTTATCCACGTGTTACTACCCGTCCGCCGCTAACATCAGAGAAGCA AGCTTCTCGTCCGTTGCTCGACTTGCATGTATTAGGCACGCCGCCAGCGTTCATCCTGAGCCAGG ATCAAACCTCT
SEQ ID NO: 28	CGCGCTTACGCCCAATAATTCCGGATAACGCTTGCCACCTACGTATTACCGCGGCTGCTGGCAGC TAGTTAGCCGTGGCTTTCTGATTAGGTACCGTCAAGATGTGCACAGTTACTTACACATATGTTCTT CCCTAATAACAGAGTTTTACGATCCGAAGACCTTCATCACTCACGCGGCGTTGCTCCGTCAGGCTT TCGCCATTGCGGAAGATTCCCTACTGCTGCCTCCCGTAGGAGTCTGGACCGTGTCTCAGTTCAG TGTGGCCGATCACCTCTCAGGTGGCTATGCATCGTTGCCTTGGTAAGCCGTTACCTTACCAACT AGCTAATGCAGCGCGGATCCATCTATAAGTGACAGCAAGACCGTCTTTCACTTTTGAACCATGCG GTTCAAATATTATCCGGTATTAGCTCCGGTTTCCGAAGTTATCCAGTCTTATAGGTAGGTTAT CCACGTGTTACTACCCGTCCGCCGCTAACATCAGAGAAGCAAGCTTCTCGTCCGTTGCTCGACT TGCATGTATTAGGCACGCCGCCAGCGTTCATCCTGAGCCAGGATCAAACCTCT
SEQ ID NO: 29	TTTGATCCCCACGCTTTCGCACATCAGCGTCAGTTACAGACCAGAAAGTCGCCTTCGCCACTGGTG TTCCTCCATATCTCTGCGCATTTACCGCTACACATGGAATTCACCTTCTCTTCTGCACTCAAGTT TTCCAGTTTCAATGACCTCCACGGTTGAGCCGTGGGCTTTCACATCAGACTTAAAAAACCGCCT ACGCGCGCTTTACGCCCAATAATTCCGGATAACGCTTGCCACCTACGTATTACCGCGGCTGCTGGC ACGTAGTTAGCCGTGGCTTTCTGATTAGGTACCGTCAAGATGTGCACAGTTACTTACACATATGTT CTTCCCTAATAACAGAGTTTTACGATCCGAAGACCTTCATCACTCACGCGGCGTTGCTCCGTCAGG CTTTCGCCATTGCGGAAGATTCCCTACTGCTGCCTCCCGTAGGAGTCTGGACCGTGTCTCAGTTC CAGTGTGGCCGATCACCTCTCAGGTGGCTATGCATCGTTGCCTTGGTAAGCCGTTACCTTACCA ACTAGCTAATGCAGCGCGGATCCATCTATAAGTGACAGCAAGACCGTCTTTCACTTTTGAACCATG CGGTTCAAATATTATCCGGTATTAGCTCCGGTTTCCGAAGTTATCCAGTCTTATAGGTAGGTT ATCCACGTGTTACTACCCGTCCGCCGCTAACATCAGAGAAGCAAGCTTCTCGTCCGTTGCTCGA CTTGCATGTATTAGGCACGCCGCCAGCGTTCATCCTGAGCCAGGATCAAACCTCT
SEQ ID NO: 30	CGGCTAACTACGTGCCAGCAGCCGCGGTAATACGTAGGTGGCAAGCGTTATCCGGAATTATTGG GCGTAAAGCGCG
SEQ ID NO: 31	CCAGCAGCCGCGGTAATACGTAGGTGGCAAGCGTTATCCGGAATTATTGGGCGTAAAGCGCG

SEQ ID NO: 32	CCAGCAGCCGCGGTAATACGTAGGTGGCAAGCGTTATCCGGAATTATTGGGCGTAAAG
SEQ ID NO: 33	TGTGTAGCGGTGAAATGCGCAGAGATATGGAGGAACACCAGTGGCGAAGGCGACTTTCTGGTCT GTAAGTACGCTGATGTGCGAAAGCGTGGGGATCAA
SEQ ID NO: 34	TGTGTAGCGGTGAAATGCGCAGAGATATGGAGGAACACCAGTGGCGAAGGCGACTTTCTGGTCT GTAAGTACGCTGATGTGCGAAAGCGTGGGGATCAAACAGGATTAGATACCCTGGTAGTCCACG CCGTAAACGATG
SEQ ID NO: 35	CCGCCTGGGGAGTACGACCGCAAGGTTGAAACTCAAAGGAATTGACGGGGACCCGCACAAGCG GTGGAGCATGTGGTTTAATTCTGAAGCAACGCGAAGAACCTTACC
SEQ ID NO: 36	GGGAGTACGACCGCAAGGTTGAAACTCAAAGGAATTGACGGGGACCCGCACAAGCGGTGGAGC ATGTGGTTTAATTCTGAAGCAACGCGAAGAACCTTACC
SEQ ID NO: 37	CGCAAGGTTGAAACTCAAAGGAATTGACGGGGACCCGCACAAGCGGTGGAGCATGTGGTTTAAT TCGAAGCAACGCGAAGAACCTTACC
SEQ ID NO: 38	GCAAGGTTGAAACTCAAAGGAATTGACGGGGACCCGCACAAGCGGTGGAGCATGTGGTTTAATT CGAAGCAACGCGAAGAACCTTACC
SEQ ID NO: 39	CGGTGAATACGTTCCCGGGTCTTGTACACACCGCCCGTCACACCACGAGAGTTTGTAAACACCCGA AGCCGGTGGAGTAACCTTTTAGGAGCTAGCCGTCGAAGGTGGGACAAATGATTGGGGTGAAGTC GTAACAAGG
SEQ ID NO: 40	CGGTGAATACGTTCCCGGGTCTTGTACACACCGCCCGTCACACCACGAGAGTTTGTAAACACCCGA AGCCGGTGGAGTAACCTTTTAGGAGCTAGCCGTCGAAGGTGGGACAAATGATTGGGGTGAAGTC GTAACAAGGTAGC
SEQ ID NO: 41	TGTACACACCGCCCGTCACACCACGAGAGTTTGTAAACACCCGAAGCCGGTGGAGTAACCTTTAG GAGCTAGCCGTCGAAGGTGGGACAAATGATTGGGGTGAAGTCGTAACAAGGTAGCCGTATCGG AAGGTGCGGCTGGATCACCTCCTT

[0087] Table 2: Exemplary Primer Sequences

SEQ ID NO: 4	GGTAAGGTTCTTCGCGTTGC
SEQ ID NO: 5	CAAGGTTGAAACTCAAAGGAATTGA
SEQ ID NO: 6	CAAGGTTAAACTCAAATGAATTGA
SEQ ID NO: 7	TGCGGGACTTAACCAACAT
SEQ ID NO: 8	GCAACGCGAAGAACCTTACC
SEQ ID NO: 9	CCATTGTAGCACGTGTGTAGCC
SEQ ID NO: 10	GCAACGAGCGCAACCC
SEQ ID NO: 42	GGTAAGGTTCTACGCGTTGC
SEQ ID NO: 43	CAAGGCTGAAACTCAAAGGAATTGA

SEQ ID NO: 44	CAAGGCTAAACTCAAAGGAATTGA
SEQ ID NO: 45	TACGGGACTTAACCCAACAT
SEQ ID NO: 46	GCAACGCGTAGAACCTTACC
SEQ ID NO: 47	CCATTGTAGCATGCGTGAAGCC
SEQ ID NO: 48	GTAACGAGCGCAACCC
SEQ ID NO: 49	CCATTGTAGCACGTGTGTAGCCC
SEQ ID NO: 50	CCATTGTAGCATGCGTGAAGCCC
SEQ ID NO: 51	AGAGTTTGATCCTGGCTCAG
SEQ ID NO: 52	TGCATGTATTAGGCACGCC
SEQ ID NO: 53	TGCATGTGTTAGGCCTGCC
SEQ ID NO: 54	TGCATGTGTTAAGCACGCC
SEQ ID NO: 55	ACTTG CATGTATTAGGCACG
SEQ ID NO: 56	ACTTG CATGTGTTAGGCCTG
SEQ ID NO: 57	ACTTG CATGTGTTAAGCACG
SEQ ID NO: 58	T TACTACCCGTC CGCC
SEQ ID NO: 59	T TACTACCCGTT CGCA
SEQ ID NO: 60	T TACTACCCATC CGCC
SEQ ID NO: 61	T TACTACCCGTT CGCC
SEQ ID NO: 62	AGTCTGGACCGTGTCTCAGTTC
SEQ ID NO: 63	AGTCTGGGCCGTGTCTCAGTCC
SEQ ID NO: 64	AGTTTGGGCCGTGTCTCAGTCC
SEQ ID NO: 65	AGTCTGGGCCGTATCTCAGTCC
SEQ ID NO: 66	CTTTACGCCCAATAATTCCG
SEQ ID NO: 67	CTTTACGCCCAGTAATTCCG
SEQ ID NO: 68	CTTTACGCCCAATAAATCCG
SEQ ID NO: 69	TTTGATCCCCACGCTTT
SEQ ID NO: 70	TTTGCTCCCCACGCTTT
SEQ ID NO: 71	TTCGCTACCCATGCTTT
SEQ ID NO: 72	TTCGCTCCCCACGCTTT
SEQ ID NO: 73	CGGCTAACTACGTGCCAGC
SEQ ID NO: 74	CGGCTAACTCCGTGCCAGC
SEQ ID NO: 75	CGGCTAACTTCGTGCCAGC
SEQ ID NO: 76	CCAGCAGCCGCGGTAAT

SEQ ID NO: 77	CCAGCAGCCGCGGTGAT
SEQ ID NO: 78	CGCGCTTTACGCCAATA
SEQ ID NO: 79	TGCGCTTTACGCCAGTA
SEQ ID NO: 80	CTCGCTTTACGCCAATA
SEQ ID NO: 81	AGCCCTTTACGCCAATA
SEQ ID NO: 82	TGTGTAGCGGTGAAATGCG
SEQ ID NO: 83	GGTGTAGCGGTGAAATGCG
SEQ ID NO: 84	GTGTAGCGGTGGAATGCG
SEQ ID NO: 85	GTGGAGCGGTGGAATGCG
SEQ ID NO: 86	TTGATCCCCACGCTTTCG
SEQ ID NO: 87	TTGCTCCCCACGCTTTCG
SEQ ID NO: 88	TCGCTACCCATGCTTTCG
SEQ ID NO: 89	TCGCTCCCCACGCTTTCG
SEQ ID NO: 90	CATCGTTTACGGCGTGGA
SEQ ID NO: 91	CATCGTTTACAGCGTGGA
SEQ ID NO: 92	CATCGTTTACGGCATGGA
SEQ ID NO: 93	CACCGTTTACAGCGTGGA
SEQ ID NO: 94	GGGAGTACGACCGCAAGGT
SEQ ID NO: 95	GGGGAGTACGGCCGCAAGG
SEQ ID NO: 96	CCGCCTGGGGAGTACG
SEQ ID NO: 97	CGCAAGGTTGAAACTCAAAGG
SEQ ID NO: 98	CGCAAGGTTAAACTCAAATG
SEQ ID NO: 99	CGCAAGGCTGAAACTCAAAGG
SEQ ID NO: 100	CGCAAGGCTAAACTCAAAGG
SEQ ID NO: 101	GCAAGGTTGAAACTCAAAGGAATT
SEQ ID NO: 102	GCAAGGTTAAACTCAAATGAATT
SEQ ID NO: 103	GCAAGGCTGAAACTCAAAGGAATT
SEQ ID NO: 104	GCAAGGCTAAACTCAAAGGAATT
SEQ ID NO: 105	CGGTGAATACGTTCCCGG
SEQ ID NO: 106	CCTTGTTACGACTTCACCCCA
SEQ ID NO: 107	CCTTGTTACGACTTAGTCCTA
SEQ ID NO: 108	CGGTGAATACGTTCCCGG
SEQ ID NO: 109	GCTACCTTGTTACGACTTCACCC

SEQ ID NO: 110	GTTACCTTGTTACGACTTCACCC
SEQ ID NO: 111	GCTACCTTGTTACGACTTAGTCC
SEQ ID NO: 112	TGTACACACCGCCCGTCACA
SEQ ID NO: 113	TGTACACACCGCCCGTCAAG
SEQ ID NO: 114	AAGGAGGTGATCCAGCCGC
SEQ ID NO: 115	AAGGAGGTGATCCAACCGC
SEQ ID NO: 116	TTTGATCCTGGCTCAG
SEQ ID NO: 117	TTTGATCATGGCTCAG
SEQ ID NO: 118	GAACGCTGGCGGC
SEQ ID NO: 119	GCCTAATACATGCAAGT
SEQ ID NO: 120	GCCTAACACATGCAAGT
SEQ ID NO: 121	GGCGTGCCTAATACATGCA
SEQ ID NO: 122	GGCAGGCCTAACACATGCA
SEQ ID NO: 123	GGCGTGCTTAACACATGCA
SEQ ID NO: 124	CGTGCCTAATACATGCAAGT
SEQ ID NO: 125	CAGGCCTAACACATGCAAGT
SEQ ID NO: 126	CGTGCTTAACACATGCAAGT

[0088] Table 3: Exemplary Probe Sequences

SEQ ID NO: 11	TCGAATTAAACCACATGCTCCACCGCT
SEQ ID NO: 12	TCGAATTAATCCGCATGCTCCGCCGCT
SEQ ID NO: 13	TCGAATTAAACCACATGCTCCGCTACT
SEQ ID NO: 14	AGCTGACGACAGCCATGCAGCACCT
SEQ ID NO: 15	AGCTGACGACAACCATGCACCACCT
SEQ ID NO: 16	TGACGTCATCCCCACCTTCCTCC
SEQ ID NO: 127	AGCTGACGACAGCCATGCACCACCT
SEQ ID NO: 128	ACACGAGCTGACGACAACCATGCACCACCTGT
SEQ ID NO: 129	ACAGGTGCTGCATGGCTGTCGTCAGCTCGTGT
SEQ ID NO: 130	ACAGGTGGTGCATGGCTGTCGTCAGCTCGTGT
SEQ ID NO: 131	AACGCTGGCGGCGTGC
SEQ ID NO: 132	AACGCTGGCGGCAGGC
SEQ ID NO: 133	CGGCGTGCCTAATACATGCAAG
SEQ ID NO: 134	CGGCAGGCCTAACACATGCAAG

SEQ ID NO: 135	CGGCAGGCTTAACACATGCAAG
SEQ ID NO: 136	CGGCGTGCTTAACACATGCAAG
SEQ ID NO: 137	CGTAGGTGGCAAGCGTTATCCGGAA
SEQ ID NO: 138	CGGAGGGTGCAAGCGTTAATCGGAA
SEQ ID NO: 139	CGTAGGTCCCGAGCGTTGTCCGGAT
SEQ ID NO: 140	CAGTGGCGAAGGCGACTTTCTG
SEQ ID NO: 141	CAGGGGGCCGCCTTCGCCACCG
SEQ ID NO: 142	CAGAGAGCCGCTTTCGCCACCG
SEQ ID NO: 143	GGGATCAAACAGGATTAGATACCCTGGT
SEQ ID NO: 144	GGGAGCAAACAGGATTAGATACCCTGGT
SEQ ID NO: 145	GGGAGCGAACAGGCTTAGATACCCTGGT
SEQ ID NO: 146	ACAAGCGGTGGAGCATGTGGTTTAATTC
SEQ ID NO: 147	ACAAGCGGCGGAGCATGCGGATTAATTC
SEQ ID NO: 148	ACAAGTAGCGGAGCATGTGGTTTAATTC
SEQ ID NO: 149	AGCGGTGGAGCATGTGGTTTAATTCG
SEQ ID NO: 150	AGCGGCGGAGCATGCGGATTAATTCG
SEQ ID NO: 151	AGTAGCGGAGCATGTGGTTTAATTCG
SEQ ID NO: 152	AAGCGGTGGAGCATGTGGTTTAATTCG
SEQ ID NO: 153	AGCGGCGGAGCATGCGGATTAATTCG
SEQ ID NO: 154	AGTAGCGGAGCATGTGGTTTAATTCG
SEQ ID NO: 155	TGTACACACCGCCCGTCA

[0089] Table 15: Exemplary Pairing of Sequences as Primers

Exemplary Primer Set 1	Included or Optional	Bacteria Target Coverage
SEQ ID NO: 4	Included	Staphylococcus aureus Staphylococcus aureus Mu3; Staphylococcus epidermidis Streptococcus agalactiae Streptococcus pyogenes Streptococcus pneumonia Escherichia coli Citrobacter koseri Clostridium perfringens Enterococcus faecalis Klebsiella pneumonia Lactobacillus acidophilus Listeria monocytogenes Pseudomonas aeruginosa Serratia marcescens Staphylococcus aureus Mu50 Yersinia enterocolitica Staphylococcus simulans Micrococcus luteus and Enterobacter aerogenes
SEQ ID NO: 5	Included	
SEQ ID NO: 6	Included	
SEQ ID NO: 42	Optional	Improves Propionibacterium sp. amplification based on sequence homology
SEQ ID NO: 43	Optional	Improves Bacillus cereus amplification based on sequence homology
SEQ ID NO: 44	Optional	Improves Propionibacterium sp. amplification based on sequence homology

Exemplary Primer Set 2	Included or Optional	Bacteria Target Coverage
SEQ ID NO: 7	Included	Staphylococcus aureus Staphylococcus aureus Mu3; Staphylococcus epidermidis Streptococcus agalactiae Streptococcus pyogenes Streptococcus pneumonia Escherichia coli Citrobacter koseri Clostridium perfringens Enterococcus faecalis Klebsiella pneumonia Lactobacillus acidophilus Listeria monocytogenes Serratia marcescens Bacillus cereus Staphylococcus aureus Mu50 Yersinia enterocolitica Staphylococcus simulans Micrococcus luteus and Enterobacter aerogenes
SEQ ID NO: 8	Included	
SEQ ID NO: 45	Optional	Improves Pseudomonas aeruginosa amplification based on sequence homology
SEQ ID NO: 46	Optional	Improves Propionibacterium sp. amplification based on sequence homology

Exemplary Primer Set 3	Included or Optional	Bacteria Target Coverage
SEQ ID NO: 9	Included	Staphylococcus aureus Staphylococcus aureus Mu3; Staphylococcus epidermidis Streptococcus agalactiae Streptococcus pyogenes Streptococcus pneumonia Escherichia coli Citrobacter koseri Clostridium perfringens Enterococcus faecalis Klebsiella pneumonia Propionibacterium sp. Pseudomonas aeruginosa Lactobacillus acidophilus Listeria monocytogenes Serratia marcescens Bacillus cereus Staphylococcus aureus Mu50 Yersinia enterocolitica Staphylococcus simulans Micrococcus luteus and Enterobacter aerogenes
SEQ ID NO: 10	Included	
SEQ ID NO: 47	Optional	Improves Propionibacterium sp. amplification based on sequence homology
SEQ ID NO: 48	Optional	Improves Pseudomonas aeruginosa amplification based on sequence homology

Exemplary Primer Set 4	Included or Optional	Bacteria Target Coverage
SEQ ID NO: 51	Included	Staphylococcus aureus Staphylococcus aureus Mu3; Staphylococcus epidermidis Streptococcus agalactiae Streptococcus pyogenes Streptococcus pneumonia Escherichia coli Citrobacter koseri Clostridium perfringens Enterococcus faecalis Klebsiella pneumonia Lactobacillus acidophilus Listeria monocytogenes Pseudomonas aeruginosa Serratia marcescens Bacillus cereus Staphylococcus aureus Mu50 Yersinia enterocolitica Staphylococcus simulans Micrococcus luteus and Enterobacter aerogenes
SEQ ID NO: 52	Included	
SEQ ID NO: 53	Included	
SEQ ID NO: 54	Optional	Improves Propionibacterium sp. amplification based on sequence homology

Exemplary Primer Set 5	Included or Optional	Bacteria Target Coverage
SEQ ID NO: 51	Included	Staphylococcus aureus Staphylococcus aureus Mu3; Staphylococcus epidermidis Streptococcus agalactiae Streptococcus pyogenes Streptococcus pneumonia Escherichia coli Citrobacter koseri Enterococcus faecalis Klebsiella pneumonia Lactobacillus acidophilus Listeria monocytogenes Pseudomonas aeruginosa Serratia marcescens Bacillus cereus Staphylococcus aureus Mu50 Yersinia enterocolitica Staphylococcus simulans Micrococcus luteus and Enterobacter aerogenes
SEQ ID NO: 55	Included	
SEQ ID NO: 56	Included	
SEQ ID NO: 57	Optional	Improves Propionibacterium sp. and Clostridium perfringens amplification based on sequence homology

Exemplary Primer Set 6	Included or Optional	Bacteria Target Coverage
SEQ ID NO: 58	Included	Staphylococcus aureus Staphylococcus aureus Mu3; Staphylococcus epidermidis Streptococcus agalactiae Streptococcus pyogenes Streptococcus pneumonia Escherichia coli Citrobacter koseri Clostridium perfringens Enterococcus faecalis Klebsiella pneumonia Listeria monocytogenes Pseudomonas aeruginosa Serratia marcescens Bacillus cereus Staphylococcus aureus Mu50 Yersinia enterocolitica Staphylococcus simulans Micrococcus luteus and Enterobacter aerogenes
SEQ ID NO: 59	Included	
SEQ ID NO: 121	Included	
SEQ ID NO: 122	Included	
SEQ ID NO: 60	Optional	Improves Lactobacillus acidophilus amplification based on sequence homology
SEQ ID NO: 61	Optional	Improves Propionibacterium sp. amplification based on sequence homology
SEQ ID NO: 123	Optional	Improves Propionibacterium sp. amplification based on sequence homology

Exemplary Primer Set 7	Included or Optional	Bacteria Target Coverage
SEQ ID NO: 58	Included	Staphylococcus aureus Staphylococcus aureus Mu3; Staphylococcus epidermidis Streptococcus agalactiae Streptococcus pyogenes Streptococcus pneumonia Escherichia coli Citrobacter koseri Enterococcus faecalis Klebsiella pneumonia Listeria monocytogenes Pseudomonas aeruginosa Serratia marcescens Bacillus cereus Staphylococcus aureus Mu50 Yersinia enterocolitica Staphylococcus simulans Micrococcus luteus and Enterobacter aerogenes
SEQ ID NO: 59	Included	
SEQ ID NO: 124	Included	
SEQ ID NO: 125	Included	
SEQ ID NO: 60	Optional	Improves Lactobacillus acidophilus amplification based on sequence homology
SEQ ID NO: 61	Optional	Improves Propionibacterium sp. amplification based on sequence homology
SEQ ID NO: 126	Optional	Improves Propionibacterium sp. and Clostridium perfringens amplification based on sequence homology

Exemplary Primer Set 8	Included or Optional	Bacteria Target Coverage
SEQ ID NO: 66	Included	Staphylococcus aureus Staphylococcus aureus Mu3; Staphylococcus epidermidis Streptococcus agalactiae Streptococcus pyogenes Streptococcus pneumonia Escherichia coli Citrobacter koseri Clostridium perfringens Enterococcus faecalis Klebsiella pneumonia Lactobacillus acidophilus Listeria monocytogenes Pseudomonas aeruginosa Serratia marcescens Bacillus cereus Staphylococcus aureus Mu50 Yersinia enterocolitica Staphylococcus simulans Micrococcus luteus and Enterobacter aerogenes
SEQ ID NO: 67	Included	
SEQ ID NO: 68	Included	
SEQ ID NO: 121	Included	
SEQ ID NO: 122	Included	
SEQ ID NO: 123	Optional	Improves Propionibacterium sp. amplification based on

		sequence homology
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Exemplary Primer Set 9	Included or Optional	Bacteria Target Coverage
SEQ ID NO: 66	Included	Staphylococcus aureus Staphylococcus aureus Mu3; Staphylococcus epidermidis Streptococcus agalactiae Streptococcus pyogenes Streptococcus pneumonia Escherichia coli Citrobacter koseri Enterococcus faecalis Klebsiella pneumonia Lactobacillus acidophilus Listeria monocytogenes Pseudomonas aeruginosa Serratia marcescens Bacillus cereus Staphylococcus aureus Mu50 Yersinia enterocolitica Staphylococcus simulans Micrococcus luteus and Enterobacter aerogenes
SEQ ID NO: 67	Included	
SEQ ID NO: 68	Included	
SEQ ID NO: 124	Included	
SEQ ID NO: 125	Included	
SEQ ID NO: 126	Optional	Improves Propionibacterium sp. and Clostridium perfringens amplification based on sequence homology

Exemplary Primer Set 1	Included or Optional	Bacteria Target Coverage
SEQ ID NO: 51	Included	Staphylococcus aureus Staphylococcus aureus Mu3; Staphylococcus epidermidis Streptococcus agalactiae Streptococcus pyogenes Streptococcus pneumonia Escherichia coli Citrobacter koseri Clostridium perfringens Enterococcus faecalis Klebsiella pneumonia Listeria monocytogenes Pseudomonas aeruginosa Serratia marcescens Bacillus cereus Staphylococcus aureus Mu50 Yersinia enterocolitica Staphylococcus simulans Micrococcus luteus and Enterobacter aerogenes
SEQ ID NO: 58	Included	
SEQ ID NO: 59	Included	
SEQ ID NO: 60	Optional	Improves Lactobacillus acidophilus amplification based on sequence homology
SEQ ID NO: 61	Optional	Improves Propionibacterium sp. amplification based on sequence homology

Exemplary Primer Set 11	Included or Optional	Bacteria Target Coverage
SEQ ID NO: 51	Included	Staphylococcus aureus Staphylococcus aureus Mu3; Staphylococcus epidermidis Streptococcus agalactiae Streptococcus pyogenes Streptococcus pneumonia Escherichia coli Citrobacter koseri Clostridium perfringens Enterococcus faecalis Klebsiella pneumonia Listeria monocytogenes Pseudomonas aeruginosa Serratia marcescens Bacillus cereus Staphylococcus aureus Mu50 Yersinia enterocolitica Staphylococcus simulans Micrococcus luteus and Enterobacter aerogenes
SEQ ID NO: 62	Included	
SEQ ID NO: 63	Included	
SEQ ID NO: 64	Optional	Improves Lactobacillus acidophilus amplification based on sequence homology
SEQ ID NO: 65	Optional	Improves Propionibacterium sp. amplification based on sequence homology

Exemplary Primer Set 12	Included or Optional	Bacteria Target Coverage
SEQ ID NO: 51	Included	Staphylococcus aureus Staphylococcus aureus Mu3; Staphylococcus epidermidis Streptococcus agalactiae Streptococcus pyogenes Streptococcus pneumonia Escherichia coli Citrobacter koseri Clostridium perfringens Enterococcus faecalis Klebsiella pneumonia Lactobacillus acidophilus Listeria monocytogenes Propionibacterium granulosum Pseudomonas aeruginosa Serratia marcescens Bacillus cereus Staphylococcus aureus Mu50 Yersinia enterocolitica Staphylococcus simulans Micrococcus luteus and Enterobacter aerogenes
SEQ ID NO: 66	Included	
SEQ ID NO: 67	Included	
SEQ ID NO: 68	Included	

Exemplary Primer Set 13	Included or Optional	Bacteria Target Coverage
SEQ ID NO: 51	Included	Staphylococcus aureus Staphylococcus aureus Mu3; Staphylococcus epidermidis Streptococcus agalactiae Streptococcus pyogenes Streptococcus pneumonia Escherichia coli Citrobacter koseri Clostridium perfringens Enterococcus faecalis Klebsiella pneumonia Listeria monocytogenes Pseudomonas aeruginosa Serratia marcescens Bacillus cereus Staphylococcus aureus Mu50 Yersinia enterocolitica Staphylococcus simulans Micrococcus luteus and Enterobacter aerogenes
SEQ ID NO: 69	Included	
SEQ ID NO: 70	Included	
SEQ ID NO: 71	Optional	Improves Lactobacillus acidophilus amplification based on sequence homology
SEQ ID NO: 72	Optional	Improves Propionibacterium sp. amplification based on sequence homology

Exemplary Primer Set 14	Included or Optional	Bacteria Target Coverage
SEQ ID NO: 73	Included	Staphylococcus aureus Staphylococcus aureus Mu3; Staphylococcus epidermidis Streptococcus agalactiae Streptococcus pyogenes Streptococcus pneumonia Escherichia coli Citrobacter koseri Clostridium perfringens Enterococcus faecalis Klebsiella pneumonia Listeria monocytogenes Serratia marcescens Bacillus cereus Staphylococcus aureus Mu50 Yersinia enterocolitica Staphylococcus simulans Micrococcus luteus and Enterobacter aerogenes
SEQ ID NO: 74	Included	
SEQ ID NO: 63	Included	
SEQ ID NO: 62	Included	
SEQ ID NO: 75	Optional	Improves Pseudomonas aeruginosa amplification based on sequence homology
SEQ ID NO: 64	Optional	Improves Lactobacillus acidophilus amplification based on sequence homology
SEQ ID NO: 65	Optional	Improves Propionibacterium sp. amplification based on sequence homology

Exemplary Primer Set 15	Included or Optional	Bacteria Target Coverage
SEQ ID NO: 76	Included	Staphylococcus aureus Staphylococcus aureus Mu3; Staphylococcus epidermidis Streptococcus agalactiae Streptococcus pyogenes Streptococcus pneumonia Escherichia coli Citrobacter koseri Clostridium perfringens Enterococcus faecalis Klebsiella pneumonia Lactobacillus acidophilus Listeria monocytogenes Pseudomonas aeruginosa Serratia marcescens Bacillus cereus Staphylococcus aureus Mu50 Yersinia enterocolitica Staphylococcus simulans Micrococcus luteus and Enterobacter aerogenes
SEQ ID NO: 78	Included	
SEQ ID NO: 79	Included	
SEQ ID NO: 80	Included	
SEQ ID NO: 77	Optional	Improves Propionibacterium sp. amplification based on sequence homology
SEQ ID NO: 81	Optional	Improves Propionibacterium sp. amplification based on sequence homology

Exemplary Primer Set 16	Included or Optional	Bacteria Target Coverage
SEQ ID NO: 76	Included	Staphylococcus aureus Staphylococcus aureus Mu3; Staphylococcus epidermidis Streptococcus agalactiae Streptococcus pyogenes Streptococcus pneumonia Escherichia coli Citrobacter koseri Clostridium perfringens Enterococcus faecalis Klebsiella pneumonia Lactobacillus acidophilus Listeria monocytogenes Pseudomonas aeruginosa Serratia marcescens Bacillus cereus Staphylococcus aureus Mu50 Yersinia enterocolitica Staphylococcus simulans Micrococcus luteus and Enterobacter aerogenes
SEQ ID NO: 66	Included	
SEQ ID NO: 67	Included	
SEQ ID NO: 68	Included	
SEQ ID NO: 77	Optional	Improves Propionibacterium sp. amplification based on sequence homology

Exemplary Primer Set 17	Included or Optional	Bacteria Target Coverage
SEQ ID NO: 82	Included	Staphylococcus aureus Staphylococcus aureus Mu3; Staphylococcus epidermidis Streptococcus agalactiae Streptococcus pyogenes Streptococcus pneumonia Escherichia coli Citrobacter koseri Clostridium perfringens Enterococcus faecalis Klebsiella pneumonia Listeria monocytogenes Pseudomonas aeruginosa Serratia marcescens Bacillus cereus Staphylococcus aureus Mu50 Yersinia enterocolitica Staphylococcus simulans Micrococcus luteus and Enterobacter aerogenes
SEQ ID NO: 83	Included	
SEQ ID NO: 86	Included	
SEQ ID NO: 87	Included	
SEQ ID NO: 84	Optional	Improves Lactobacillus acidophilus amplification based on sequence homology
SEQ ID NO: 85	Optional	Improves Propionibacterium sp. amplification based on sequence homology
SEQ ID NO: 88	Optional	Improves Lactobacillus acidophilus amplification based on sequence homology
SEQ ID NO: 89	Optional	Improves Propionibacterium sp. amplification based on sequence homology

Exemplary Primer Set 18	Included or Optional	Bacteria Target Coverage
SEQ ID NO: 82	Included	Staphylococcus aureus Staphylococcus aureus Mu3; Staphylococcus epidermidis Streptococcus agalactiae Streptococcus pyogenes Streptococcus pneumonia Escherichia coli Citrobacter koseri Clostridium perfringens Enterococcus faecalis Klebsiella pneumonia Listeria monocytogenes Pseudomonas aeruginosa Serratia marcescens Bacillus cereus Staphylococcus aureus Mu50 Yersinia enterocolitica Staphylococcus simulans Micrococcus luteus and Enterobacter aerogenes
SEQ ID NO: 83	Included	
SEQ ID NO: 90	Included	
SEQ ID NO: 91	Included	
SEQ ID NO: 84	Optional	Improves Lactobacillus acidophilus amplification based on sequence homology
SEQ ID NO: 85	Optional	Improves Propionibacterium sp. amplification based on sequence homology
SEQ ID NO: 92	Optional	Improves Lactobacillus acidophilus amplification based on sequence homology
SEQ ID NO: 93	Optional	Improves Propionibacterium sp. amplification based on sequence homology

Exemplary Primer Set 19	Included or Optional	Bacteria Target Coverage
SEQ ID NO: 96	Included	Staphylococcus aureus Staphylococcus aureus Mu3; Staphylococcus epidermidis Streptococcus agalactiae Streptococcus pyogenes Streptococcus pneumonia Escherichia coli Citrobacter koseri Clostridium perfringens Enterococcus faecalis Klebsiella pneumonia Lactobacillus acidophilus Listeria monocytogenes Pseudomonas aeruginosa Serratia marcescens Bacillus cereus Staphylococcus aureus Mu50 Yersinia enterocolitica Staphylococcus simulans Micrococcus luteus and Enterobacter aerogenes
SEQ ID NO: 4	Included	
SEQ ID NO: 42	Optional	Improves Propionibacterium sp. amplification based on sequence homology

Exemplary Primer Set 2	Included or Optional	Bacteria Target Coverage
SEQ ID NO: 94	Included	Staphylococcus aureus Staphylococcus aureus Mu3; Staphylococcus epidermidis Streptococcus agalactiae Streptococcus pyogenes Streptococcus pneumonia Escherichia coli Citrobacter koseri Clostridium perfringens Enterococcus faecalis Klebsiella pneumonia Lactobacillus acidophilus Listeria monocytogenes Pseudomonas aeruginosa Serratia marcescens Bacillus cereus Staphylococcus aureus Mu50 Yersinia enterocolitica Staphylococcus simulans Micrococcus luteus and Enterobacter aerogenes
SEQ ID NO: 95	Included	
SEQ ID NO: 4	Included	
SEQ ID NO: 42	Optional	Improves Propionibacterium sp. amplification based on sequence homology

Exemplary Primer Set 21	Included or Optional	Bacteria Target Coverage
SEQ ID NO: 98	Included	Staphylococcus aureus Staphylococcus aureus Mu3; Staphylococcus epidermidis Streptococcus agalactiae Streptococcus pyogenes Streptococcus pneumonia Escherichia coli Citrobacter koseri Clostridium perfringens Enterococcus faecalis Klebsiella pneumonia Lactobacillus acidophilus Listeria monocytogenes Pseudomonas aeruginosa Serratia marcescens Staphylococcus aureus Mu50 Yersinia enterocolitica Staphylococcus simulans Micrococcus luteus and Enterobacter aerogenes
SEQ ID NO: 4	Included	
SEQ ID NO: 99	Optional	Improves Bacillus cereus amplification based on sequence homology
SEQ ID NO: 100	Optional	Improves Propionibacterium sp. amplification based on sequence homology
SEQ ID NO: 42	Optional	Improves Propionibacterium sp. amplification based on sequence homology

Exemplary Primer Set 22	Included or Optional	Bacteria Target Coverage
SEQ ID NO: 102	Included	Staphylococcus aureus Staphylococcus aureus Mu3; Staphylococcus epidermidis Streptococcus agalactiae Streptococcus pyogenes Streptococcus pneumonia Escherichia coli Citrobacter koseri Clostridium perfringens Enterococcus faecalis Klebsiella pneumonia Lactobacillus acidophilus Listeria monocytogenes Pseudomonas aeruginosa Serratia marcescens Staphylococcus aureus Mu50 Yersinia enterocolitica Staphylococcus simulans Micrococcus luteus and Enterobacter aerogenes
SEQ ID NO: 4	Included	
SEQ ID NO: 103	Optional	Improves Bacillus cereus amplification based on sequence homology
SEQ ID NO: 104	Optional	Improves Propionibacterium sp. amplification based on sequence homology
SEQ ID NO: 42	Optional	Improves Propionibacterium sp. amplification based on sequence homology

Exemplary Primer Set 23	Included or Optional	Bacteria Target Coverage
SEQ ID NO: 105	Included	Staphylococcus aureus Staphylococcus aureus Mu3; Staphylococcus epidermidis Streptococcus agalactiae Streptococcus pyogenes Streptococcus pneumonia Escherichia coli Citrobacter koseri Clostridium perfringens Enterococcus faecalis Klebsiella pneumonia Lactobacillus acidophilus Listeria monocytogenes Pseudomonas aeruginosa Serratia marcescens Bacillus cereus Staphylococcus aureus Mu50 Yersinia enterocolitica Staphylococcus simulans Micrococcus luteus and Enterobacter aerogenes
SEQ ID NO: 106	Included	
SEQ ID NO: 107	Optional	Improves Propionibacterium sp. amplification based on sequence homology

Exemplary Primer Set 24	Included or Optional	Bacteria Target Coverage
SEQ ID NO: 108	Included	Staphylococcus aureus Staphylococcus aureus Mu3; Staphylococcus epidermidis Streptococcus agalactiae Streptococcus pyogenes Streptococcus pneumonia Escherichia coli Citrobacter koseri Clostridium perfringens Enterococcus faecalis Klebsiella pneumonia Lactobacillus acidophilus Listeria monocytogenes Pseudomonas aeruginosa Serratia marcescens Bacillus cereus Staphylococcus aureus Mu50 Yersinia enterocolitica Staphylococcus simulans Micrococcus luteus and Enterobacter aerogenes
SEQ ID NO: 109	Included	
SEQ ID NO: 110	Included	
SEQ ID NO: 111	Optional	Improves Propionibacterium sp. amplification based on sequence homology

Exemplary Primer Set 25	Included or Optional	Bacteria Target Coverage
SEQ ID NO: 112	Included	Staphylococcus aureus Staphylococcus aureus Mu3; Staphylococcus epidermidis Streptococcus agalactiae Streptococcus pyogenes Streptococcus pneumonia Escherichia coli Citrobacter koseri Clostridium perfringens Enterococcus faecalis Klebsiella pneumonia Lactobacillus acidophilus Listeria monocytogenes Pseudomonas aeruginosa Serratia marcescens Bacillus cereus Staphylococcus aureus Mu50 Yersinia enterocolitica Staphylococcus simulans Micrococcus luteus and Enterobacter aerogenes
SEQ ID NO: 114	Included	
SEQ ID NO: 115	Included	
SEQ ID NO: 113	Optional	Improves Propionibacterium sp. amplification based on sequence homology

EXAMPLES

[0090] The following examples are given for the purpose of illustrating various embodiments of the invention and are not meant to limit the present invention in any fashion. The present examples, along with the methods described herein are presently representative of preferred embodiments, are exemplary, and are not intended as limitations on the scope of the invention. Changes therein and other uses which are encompassed within the spirit of the invention as defined by the scope of the claims will occur to those skilled in the art.

Example 1:

[0091] An example pair of primers and an example probe for the corresponding amplicon were evaluated for specificity, detection range, and ability to detect a variety of bacterial species from multiple different genera. In this example, a primer having sequence SEQ ID NO: 9, a primer having sequence SEQ ID NO: 10, and a probe having sequence SEQ ID NO: 16, were used to amplify and detect a conserved portion of 16S rRNA gene. The primers and probe were designed against the sequence SEQ ID NO: 3. Real-time PCR reactions were prepared with the indicated amount of bacterial genomic DNA, as well as primers, probe, enzyme, dNTP's, and other standard reagents.

[0092] To evaluate sensitivity of the primer-probe combination, amplification reactions containing 10ng, 1ng, 100pg, 10pg, 1pg, and 0.1pg of *E. coli* DNA extract were prepared in duplicate. No-template controls, containing all common reagents but replacing DNA extract with water, were prepared in quadruplicate. A graphical display of the results of real-time PCR amplification is shown in Fig. 1. A log-scale of arbitrary fluorescence intensity along the y-axis (0 to 10) is plotted against cycle number along the x-axis (0 to 40). From left to right, the first pair of curves correspond to the 10ng sample (average C_T of about 14.5), followed by overlapping pairs of curves corresponding to the 1ng, 100pg, 10pg, 1pg, and 0.1pg samples (C_T 's of about 17.5, 21, 24.5, 27.5, and 31). Without wishing to be bound by theory, it is possible that the amplification signal around C_T of 36 for the four no-template control samples may result from residual bacterial polynucleotides in the commercially obtained enzyme. Nevertheless, specific amplification signals with this combination of primers and probe provide a 6-log range of detection, with 0.1pg of starting template detected at least 5 full cycles before signal from the negative control. In fact, the detection over this range is linear, as shown in Fig. 2 (R^2 of about 0.999, and amplification efficiency of about 95.5% over this range), and may therefore be used to quantify amounts of starting material in unknown samples.

[0093] In a similar series of amplification reactions, this set of primers and probes were tested for amplifying and detecting 100pg of DNA from *Staphylococcus aureus* Mu3 (also known as methicillin-resistant *Staphylococcus aureus*), *Staphylococcus aureus*, *Staphylococcus epidermidis*, *Streptococcus agalactiae*, *Streptococcus pyogenes*, and *Streptococcus pneumoniae*, alongside 10pg of *E. coli* for comparison, and a no-template control (NTC), all in duplicate. It is noted that the tested

bacteria include both Gram-positive and Gram-negative bacteria. Real-time amplification results are shown in Table 4 (“EP” refers to endpoint).

[0094] Table 4

Sample		C _T	End Point at c40)
Staphylococcus aureus Mu3	100pg	22.2	130832
Staphylococcus aureus Mu3	100pg	21.7	136136
Staphylococcus aureus	100pg	21.8	124004
Staphylococcus aureus	100pg	21.8	135570
Staphylococcus epidermidis	100pg	19.0	132983
Staphylococcus epidermidis	100pg	18.9	144509
Streptococcus agalactiae	100pg	20.2	116510
Streptococcus agalactiae	100pg	20.4	90608
Streptococcus pyogenes	100pg	21.0	135415
Streptococcus pyogenes	100pg	21.0	136506
Streptococcus pneumonia	100pg	21.3	141007
Streptococcus pneumonia	100pg	21.2	132592
E. coli	10pg	28.6	93763
E. coli	10pg	28.6	94028
NTC	0	35.9	55749
NTC	0	35.3	57366

[0095] In a further series of amplification reactions, sensitivity of the same set of primers and probe were tested for amplifying and detecting 1pg or 10pg of DNA (as indicated) from *Staphylococcus aureus Mu3* *Staphylococcus aureus* *Staphylococcus epidermidis* *Streptococcus agalactiae* *Streptococcus pyogenes* *Streptococcus pneumoniae* *Citrobacter koseri* *Clostridium perfringens* *Enterococcus faecalis* *Klebsiella pneumoniae* *Lactobacillus acidophilus* *Listeria monocytogenes* *Propionibacterium granulosum* *Pseudomonas aeruginosa* *Serratia marcescens* and *Escherichia coli*, as compared to a no-template control (NTC). Real-time amplification results are shown in Table 5A (an asterisk denotes an outlier excluded from calculations of average and standard deviation (SD); “reaction” is abbreviate “rxn”).

[0096] Table 5A

Sample Name	T	End Point cycle 32)
Staphylococcus aureus Strain Mu3 10pg/rxn)	24.6	146298
	24.0	150759
	23.9	144630
	23.9	160607
Average	24.1	150573

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SD	0.3	7172
Staphylococcus aureus Strain 10pg/rxn)	24.6	140140
	24.7	149047
	24.8	143579
	24.9	141319
Average	24.7	143521
SD	0.1	3950
Staphylococcus epidermidis 10pg/rxn)	25.1	143624
	25.4	131812
	24.9	149217
	25.4	140835
Average	25.2	141372
SD	0.3	7264
Streptococcus agalactiae 10pg/rxn)	23.6	154101
	23.6	162176
	23.3	155802
	22.9	174359
Average	23.3	161610
SD	0.3	9183
Streptococcus pneumoniae 10pg/rxn)	20.2	231483
	24.8	150798
	24.7	143049
	24.9	143045
Average	23.7	167094
SD	2.3	43082
Streptococcus pyogenes 10pg)	24.5	146391
	24.7	142812
	24.6	152659
	25.0	150118
Average	24.7	147995
SD	0.2	4309
Citrobacter koseri 100pg/rxn)	21.5	180338
	21.2	174188
	21.2	173076
	32 *	36959
Average	21.3	175868
SD	0.2	3911
Clostridium perfringens 100pg/rxn)	20.5	223840
	20.2	214568
	20.5	197004
	20.3	208528
Average	20.4	210985
SD	0.2	11249
Enterococcus faecalis	21.6	191301

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100pg/rxn)	21.6	187678
	21.7	197721
	21.8	193930
Average	21.7	192658
SD	0.1	4238
Klebsiella pneumoniae 100pg/rxn)	22.0	170031
	22.0	179388
	22.0	175661
	22.0	175162
Average	22.0	175060
SD	0.0	3847
Lactobacillus acidophilus 100pg/rxn)	20.9	191479
	22.8	157107
	21.0	181977
	21.0	176702
Average	21.4	176816
SD	0.9	14492
Listeria monocytogenes 100pg/rxn)	20.6	204487
	20.7	190711
	20.6	194739
	21.2	202970
Average	20.8	198227
SD	0.3	6592
Propionibacterium granulosum 100pg/rxn)	28.0	89600
	27.6	101429
	27.6	97531
	27.5	93514
Average	27.7	95519
SD	0.2	5100
Pseudomonas aeruginosa 100pg/rxn)	21.1	194285
	21.0	186576
	21.0	184570
	21.1	177176
Average	21.1	185652
SD	0.1	7033
Serratia marcescens 100pg/rxn)	21.1	193938
	21.0	173987
	21.1	195749
	21.4	188730
Average	21.1	188101
SD	0.2	9868
Escherichia coli 100pg/rxn)	21.5	167341
	21.4	190853
	21.4	194130

	21.5	172951
Average	21.4	181319
SD	0.1	13171
NTC	32.0	39254
	32.0	36797
	32.0	37280
	32.0	38202
Average	32.0	37883
SD	0.0	1084

[0097] Similar reactions were prepared to test amplification of DNA from *B. cereus* as template (100pg), with separate reactions for *E. coli* template (100pg) and no-template control for comparison. Real-time amplification results are shown in Table 5B.

[0098] Table 5B

Sample Name	T	End Point cycle 32)
B. cereus 100pg/rxn)	22.0	97954
	21.9	92258
	21.9	95435
	21.8	97702
	22.0	98468
	21.9	97108
Average	21.9	96488
SD	0.1	2321
E.coli 100pg/rxn)	26.3	61129
	26.3	58532
Average	26.3	59830
SD	0.0	1836
NTC	32.0	16770
	32.0	18341
	32.0	14549
Average	32.0	16445
SD	0.0	2681

Example 2: Comparison of probe and primer sets

[0099] Real-time PCR reactions were prepared as in Example 1 for 100pg of *Staphylococcus aureus*, 100pg of *E. Coli*, or a no template control (NTC), using one of three primer sets and corresponding probe(s) as indicated below. Primer set 1 consisted of a forward primer having sequence SEQ ID NO: 4 and two reverse primers, one having sequence SEQ ID NO: 5 and the other having sequence SEQ

ID NO: 6. Amplification products of primer set 1 were detected with a mixture of three probes having sequences of SEQ ID NO: 11-13, each of which was detected independently based on association with a different reporter. Primer set 1 probes were designed to collectively detect a broad range of bacteria. SEQ ID NO: 12, for example, was designed to detect species other than *S. aureus* and *E. coli*. Final reagent concentrations for each primer set 1 amplification reaction were as follows: 1X Taqman Universal Master Mix II; 500nM of each primer; and 500nm of each probe. Primer set 2 consisted of a primer having sequence SEQ ID NO: 7 and a primer having sequence SEQ ID NO: 8. Amplification products of primer set 2 were detected with a mixture of two probes having sequences SEQ ID NO: 14-15, each of which was detected independently based on association with a different reporter. Primer set 2 probes were designed to collectively detect a broad range of bacteria, with SEQ ID NO: 14 designed to detect multiple Gram-negative bacteria (though not exclusively), and SEQ ID NO: 15 designed to detect multiple Gram-positive bacteria (though exclusively). Final reagent concentrations for each primer set 2 amplification reaction were as follows: 1X Taqman Universal Master Mix II; 500nM of each primer; and 500nm of each probe. Primer set 3 consisted of a primer pair as detailed in Example 1, the amplification products of which were detected with a probe having sequence SEQ ID NO: 16. The primer set 3 probe was designed to detect multiple bacteria. Final reagent concentrations for each primer set 3 amplification reaction were as follows: 1X Taqman Universal Master Mix II; 500nM of each primer; 500nm of the probe. PCR amplifications were performed according to TaqMan kit manufacturer recommendations (Life Technologies—Applied Biosystems, Carlsbad, CA). Each amplification was performed in duplicate for each template, and the C_T of each (C_T 1 and C_T 2) are provided in Table 6. As indicated by Table 6, multiple probes produced results similar to those obtained for the probe-primer set described in Example 1. Results for probe SEQ ID NO: 12 were as expected based on the sequences for which it was designed. Results for SEQ ID NO: 14-15 were as expected based on the sequences for which they were designed. For example, SEQ ID NO: 14 produced an early C_T for *E. coli*, a Gram-negative bacteria. Also, SEQ ID NO: 15 produced the earliest C_T for *S. aureus*, a Gram-positive bacteria, while also able to detect *E. coli*, though with a later C_T .

[00100] Table 6

Probe	Template	Reporter	C_T 1	C_T 2	C_T Mean	C_T SD
SEQ ID NO: 11	NTC	FAM	32.3	35.9	34.1	2.6
	<i>S. aureus</i>	FAM	24.0	24.1	24.1	0.1
	<i>E. coli</i>	FAM	24.2	24.1	24.2	0.0
SEQ ID NO: 12	NTC	JOE	36.0	40.0	36.0	2.8
	<i>S. aureus</i>	JOE	40.0	40.0	40.0	0.0
	<i>E. coli</i>	JOE	40.0	25.3	32.6	10.4
SEQ ID NO: 13	NTC	TAMARA	33.3	37.0	35.2	2.6
	<i>S. aureus</i>	TAMARA	25.1	25.2	25.2	0.1

	E. coli	TAMARA	25.7	40.0	25.5	10.1
SEQ ID NO: 14	NTC	FAM	35.5	36.0	35.7	0.3
	S. aureus	FAM	40.0	40.0	40.0	0.0
	E. coli	FAM	23.2	23.2	23.2	0.0
SEQ ID NO: 15	NTC	JOE	36.1	34.1	35.1	1.4
	S. aureus	JOE	23.5	23.5	23.5	0.0
	E. coli	JOE	25.8	26.0	25.9	0.1
SEQ ID NO:16	NTC	FAM	37.1	36.9	37.0	0.1
	S. aureus	FAM	22.4	22.4	22.4	0.0
	E. coli	FAM	22.3	22.2	22.3	0.1

Example 3: Simulated platelet samples—no signal from human DNA

[00101] DNA extracted from a patient sample, such as a platelet sample, will typically include human genomic DNA. Accordingly, a sample set of primers and a probe were tested in an amplification reaction in the presence of human genomic DNA. Real-time PCR reactions were prepared as in Example 1, including the same primers and probe. However, instead of bacterial DNA, amplification reactions included 10ng of human genomic DNA, or water as the no-template control, both in duplicate. A graphical display of the results of real-time PCR amplification for the human DNA and the no-template control are shown in Figs. 3A and 3B, respectively. No amplification signal was obtained for the human DNA samples until around cycle 39 (FAM), indicating that the primers and probe are specific to bacterial sequences and would specifically amplify those sequences in a mixed sample containing human DNA. Moreover, the end-point signal intensity for the human DNA sample was actually lower than that of the no-template control, suggesting that human DNA in a sample may actually reduce formation of potentially non-specific amplification products at late cycles.

Example 4: Probe set comparison

[00102] Examples 1-3 demonstrate the specificity and sensitivity of bacterial polynucleotide detection of primers and probes in accordance with the disclosure. In this example, the sensitivity of the primers and probes described in Example 1 (collectively, “Set 3”) were compared to primers and probes described by Liu et al. (Chin. J. Blood Transfusion, September 2008, vol. 21, No. 9) and Nadkarni et al. (Microbiology (2002), 148, 257–266). Liu and Nadkarni describe use of primers having sequences SEQ ID NO: 17 (TCCTACGGGAGGCAGCAGT) and SEQ ID NO: 18 (GGACTACCAGGGTATCTAATCCTGTT) to amplify a 466bp region of bacterial 16S rRNA detected with a probe having sequence SEQ ID NO: 19 (CGTATTACCGCGGCTGCTGGCAC), collectively the “Liu Set.” Nadkarni describes the manual selection of this large amplicon due to an inability to identify an amplicon having corresponding primer and probe target sequences sufficiently conserved across multiple bacteria. In a first comparison, detection efficiency is compared for real-

time PCR amplification of 100pg of *Staphylococcus aureus*, 100pg of *E. Coli*, or a no template control (NTC). The results for amplification and detection of 100pg of *Staphylococcus aureus* are illustrated graphically in Fig. 4A, with results for Set 3 on the top and the Liu Set on the bottom. The results for amplification and detection of 100pg of *E. Coli* are illustrated graphically in Fig. 4B, with results for Set 3 on the top and the Liu Set on the bottom. The figures illustrate that detection using Set 3 is consistent and robust. Detection of even 100pg with the Liu Set is weaker, occurs at a later C_T .

[00103] A second comparison repeated the above conditions for comparison of Set 3 to the Liu Set using a lower amount of target DNA. In this second comparison, only 10pg of *E coli* DNA were included in the reactions, which were run alongside no-template control reactions. Each reaction condition was run in duplicate. Real-time amplification results are shown in Table 7.

[00104] Table 7

Primer/Probe	Sample	C_T	End Point at 40 cycles)
Set 3	10 pg E coli	28.6	93763
Set 3	10 pg E coli	28.6	94028
Set 3	NTC	35.9	55749
Set 3	NTC	35.3	57366
Liu Set	10 pg E coli	35.9	57975
Liu Set	10 pg E coli	34.9	60091
Liu Set	NTC	40.0	51938
Liu Set	NTC	40.0	52522

[00105] The results in Table 7 second comparison illustrate that the Liu Set is not sufficiently sensitive to distinguish 10pg of bacterial DNA from a no-template control, and is therefore inadequate for detecting contamination at such a low level. In contrast, the C_T for 10pg of DNA using Set 3 is about seven cycles earlier than that of the no-template control, indicating a substantially increased sensitivity for bacterial DNA. Without wishing to be bound by theory, it is possible that the shorter amplicon (about 143bp for Set 3, corresponding to SEQ ID NO: 3; compared to about 466bp for the Liu Set) and/or lower variability within the amplicon for Set 3 improved sensitivity of the assay. Other potentially contributing factors to the lower sensitivity of the Liu Set include relatively stable homodimerization of SEQ ID NO: 17 primer (Fig. 6A), and hybridization between this primer and the SEQ ID NO: 19 probe (Fig. 6B). To evaluate primer-primer, and primer-probe hybridization, dimer formation was tested using OligoAnalyzer 3.1 (www.idtdna.com/analyzer/Applications/OligoAnalyzer/), using default settings (target type—DNA; oligo concentration—0.25 μ M; Na⁺ conc.—50mM; Mg⁺⁺ conc.—0mM; dNTPs conc.—0mM). Given the results of Nadkarni, it was both surprising and unexpected that primers and probes to a 16S rRNA

target sequence could provide such sensitivity and specificity across multiple bacterial species and genera.

Example 4: Effects of different quenchers

[00106] Because the reaction conditions used in Example 4 and those used in Liu were comparable, possible effects from the use of different quenchers was tested. The Set 3 probe in Example 3 used a ZenTM internal quencher (Integrated DNA Technologies, Inc.; Coralville, IA), while the Liu Set probe used a 3'-terminal Iowa Black^R quencher (Integrated DNA Technologies, Inc.; Coralville, IA), the original position used by Liu et al. To test the effect of different quenchers, real-time PCR reactions were prepared as in Example 1 using Set 3 primers and the corresponding FAM-labeled probe with either the Zen quencher or the 3'-terminal Iowa Black quencher. These primer-probe combinations were tested for detection of a range of amounts of *E. coli* DNA, as indicated below. A reaction for each template was prepared in duplicate. Real-time amplification results are shown in Table 8. As shown by the comparable results across quenchers, the difference in quencher used does not account for the difference in sensitivity.

[00107] Table 8

Sample	IowaBlack quencher		Zen quencher	
	C _T	End Point at c40)	C _T	End Point at c40)
NTC	34.2	98878	35.6	60455
	37.8	104367	35.7	56212
Human 10ng	33.6	145891	35.9	42360
	36.9	118112	35.0	41708
E. coli 0.1pg	31.7	127209	30.7	92871
	31.6	149883	40.0	-1234
E. coli 1pg	27.5	91051	27.3	102092
	28.8	115428	27.1	105463
E. coli 10pg	24.8	199150	24.0	128770
	24.7	206550	23.9	130361
E. coli 100pg	21.0	206526	20.3	134254
	21.1	204175	20.3	136525
E. coli 1ng	17.5	194156	17.0	149226
	17.4	211131	16.9	147917
E.coli 10ng	13.8	204532	13.3	133282
	13.9	193499	13.8	88670

Example 5: Detecting *S. Simulans* in platelet samples

[00108] *Staphylococcus simulans* were cultured in ATCC Nutrient Broth at 37°C overnight. Cultures were diluted with pure water and plated on nutrient agar plates, and live colonies were counted after

37°C incubation overnight in order to determine the concentration of colony forming units (cfu). An *S. simulans* culture was titrated and normalized into 5µL of pure water to produce 5µL samples having 100000, 10000, 1000, 100, 50, 25, or 0 cfu. The 0 cfu sample was water only, and used as a negative control. Each of these 5µL bacterial samples was then added to 195µL of salvaged human platelets, collected by apheresis six days earlier. The effective cfu/mL for these was 500000, 50000, 5000, 500, 250, 125, and 0, respectively. DNA was extracted from the 200µL samples using GeneJET Genomic DNA Purification Kit (Thermo Scientific), with DNA eluted into 45µL elution buffer. 30-cycle, real-time PCR reactions were prepared and run in triplicate using the probes and primers as in Example 1, and approximately 14µL of each elution, such that the number of cfu per reaction was about 31250, 3125, 312.5, 31.3, 15.6, 7.6, and 0, respectively. Reactions also contained GoTaq MDx Hot Start Polymerase (Promega), and performed using a Step One Plus real time PCR machine (Life Technologies). A graph of resulting amplification curves is provided in Fig. 7A, with each square along the x-axis representing two cycles. The groups of curves from left to right correspond to 31250, 31250, 3125, 312.5, 31.3, and 15.6, with 7.6 and 0 at the far right. The limit of detection for this experiment was thus at least down to 15.6 cfu, with an average C_T of about 26.9. Fig. 7A graphically illustrates the quantitative linearity under these conditions. Separate amplification curves for 31250, 31250, 3125, 312.5, 31.3, 15.6, 7.6, and 0 cfu per reaction are illustrated in Figs. 8A-G, respectively. Real-time amplification results are also summarized in Table 9. The results for *S. simulans* titrations were similar to those obtained in the above examples using DNA spike-in procedures. PCR amplification efficiency was high, and no non-specific amplification results were observed.

[00109] Table 9

CFU/PCR rxn	Ct	Endpoint at c30)
31250.0	16.66	484371
31250.0	16.54	461482
31250.0	16.66	462721
Average	16.62	
SD	0.07	
3125.0	18.97	413503
3125.0	18.95	410119
3125.0	18.95	424044
Average	18.96	
SD	0.01	
312.5	23.05	270307
312.5	22.97	308094
312.5	22.97	329002
Average	23.00	
SD	0.05	
31.3	25.80	209835
31.3	25.75	223255
31.3	25.97	207997

Average	25.84	
SD	0.12	
15.6	27.04	200854
15.6	26.97	222568
15.6	26.96	200467
Average	26.99	
SD	0.04	
7.6	30.00	131392
7.6	30.00	144039
7.6	30.00	154508
Average	30.00	
SD	0.00	
Platelet only Control		
0.0	30.00	102501
0.0	30.00	102101
0.0	30.00	105075
Average	30.00	
SD	0.00	

Example 6: Detecting multiple different live bacteria in platelet samples

[00110] Bacterial samples were prepared for the 18 bacterial species listed in Table 10, and combined with salvaged platelets, as in Example 5. For samples containing bacteria 1-12 in Table 10, and for 12 platelet-only samples, DNA was extracted using a Maxwell 16 MDx Instrument (Promega) and Maxwell 16 LEV Blood DNA kit (Promega). For samples containing bacteria 13-18 in Table 10, and for 6 platelet-only samples, DNA was manually extracted using GeneJET Genomic DNA Purification Kit (Thermo Scientific). 30-cycle, real-time PCR reactions were prepared in triplicate, and run as in Example 5 (using probes and primers as in Example 1). Results, including the number of cfu per reaction, are provided in Table 11. 72 platelet samples in all were tested. For all samples containing bacteria, a positive signal was detected, while no positive signal was detected for the platelet-only controls. Thus, the assay was 100% sensitive and 100% specific under these complex-mixture conditions.

[00111] Table 10

	Bacteria	Vendor	Item Number
1	Listeria monocytogenes	ATCC	ATCC 19115
2	Enterococcus faecalis	ATCC	ATCC 19433
3	Staphylococcus aureus Mu50	ATCC	ATCC 700699
4	Citrobacter koseri	ATCC	ATCC BAA-895
5	Klebsiella pneumoniae	ATCC	ATCC 700603
6	Pseudomonas aeruginosa	ATCC	ATCC 10145
7	Escherichia coli	ATCC	ATCC 700928

8	<i>Streptococcus pyogenes</i>	ATCC	ATCC 49399
9	<i>Streptococcus pneumoniae</i>	ATCC	ATCC 6301
10	<i>Streptococcus agalactiae</i>	ATCC	ATCC BAA-611
11	<i>Yersinia enterocolitica</i>	ATCC	ATCC 23715
12	<i>Staphylococcus epidermidis</i>	ATCC	ATCC 12228
13	<i>Staphylococcus simulans</i>	ATCC	ATCC 11631
14	<i>Micrococcus luteus</i>	ATCC	ATCC 4698
15	<i>Enterobacter aerogenes</i>	ATCC	ATCC 13048
16	<i>Bacillus cereus</i>	ATCC	ATCC 14893
17	<i>Serratia marcescens</i>	ATCC	ATCC 8100
18	<i>Lactobacillus acidophilus</i>	ATCC	ATCC 4356

[00112] Table 11

Sample	cfu/PCR rxn	Ct	Endpoint cycle 30
Platelets only	0.0	30.0	162459
Platelets only	0.0	30.0	156179
Platelets only	0.0	30.0	158632
Platelets only	0.0	30.0	169799
Platelets only	0.0	30.0	164256
Platelets only	0.0	30.0	176073
Average		30.0	
SD		0.0	
<i>Listeria monocytogenes</i>	40,000	26.1	299936
<i>Listeria monocytogenes</i>	40,000	26.0	326216
<i>Listeria monocytogenes</i>	40,000	26.2	288790
Average		26.1	
SD		0.1	
<i>Enterococcus faecalis</i>	40,000	21.4	489164
<i>Enterococcus faecalis</i>	40,000	21.4	583293
<i>Enterococcus faecalis</i>	40,000	21.3	556506
Average		21.3	
SD		0.1	
<i>Staphylococcus aureus</i>	40,000	23.7	394106
<i>Staphylococcus aureus</i>	40,000	23.1	412728
<i>Staphylococcus aureus</i>	40,000	23.1	428943
Average		23.3	
SD		0.4	
<i>Citrobacter koseri</i>	40,000	22.0	504943
<i>Citrobacter koseri</i>	40,000	22.2	475522
<i>Citrobacter koseri</i>	40,000	22.0	503508
Average		22.0	
SD		0.1	
<i>Klebsiella pneumoniae</i>	40,000	22.4	494191

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Klebsiella pneumoniae	40,000	22.3	494349
Klebsiella pneumoniae	40,000	22.3	486965
Average		22.3	
SD		0.1	
Pseudomonas aeruginosa	40,000	24.8	352654
Pseudomonas aeruginosa	40,000	24.3	396813
Pseudomonas aeruginosa	40,000	24.2	383947
Average		24.5	
SD		0.3	
Escherichia coli	40,000	21.6	498716
Escherichia coli	40,000	21.4	589153
Escherichia coli	40,000	21.5	554276
Average		21.5	
SD		0.1	
Platelets only	0.0	30.0	167773
Platelets only	0.0	30.0	155873
Platelets only	0.0	30.0	157417
Platelets only	0.0	30.0	165834
Platelets only	0.0	30.0	168972
Platelets only	0.0	30.0	173085
Average		30.0	
SD		0.0	
Streptococcus pyogenes	40,000	14.4	762017
Streptococcus pyogenes	40,000	14.3	739994
Streptococcus pyogenes	40,000	14.4	671678
Average		14.4	
SD		0.0	
Streptococcus pneumoniae	40,000	14.6	711581
Streptococcus pneumoniae	40,000	14.6	785952
Streptococcus pneumoniae	40,000	14.5	740601
Average		14.6	
SD		0.0	
Streptococcus agalactiae	40,000	17.2	554329
Streptococcus agalactiae	40,000	17.0	606164
Streptococcus agalactiae	40,000	16.8	629203
Average		17.0	
SD		0.2	
Yersinia enterocolitica	40,000	20.3	445063
Yersinia enterocolitica	40,000	19.7	502767
Yersinia enterocolitica	40,000	20.3	480745
Average		20.1	
SD		0.4	
Staphylococcus epidermidis	40,000	20.0	533739
Staphylococcus epidermidis	40,000	20.0	473550
Staphylococcus epidermidis	40,000	19.6	454904
Average		19.9	
SD		0.2	
Platelets only	0	30.0	126143
Platelets only	0	30.0	94014
Platelets only	0	30.0	73297
Platelets only	0	30.0	141745
Platelets only	0	30.0	118017

Platelets only	0	30.0	77828
Average		30.0	
SD		0.0	
Staphylococcus simulans	3125	18.97	413503
Staphylococcus simulans	3125	18.95	410119
Staphylococcus simulans	3125	18.95	424044
Average		19.0	
SD		0.0	
Micrococcus luteus	25000	26.1	190927
Micrococcus luteus	25000	25.5	205158
Micrococcus luteus	25000	25.4	211896
Average		25.7	
SD		0.4	
Enterobacter aerogenes	2500	21.7	264655
Enterobacter aerogenes	2500	21.7	270156
Enterobacter aerogenes	2500	21.5	299383
Average		21.6	
SD		0.1	
Bacillus cereus	2500	12.9	464940
Bacillus cereus	2500	13.1	500024
Bacillus cereus	2500	12.8	493522
Average		12.9	
SD		0.1	
Serratia marcescens	2500	21.1	280877
Serratia marcescens	2500	21.1	275083
Serratia marcescens	2500	21.2	276654
Average		21.1	
SD		0.1	
Lactobacillus acidophilus	2500	23.1	254082
Lactobacillus acidophilus	2500	22.9	290639
Lactobacillus acidophilus	2500	23.1	289580
Average		23.1	
SD		0.1	

Example 7: Detecting contamination by live bacteria in whole blood and buffy coats

[00113] Salvaged whole blood and buffy coat samples were obtained from the Stanford Blood Center. Samples were spiked with either *E. coli* bacteria (as in Example 5) or with *E. coli* DNA. DNA was extracted from the spiked samples using the DNeasy Blood & Tissue Kit (Qiagen). 40-cycle, real-time PCR reactions were prepared and run in triplicate using the probes and primers as in Example 1, with either 10^4 cfu per reaction, or 10pg bacterial DNA per reaction. Real-time PCR was performed using a Step One Plus real time PCR machine (Life Technologies), as in Example 5 (using probes and primers as in Example 1). Results for spiked whole blood samples and spiked buffy coat samples are provided in Tables 12 and 13, respectively. The contamination was detected even at these low levels, indicating this method can be used for early detection of sepsis.

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Table 12

Sample Name	cfu/PCR rxn	C _T	Endpoint cycle 30
Whole blood with live E.coli	10	22.1	386844
Whole blood with live E.coli	10	22.3	430218
Whole blood with live E.coli	10	21.6	451450
Average		22.0	
SD		0.3	
Sample Name	pg/PCR rxn	C _T	Endpoint cycle 30
Whole blood with E.coli DNA	10pg	17.4	592123
Whole blood with E.coli DNA	10pg	17.5	577167
Whole blood with E.coli DNA	10pg	17.8	582917
Average		17.5	
SD		0.2	

Table 13

Sample Name	cfu/PCR rxn	C _T	Endpoint cycle 30
Buffy coat with live E.coli	10	24.1	320830
Buffy coat with live E.coli	10	23.0	362016
Buffy coat with live E.coli	10	22.8	380865
Average		23.3	
SD		0.7	
Sample Name	pg/PCR rxn	C _T	Endpoint cycle 30

Buffy coat with E.coli DNA	10pg	17.9	537282
Buffy coat with E.coli DNA	10pg	18.0	586124
Buffy coat with E.coli DNA	10pg	17.6	599668
Average		17.8	
SD		0.2	

Example 8: DNA titration and detection of *S. aureus* DNA in platelet samples

[00114] *Staphylococcus aureus* Mu3 genomic DNA was obtained from ATCC (item number 700698D-5). DNA was titrated and normalized into 5 μ L pure water to produce 5 μ L samples having 10000.0pg, 3333.3pg, 1111.1pg, 370.4pg, 123.5pg, or 0pg bacterial DNA. The 0pg sample was water only, and used as a negative control. Each of these 5 μ L bacterial DNA samples was then added to 200 μ L of salvaged human platelets, collected by apheresis 10 days earlier. The effective pg/mL for these samples was 48780.5, 16260.2, 5420.1, 1806.7, 602.2, and 0, respectively. DNA was extracted from these 205 μ L samples by an automated procedure using a Maxwell 16 MDx Instrument (Promega) and Maxwell 16 LEV Blood DNA kit (Promega). 30-cycle, real-time PCR reactions were prepared in triplicate (with 6 replicas for the negative control), and run as in Example 5 (using probes and primers as in Example 1). Each reaction contained 2 μ L of DNA extraction eluate (from 50 μ L total), representing approximately 400pg, 133.3pg, 44.4pg, 14.8pg, 4.9pg, and 0pg of starting DNA per reaction, respectively (assuming 100% efficient recovery). A graph of resulting amplification curves is provided in Fig. 9, with each square along the x-axis representing two cycles. The groups of curves from left to right correspond to reactions containing 400pg, 133.3pg, 44.4pg, 14.8pg, 4.9pg, and 0pg. Quantitative results are summarized in Table 14. Results obtained for bacterial DNA titration in platelet samples were similar to those obtained for dilution in buffer (such as in Example 1). Sensitivity of detection was high, with positive detection signal at a C_T of about 27.5 for a sample representing about 4.9pg of starting material or less. Specificity was also high, as no positive signal was detected for any of the 6 negative control samples. It is expected that automated extraction will minimize false positives arising from procedural contamination.

Table 14

Platelet Sample	DNA/PCR rxn pg)	C _T	Endpoint cycle 30
S. aureus DNA	400.0	21.9	342807
S. aureus DNA	400.0	21.7	387481

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S. aureus DNA	400.0	21.7	371539
Average		21.7	
SD		0.1	
S. aureus DNA	133.3	23.7	303528
S. aureus DNA	133.3	23.4	300532
S. aureus DNA	133.3	23.5	308639
Average		23.5	
SD		0.1	
S. aureus DNA	44.4	25.0	252438
S. aureus DNA	44.4	24.7	248917
S. aureus DNA	44.4	25.0	233241
Average		24.9	
SD		0.2	
S. aureus DNA	14.8	26.8	159733
S. aureus DNA	14.8	26.9	175803
S. aureus DNA	14.8	26.8	176431
Average		26.8	
SD		0.1	
S. aureus DNA	4.9	27.5	138280
S. aureus DNA	4.9	27.6	139288
S. aureus DNA	4.9	27.5	139297
Average		27.5	
SD		0.0	
Platelets Only	0.0	30.0	82160
Platelets only	0.0	30.0	101844
Platelets only	0.0	30.0	94452
Platelets only	0.0	30.0	84096
Platelets only	0.0	30.0	86270
Platelets only	0.0	30.0	101131
Average		30.0	
SD		0.0	

Example 9: Detection of bacterial contamination using subject primers and DNA-binding agent

[00115] Real-time PCR was conducted using a reaction mixture containing 250 pg of *S. aureus* Mu3 DNA (ATCC700698D-5), primer pairs of SEQ ID NOs. 51 and 52, and a DNA binding dye (e.g., SYBR[®] Green) along with other reagents provided in Fast SYBR[®] Green Master Mix (AB Applied Biosystems). Figure 10A depicts the real-time amplification plot showing exponential amplification of *S. aureus* DNA. The results represent triplet experiments. The resulting PRC reaction was then subject to melting curve analysis. Figure 10B depicts a single peak at the temperature expected to be indicative of specific amplification of *S. aureus* DNA. This experiment demonstrates that the subject primer pairs are amenable for a dye-based detection of amplified bacterial nucleic acid.

Example 10: Detection of many different types of bacterial strains using subject primers

[00116] Disclosed herein are a host of primer pairs capable of detecting any types of bacteria from 20 some bacterial strains that are commonly found as source of contamination in biological samples. In particular, all of the primers and probes described in Table 2 and Table 3 have been tested and shown to be able to specifically amplify one or more target bacterial sequences in Table 1 utilizing the methods disclosed herein or known in the art. In addition, Table 15 lists exemplary pairing of the sequences that have been tested and/or shown by sequence homology to be effective primers capable of specifically amplifying the listed bacterial strains using the methods disclosed in the above examples. In particular, primer set 3 containing two primers (SEQ ID NOs 9 and 10) has been tested and demonstrated to specifically amplify and hence detect in a single amplification reaction 20 some bacterial strains covering *Staphylococcus aureus* *Staphylococcus aureus* Mu3; *Staphylococcus epidermidis* *Streptococcus agalactiae* *Streptococcus pyogenes* *Streptococcus pneumonia* *Escherichia coli* *Citrobacter koseri* *Clostridium perfringens* *Enterococcus faecalis* *Klebsiella pneumonia* *Lactobacillus acidophilus* *Listeria monocytogenes* *Propionibacterium granulosum* *Pseudomonas aeruginosa* *Serratia marcescens* *Bacillus cereus* *Staphylococcus aureus* Mu50 *Yersinia enterocolitica* *Staphylococcus simulans* *Micrococcus luteus* and *Enterobacter aerogenes*.

[00117] The other SEQ ID NOs in this primer set (namely SEQ ID NOs. 47 and 48) are optional in that they are not required for amplifying the aforementioned bacterial strains in a single reaction. SEQ ID NO. 47 and/or SEQ ID No. 48 when used in the same reaction mixture with SEQ ID NOs. 9 and 10, is able to increase amplification sensitivity and enhance detection of *Propionibacterium sp.*

[00118] Similarly, primer sets 1- 2 and 4-25 each have been tested and/or shown by sequence homology to be able to amplify the listed bacterial strains. Primers noted “included” exhibit at least 85 , 90 or 95 sequence homology to a conserved region of the listed bacterial strains listed under the column “Bacterial Target Coverage.” Primers designated “optional” have been tested and/or predicted by sequence homology to provide more specific amplification of listed bacterial genome when used together with one or more of the “included” primers. “Optional” sequences typically exhibit at least 99 or 100 sequence homology with a target bacterial genome when optimally

aligned. This series of findings demonstrates the technical advantages of these primer sets as they are both specific and able to cover a wide range of bacterial strains commonly occurred in biological samples.

[00119] While preferred embodiments of the present invention have been shown and described herein, it will be obvious to those skilled in the art that such embodiments are provided by way of example only. Numerous variations, changes, and substitutions will now occur to those skilled in the art without departing from the invention. It should be understood that various alternatives to the embodiments of the invention described herein may be employed in practicing the invention. It is intended that the following claims define the scope of the invention and that methods and structures within the scope of these claims and their equivalents be covered thereby.

CLAIMS

WHAT IS CLAIMED IS:

1. A method of detecting bacterial contamination of a platelet sample by any of at least five bacterial genera, comprising:

(a) subjecting the platelet sample or a portion thereof to a nucleic acid amplification reaction under conditions to yield a detectable amount of an amplicon of no more than 300 bases in a single reaction mixture, said single reaction mixture comprising a single primer pair having a first primer and a second primer and a single detectable probe, wherein the first primer and the second primer each hybridizes to a separate conserved region of 16S rRNA polynucleotide, and the single primer pair flanks the amplicon, wherein the amplicon comprises a conserved sequence to which the single detectable probe hybridizes, and the separate conserved region is identical among the at least five bacterial genera, wherein:

(1) the first primer comprises at least 10 contiguous nucleotides of a sequence as set forth in SEQ ID NO: 4, or a complement thereof, and the second primer comprises at least 10 contiguous nucleotides of a sequence as set forth in SEQ ID NO: 5 or 6, or a complement thereof; or

(2) the first primer comprises at least 10 contiguous nucleotides of a sequence as set forth in SEQ ID NO: 7, or a complement thereof, and the second primer comprises at least 10 contiguous nucleotides of a sequence as set forth in SEQ ID NO: 8, or a complement thereof; or

(3) the first primer comprises at least 10 contiguous nucleotides of a sequence as set forth in SEQ ID NO: 9, or a complement thereof, and the second primer comprises at least 10 contiguous nucleotides of a sequence as set forth in SEQ ID NO: 10, or a complement thereof; and

(b) detecting hybridization to the amplicon by the single detectable probe, wherein the hybridization by the single detectable probe yields a detectable signal indicative of bacterial contamination of the platelet sample by the any of the at least five bacterial genera,

wherein the any of the at least five bacterial genera is *Staphylococcus*, *Streptococcus*, *Escherichia*, *Citrobacter*, *Clostridium*, *Enterococcus*, *Klebsiella*, *Lactobacillus*, *Listeria*, *Propionibacterium*, *Pseudomonas*, *Serratia*, *Bacillus*, *Yersinia*, *Micrococcus*, or *Enterobacter*.

2. The method of claim 1, wherein the platelet sample is a platelet concentrate isolated by aphaeresis.
3. The method of claim 2, wherein nucleic acids isolated from less than 5 mL of the platelet concentrate are subjected to the nucleic acid amplification reaction.
4. The method of claim 1, wherein the detecting of the bacterial contamination is completed prior to transfusion of the platelet sample into a recipient.
5. The method of claim 1, wherein the detectable signal has a linear range of detection across at least 5 logs.
6. The method of claim 5, further comprising determining an amount of bacterial contamination based on the detectable signal.
7. The method of claim 1, wherein the nucleic acid amplification reaction yields the detectable amount of the amplicon of 100-200 bases.
8. The method of claim 1, wherein the single detectable probe comprises at least 10 contiguous nucleotides of a sequence as set forth in Table 3, or a complement thereof.
9. The method of claim 1, wherein the nucleic acid amplification reaction contains less than 5 pg of starting nucleic acids from the bacterial contamination.
10. The method of claim 1, wherein the platelet sample or the portion thereof has not been cultured at a temperature above 35° C prior to amplification.
11. The method of claim 1, wherein (a) and (b) are completed within 24 hours after obtaining the

platelet sample.

12. The method of claim 1, wherein the nucleic acid amplification reaction yields the detectable amount of the amplicon of no more than 150 bases.

13. A method of detecting bacterial contamination of a platelet sample by any of at least five bacterial genera, comprising:

(a) subjecting the platelet sample or a portion thereof to a nucleic acid amplification reaction under conditions to yield a detectable amount of an amplicon of no more than 300 bases in a single reaction mixture, said single reaction mixture comprising a single primer pair and a single detectable probe, wherein the single primer pair flanks the amplicon, the amplicon comprises a conserved sequence to which the single detectable probe hybridizes, and the conserved sequence is identical among the at least five bacterial genera, and

(b) detecting hybridization to the amplicon by the single detectable probe, wherein the hybridization by the single detectable probe yields a detectable signal indicative of the bacterial contamination of the platelet sample by the any of the at least five bacterial genera,

wherein the single detectable probe comprises at least 10 contiguous nucleotides of a sequence as set forth in Table 3, or a complement thereof, and

wherein the any of the at least five bacterial genera is *Staphylococcus*, *Streptococcus*, *Escherichia*, *Citrobacter*, *Clostridium*, *Enterococcus*, *Klebsiella*, *Lactobacillus*, *Listeria*, *Propionibacterium*, *Pseudomonas*, *Serratia*, *Bacillus*, *Yersinia*, *Micrococcus*, or *Enterobacter*.

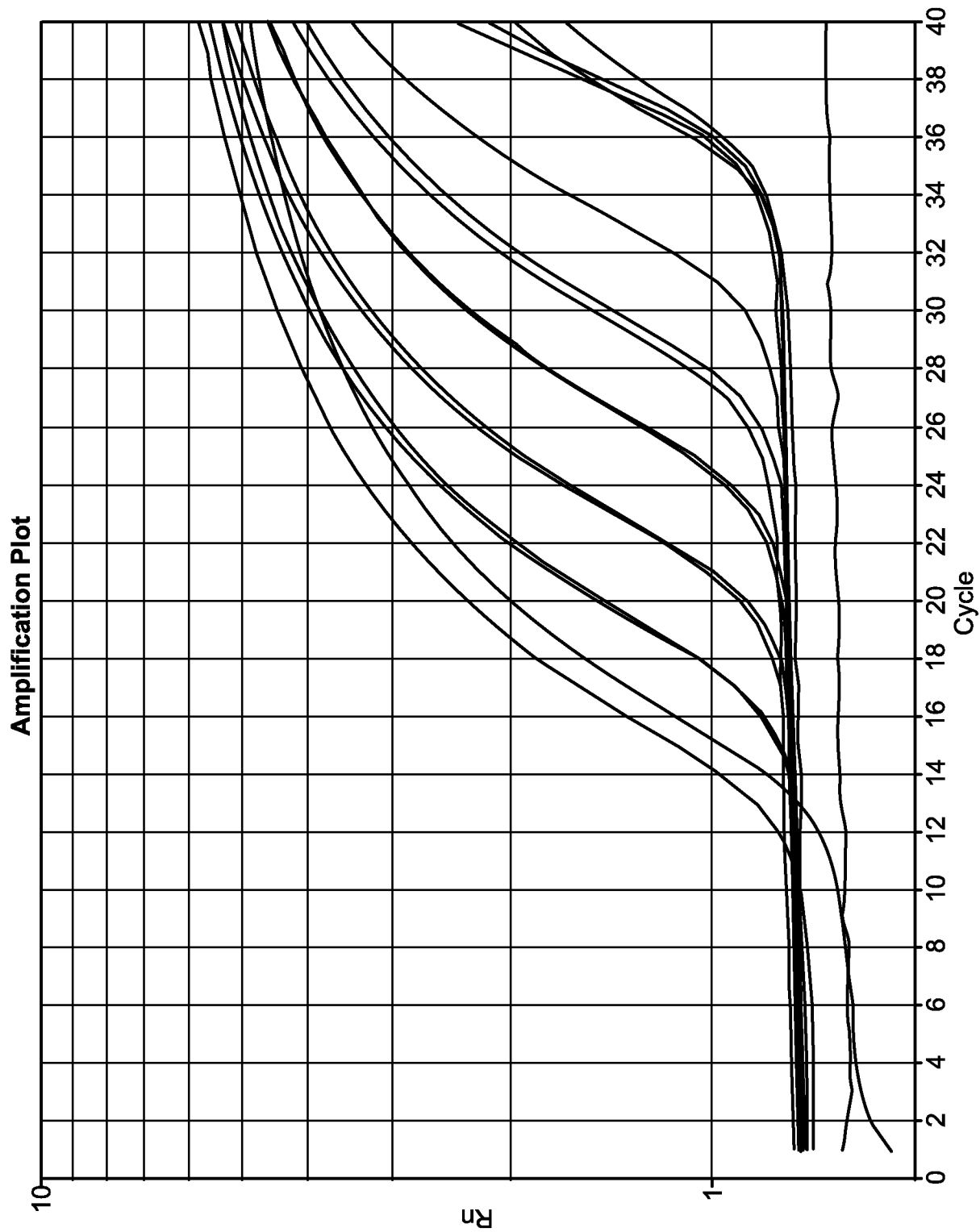
14. The method of claim 13, wherein the single primer pair comprises a first primer and a second primer, wherein the first primer and the second primer each hybridizes to a separate conserved region of 16S rRNA polynucleotide, wherein (1) the first primer comprises at least 10 contiguous nucleotides of a sequence as set forth in SEQ ID NO: 4, or a complement thereof, and the second primer comprises at least 10 contiguous nucleotides of a sequence as set forth in SEQ ID NO: 5 or 6, or a complement thereof; or (2) the first primer comprises at least 10 contiguous nucleotides of a sequence as set forth in SEQ ID NO: 7, or a complement thereof, and the second primer comprises at least 10 contiguous

nucleotides of a sequence as set forth in SEQ ID NO: 8, or a complement thereof; or (3) the first primer comprises at least 10 contiguous nucleotides of a sequence as set forth in SEQ ID NO: 9, or a complement thereof, and the second primer comprises at least 10 contiguous nucleotides of a sequence as set forth in SEQ ID NO: 10, or a complement thereof.

15. The method of claim 13, wherein the single detectable probe comprises at least 10 contiguous nucleotides of a sequence as set forth in SEQ ID NO: 11, 12, 13, 14, 15, 16, or a complement thereof.

16. The method of claim 13, wherein the nucleic acid amplification reaction yields the detectable amount of the amplicon of no more than 150 bases.

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**FIG. 1**

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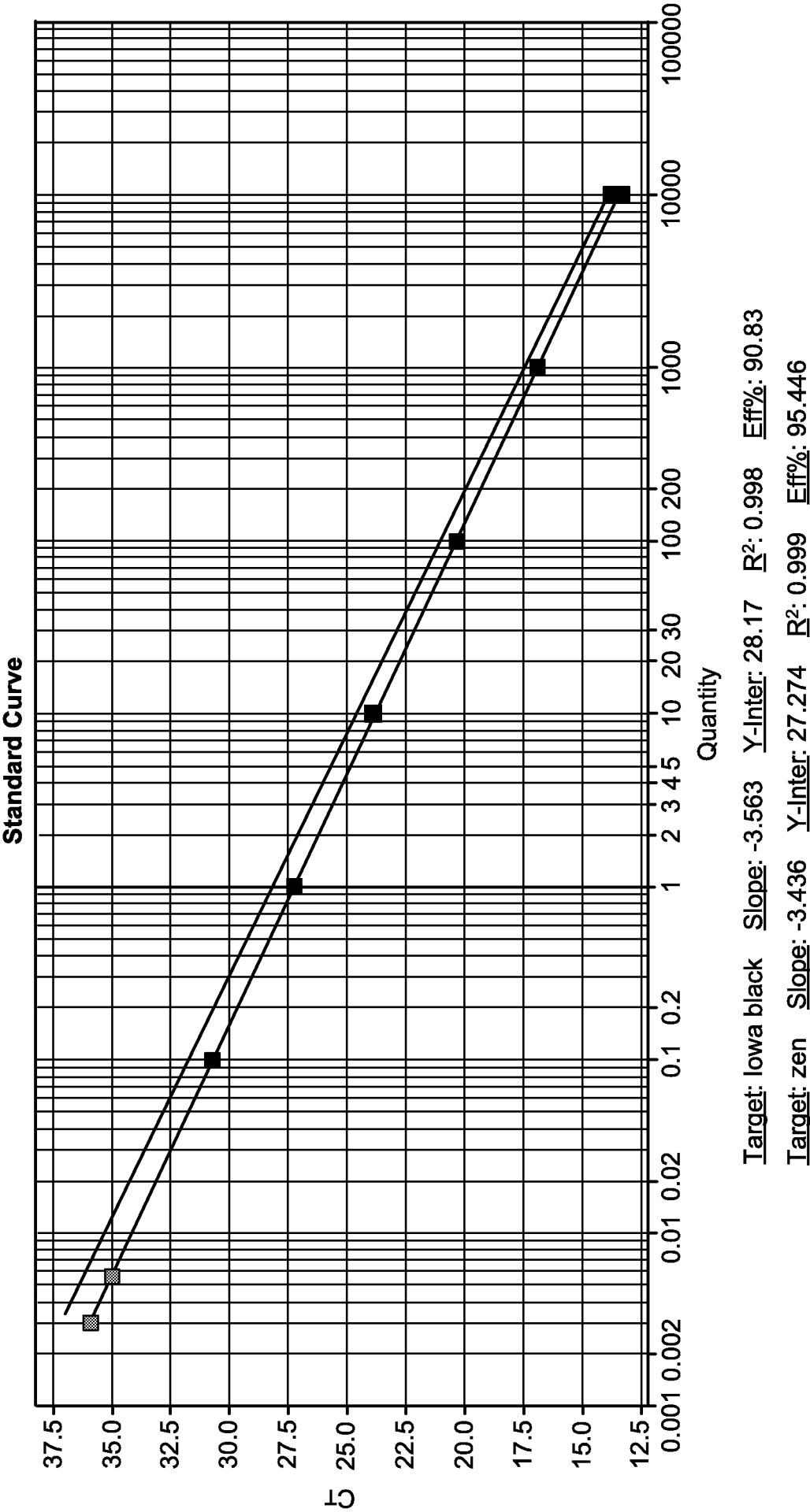


FIG. 2

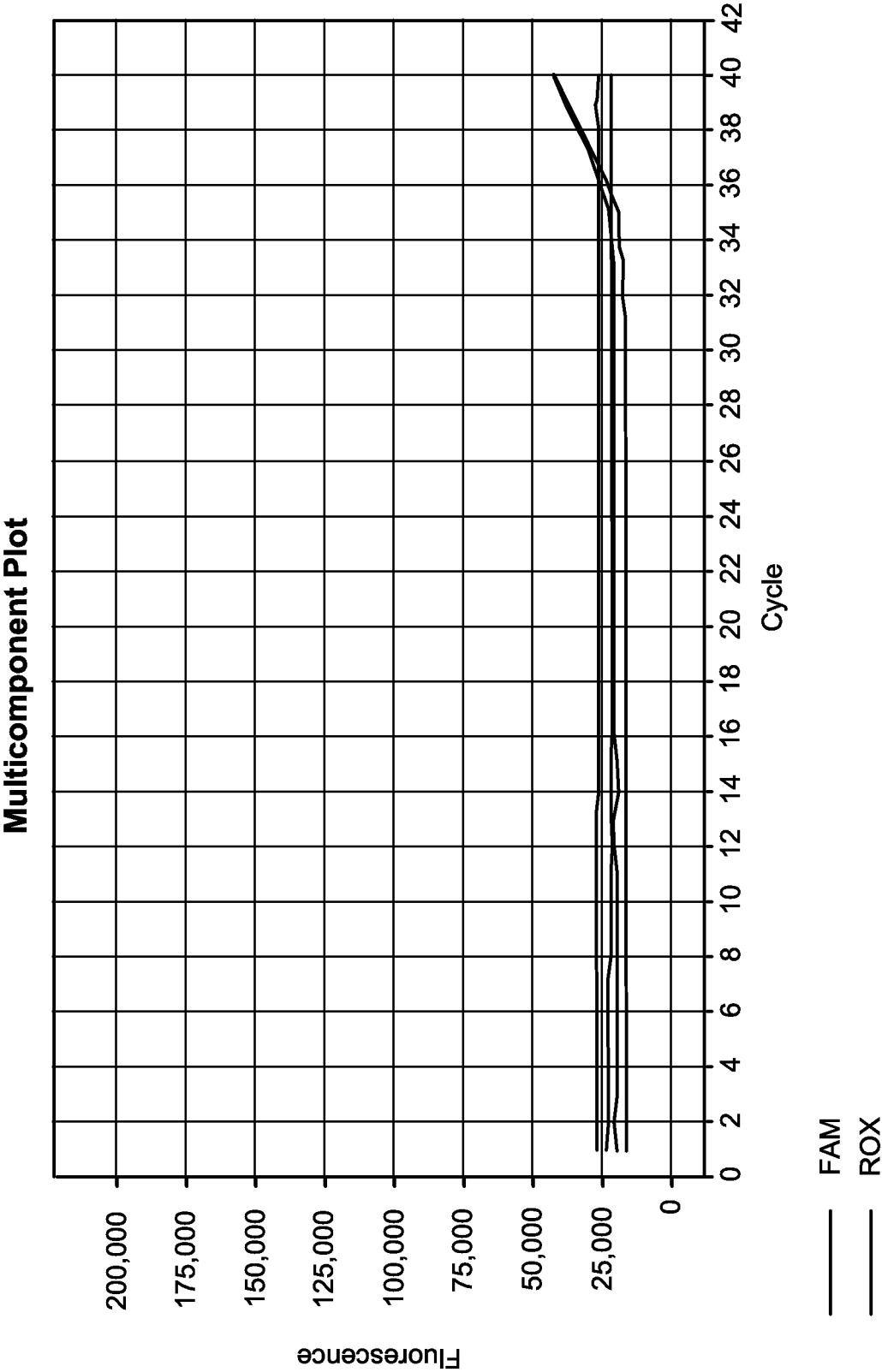
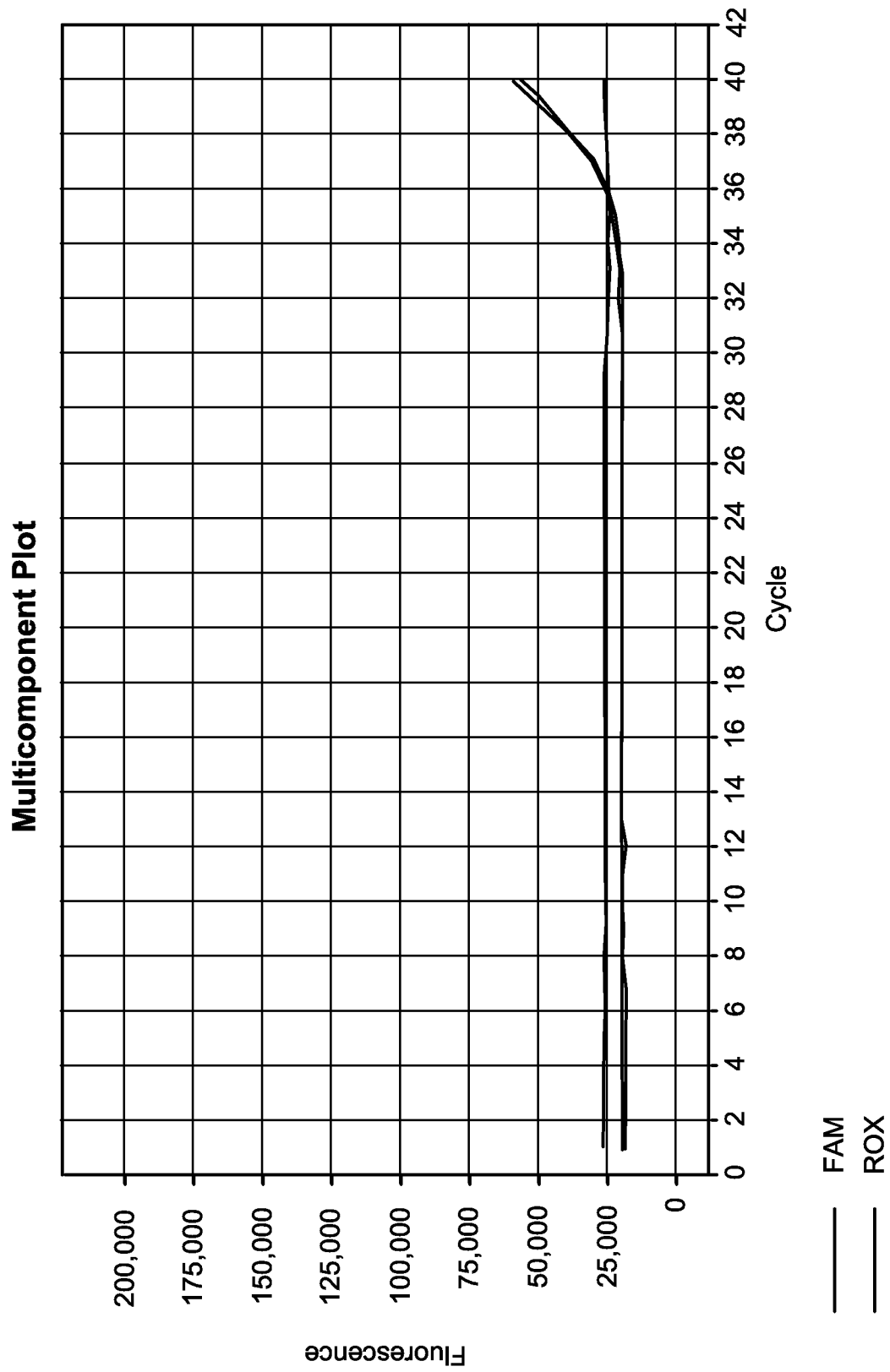
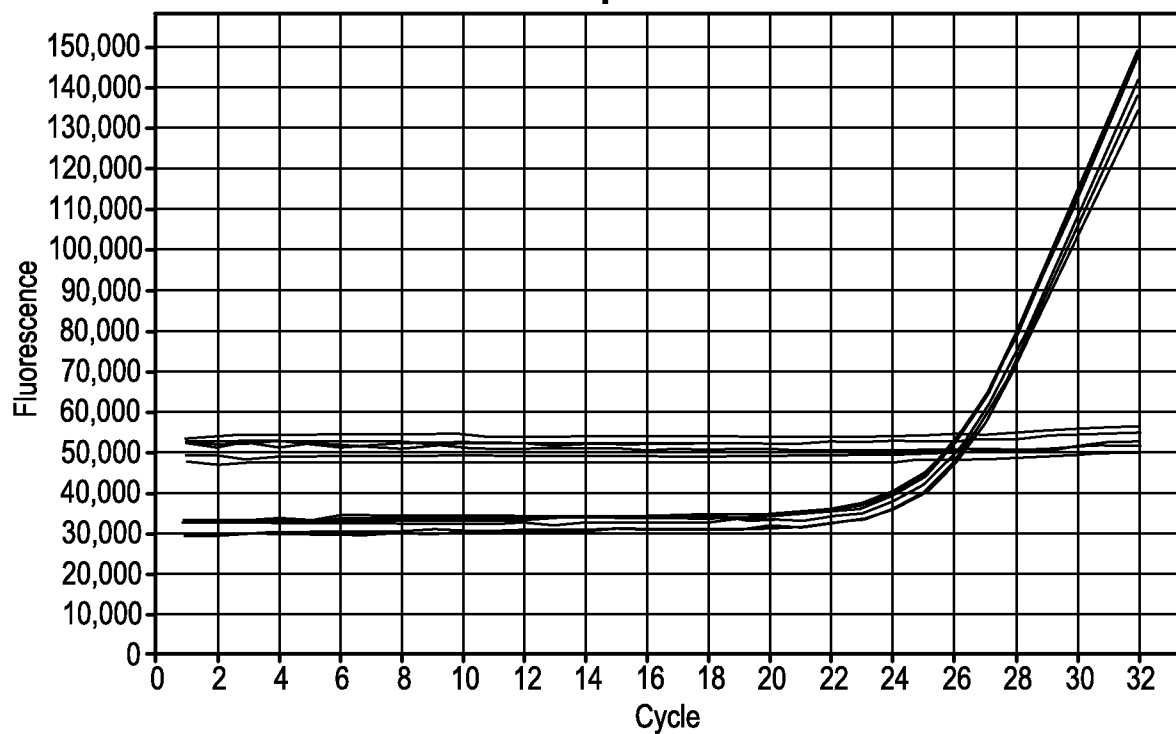


FIG. 3A

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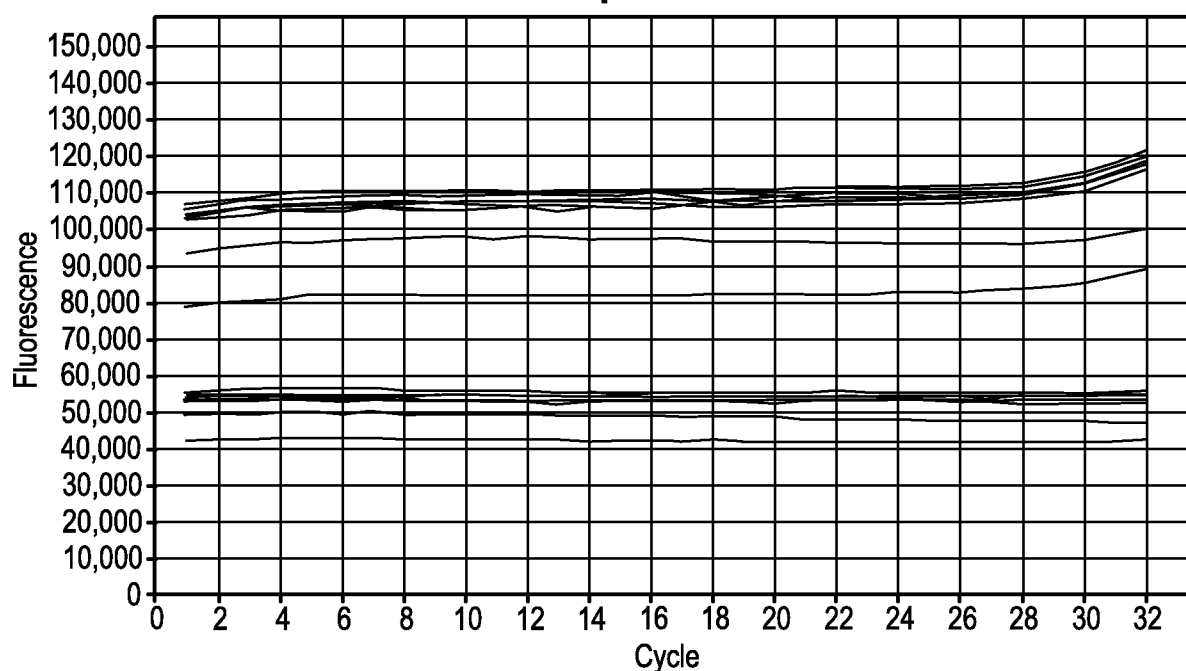
**FIG. 3B**

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Multicomponent Plot

— FAM
— ROX

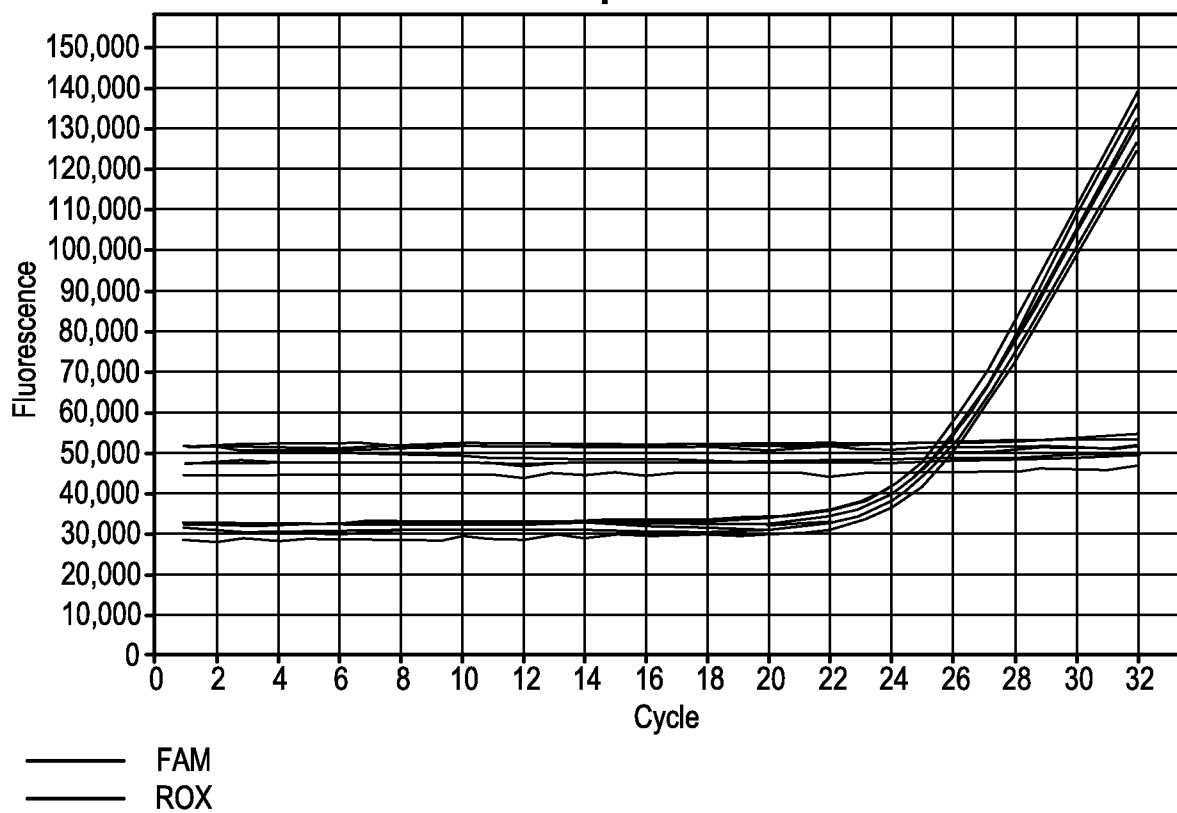
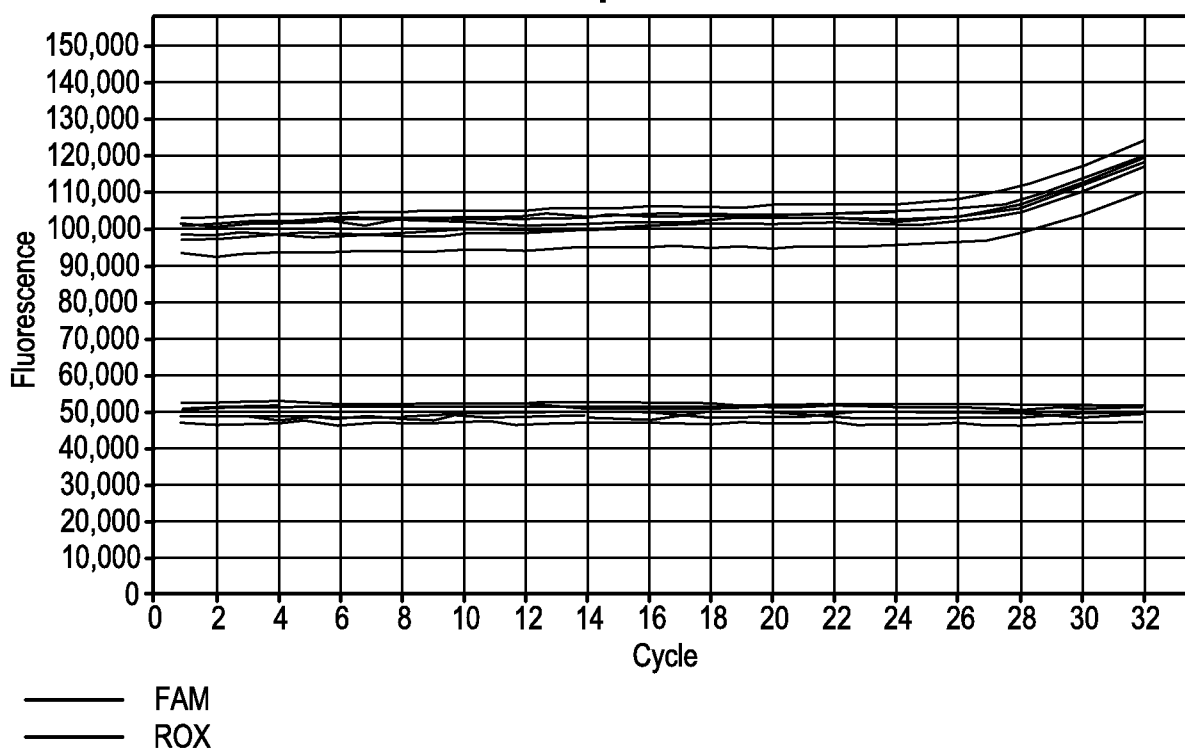
Analysis Summary: Total Wells in Plate: 96 Wells Set Up: 64 Wells Omitted Manually: 0

Multicomponent Plot

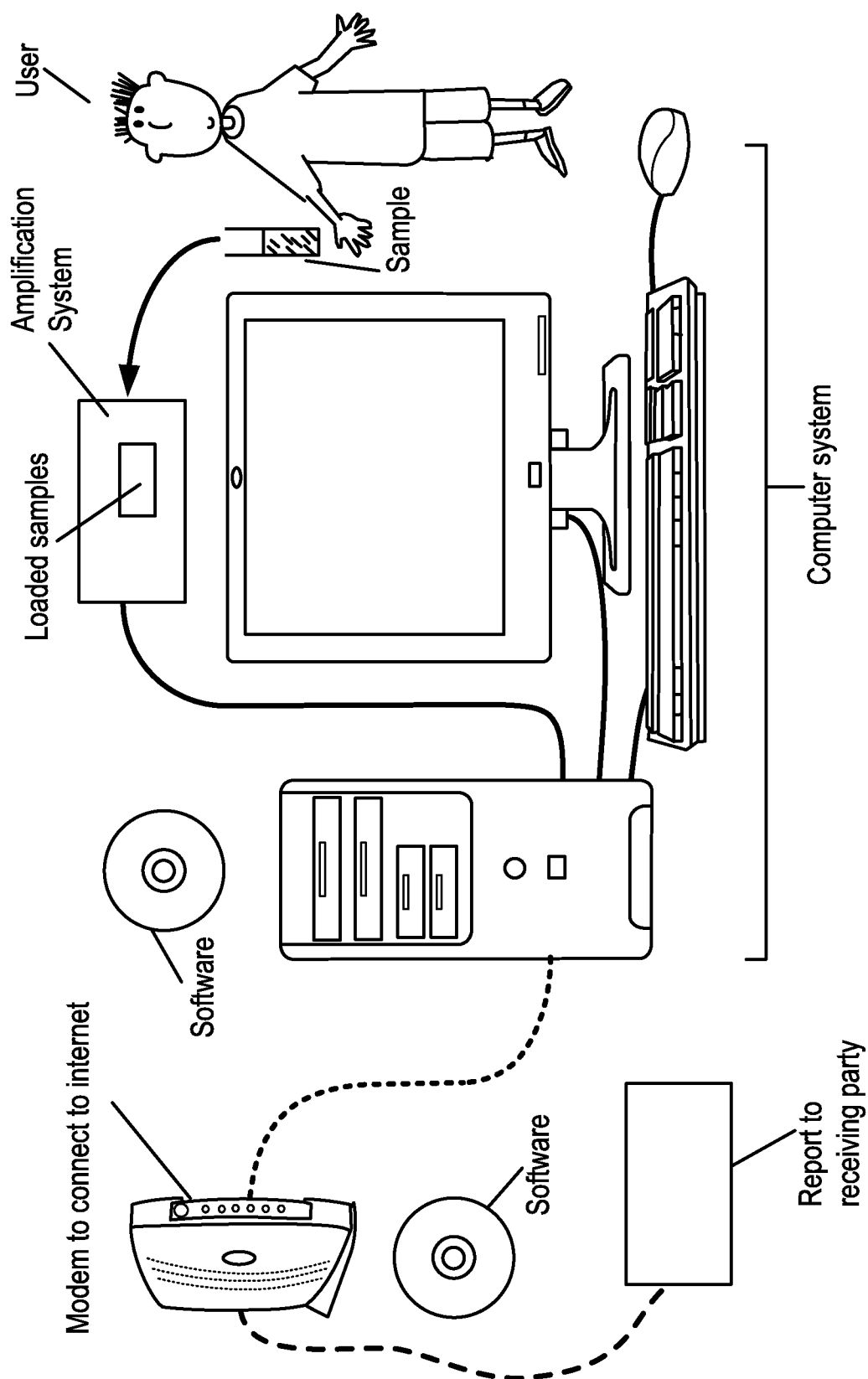
— FAM
— ROX

FIG. 4A

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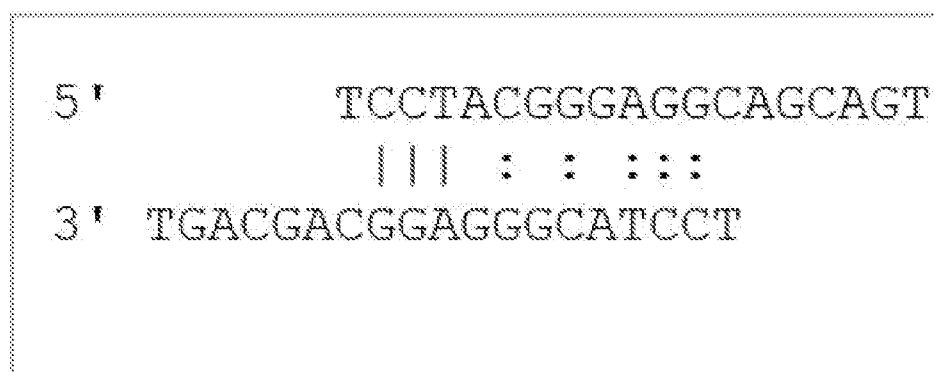
Multicomponent Plot**Multicomponent Plot****FIG. 4B**

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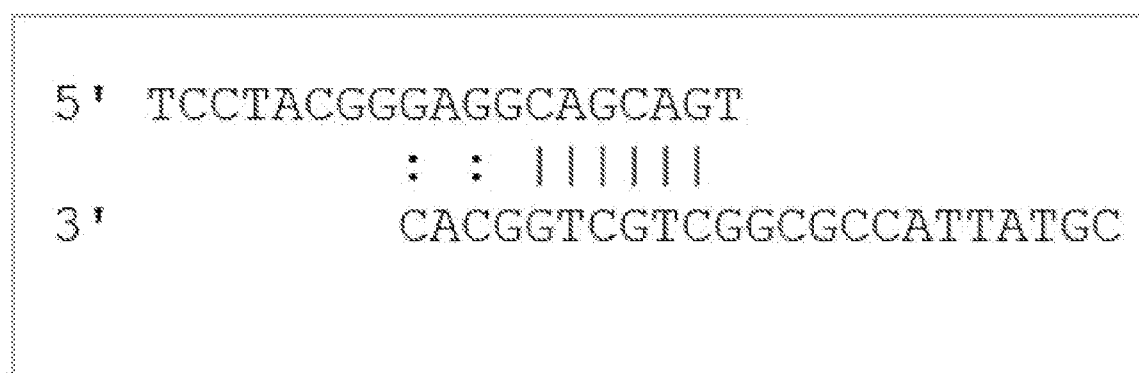
**FIG. 5**

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Delta G -4.67 kcal/mole
Base Pairs 3

**FIG 6A**

Delta G -10.24 kcal/mole
Base Pairs 6

**FIG 6B**

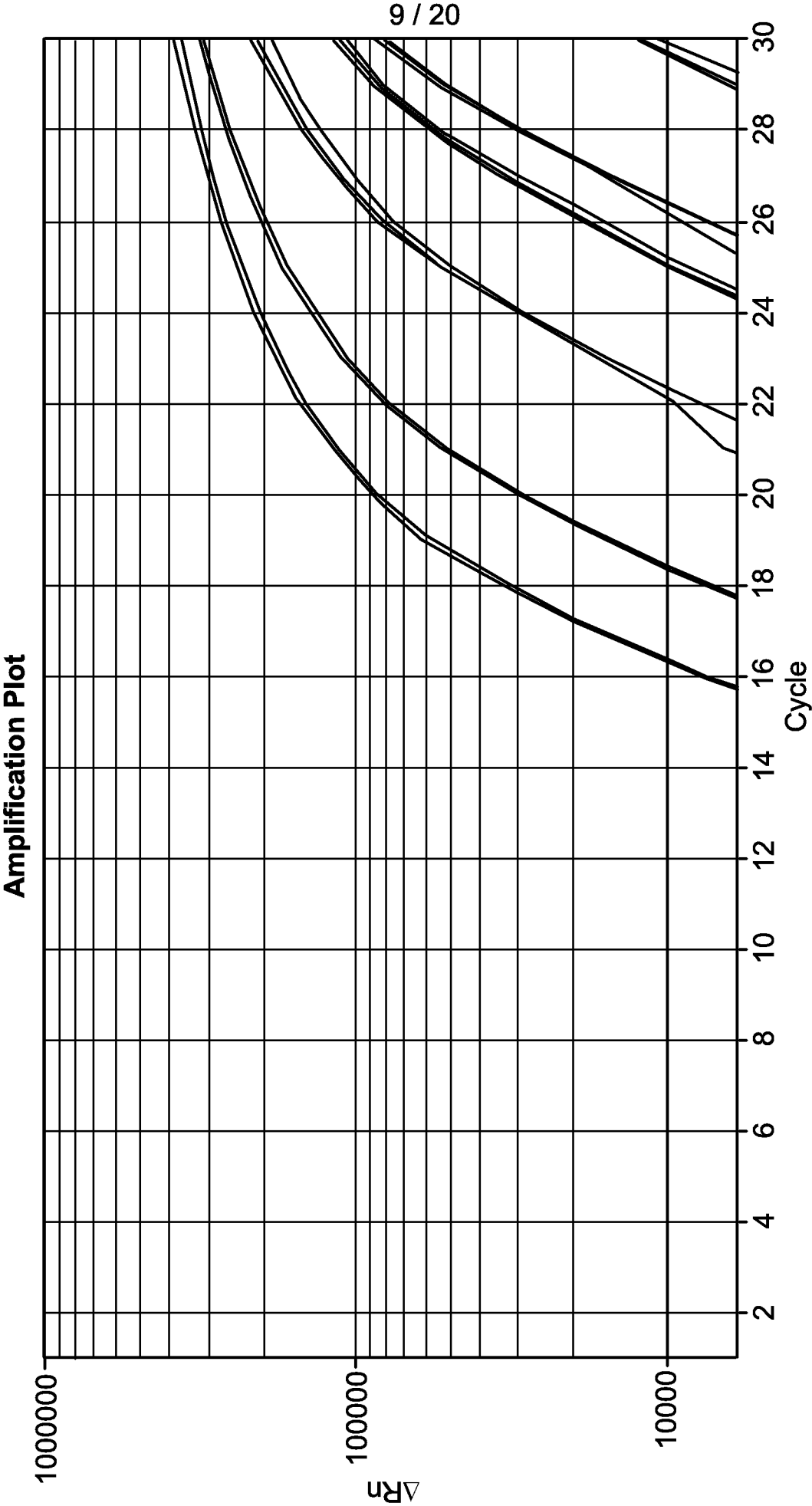


FIG. 7A

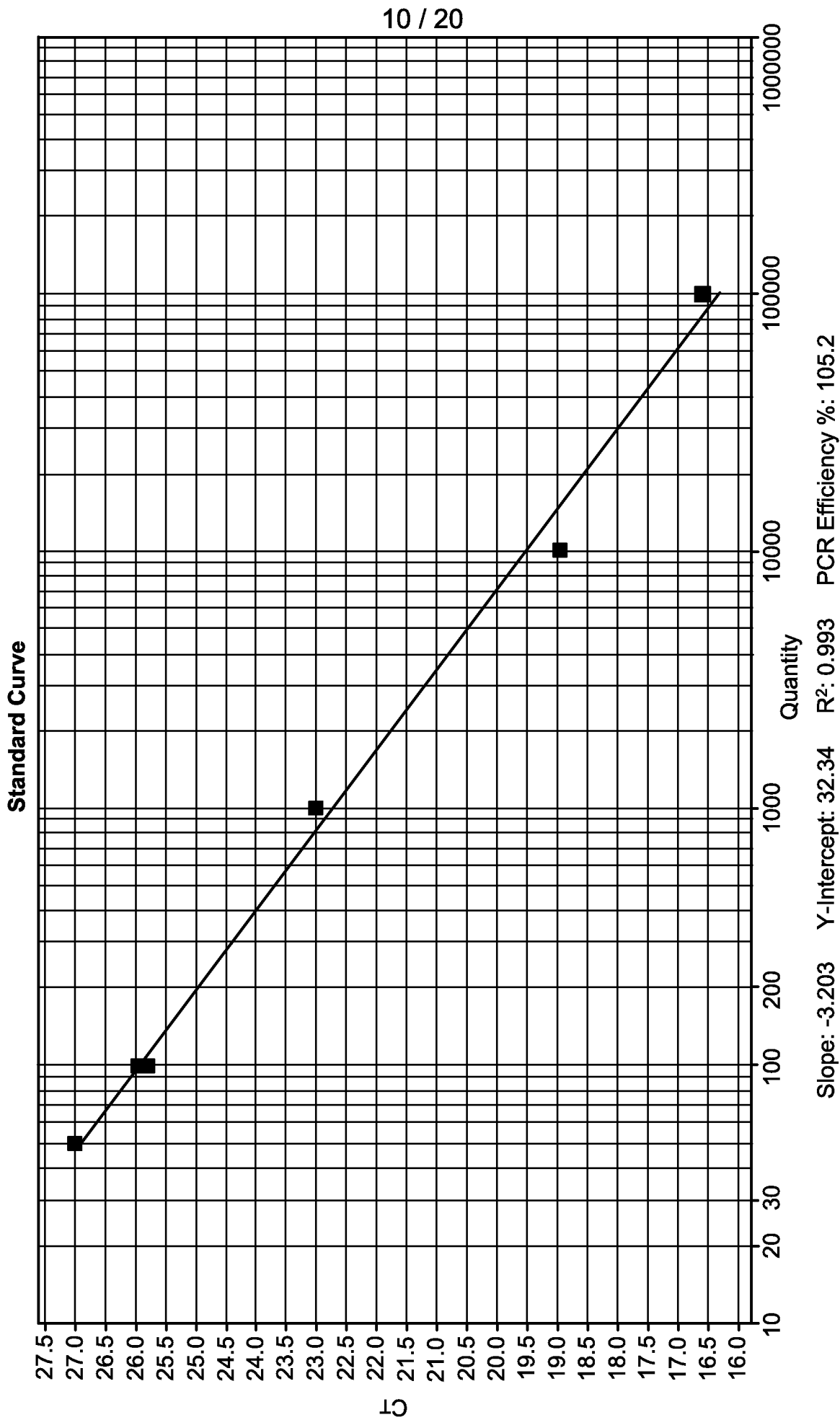
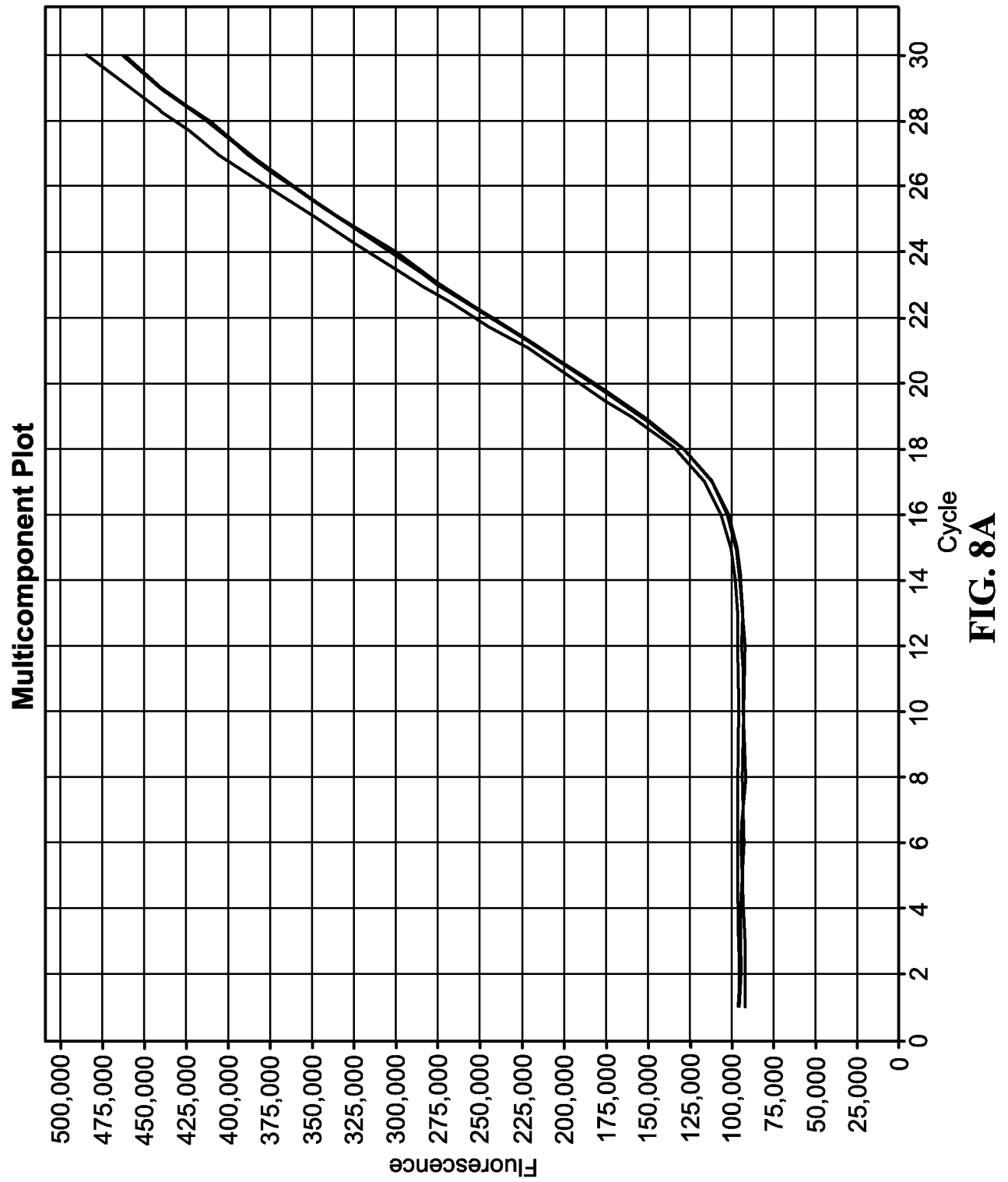


FIG. 7B

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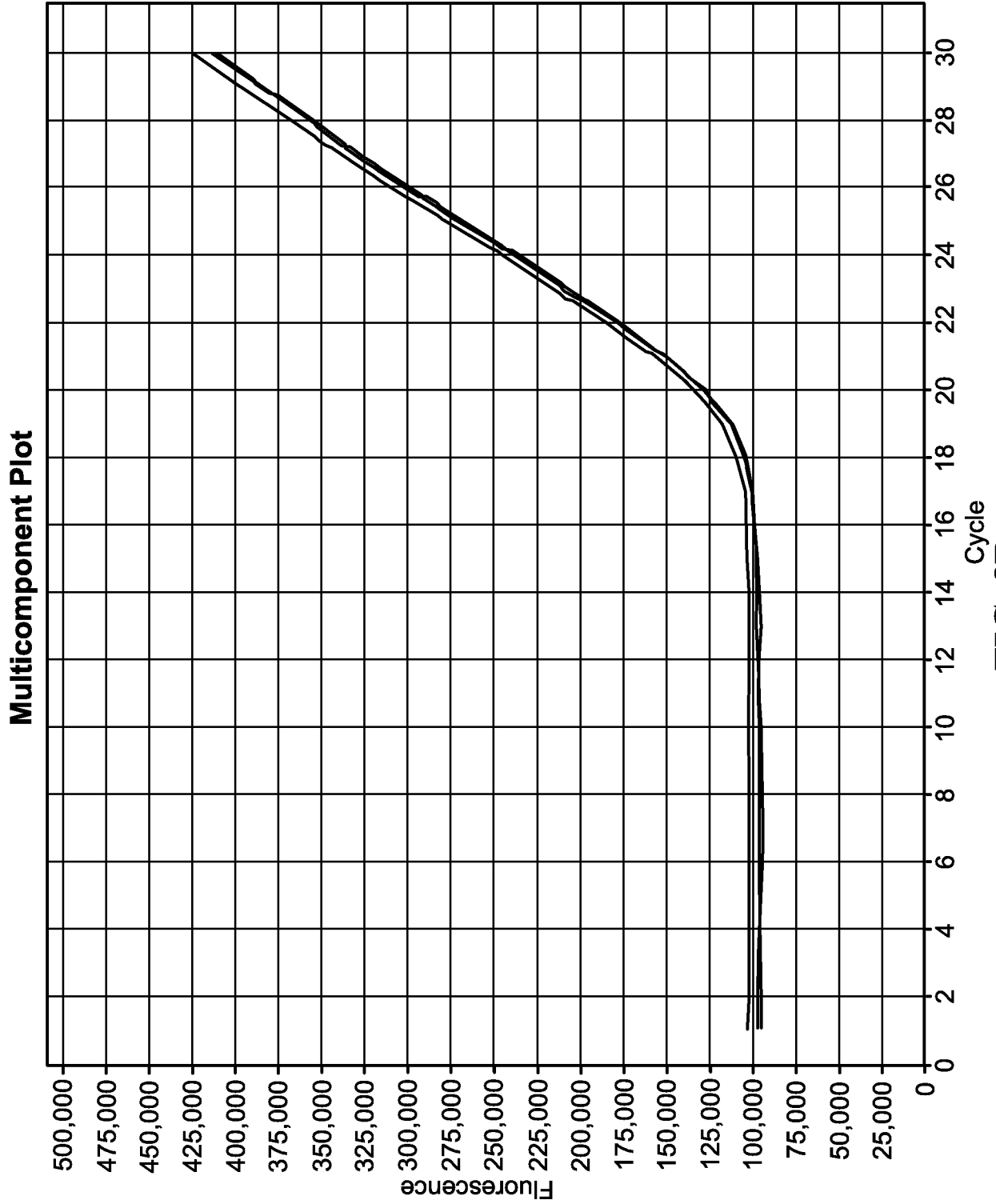
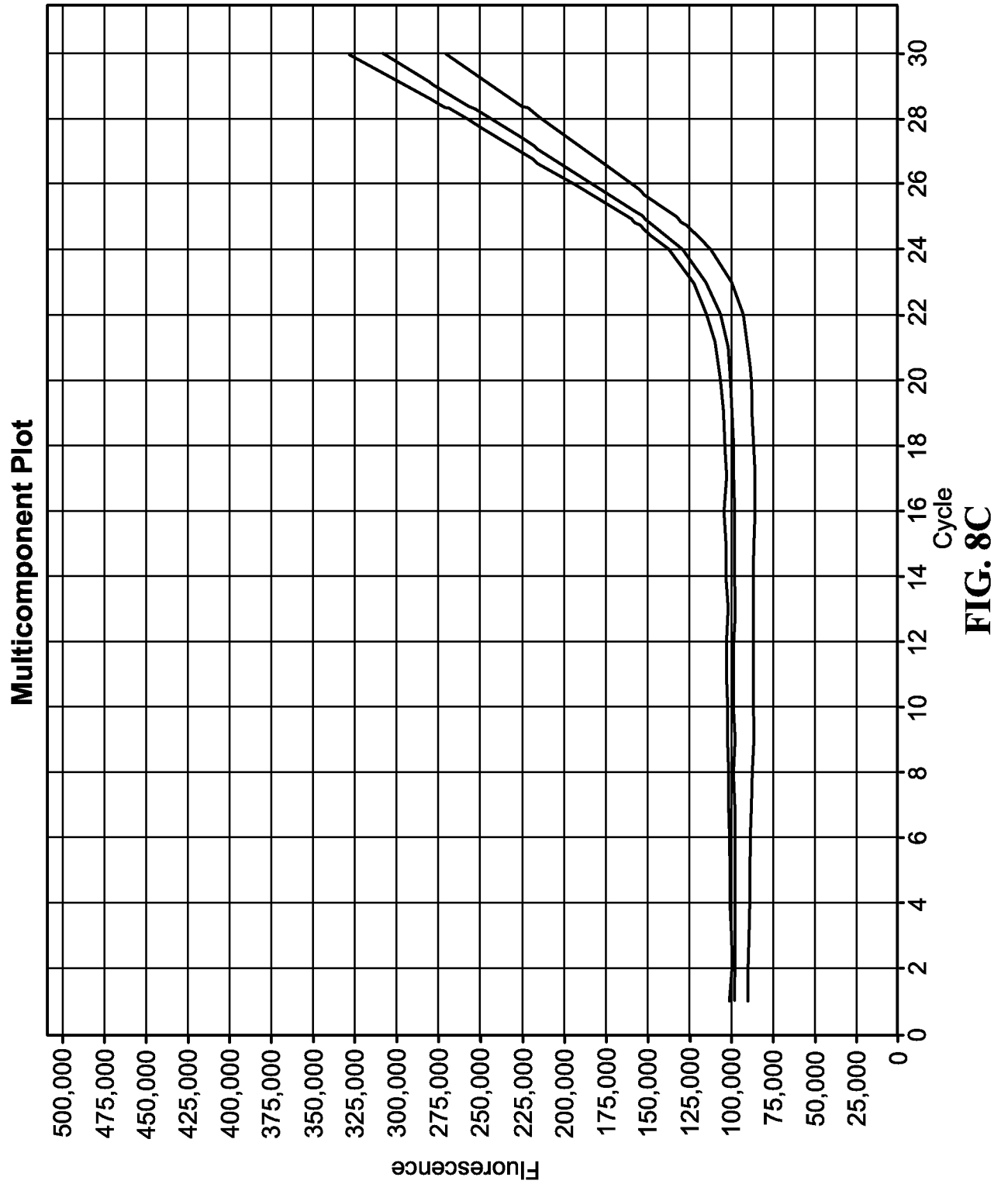
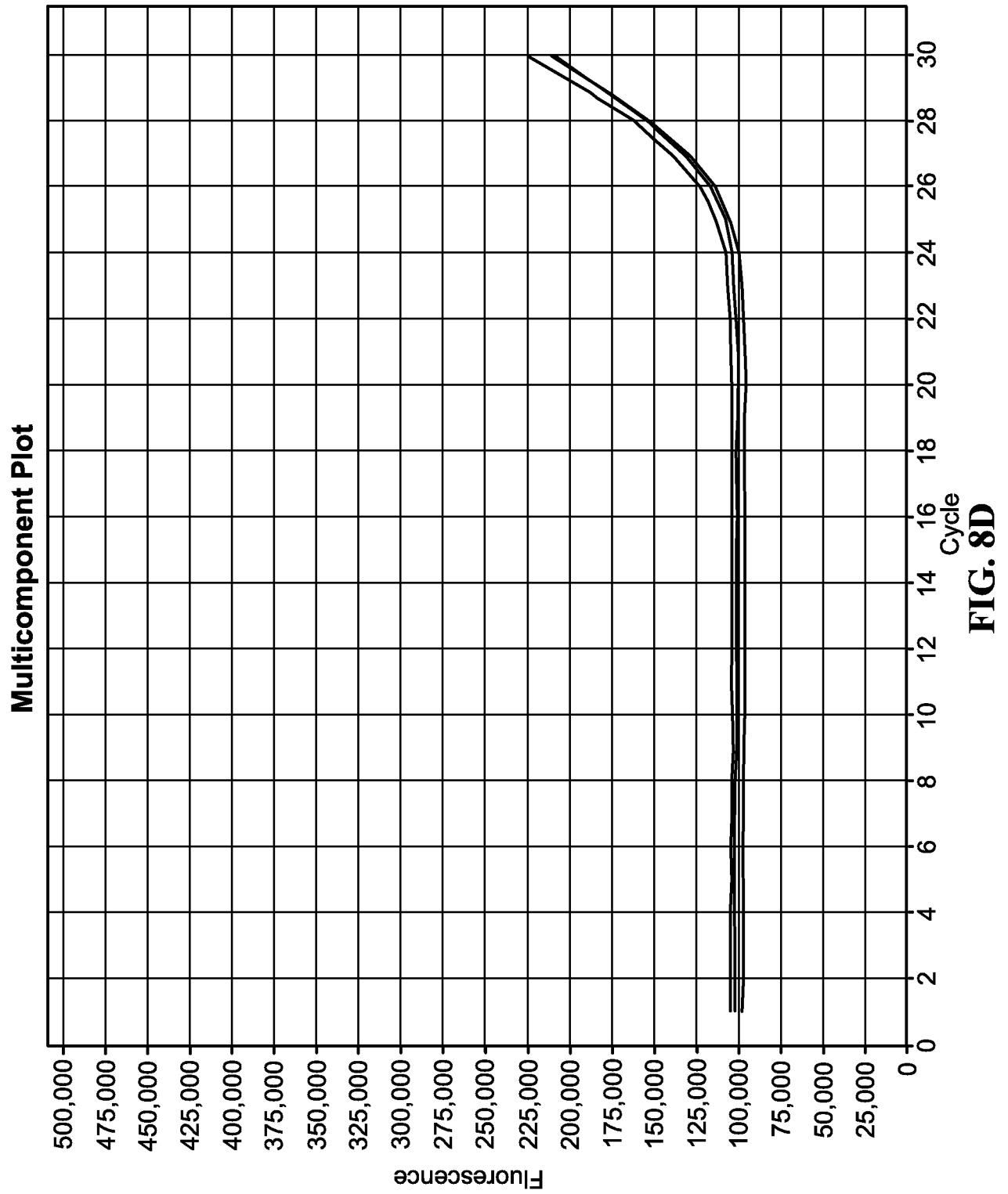


FIG. 8B

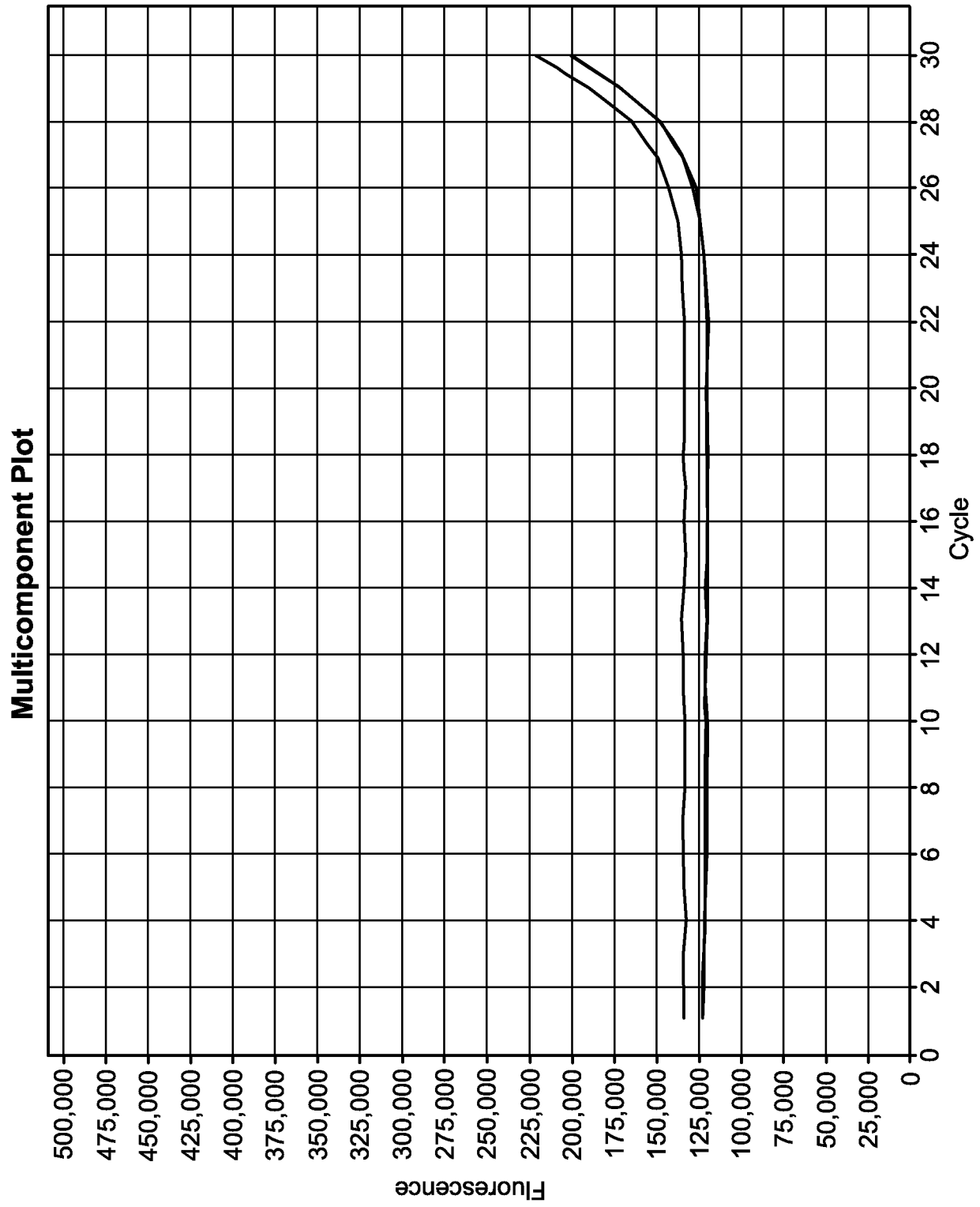
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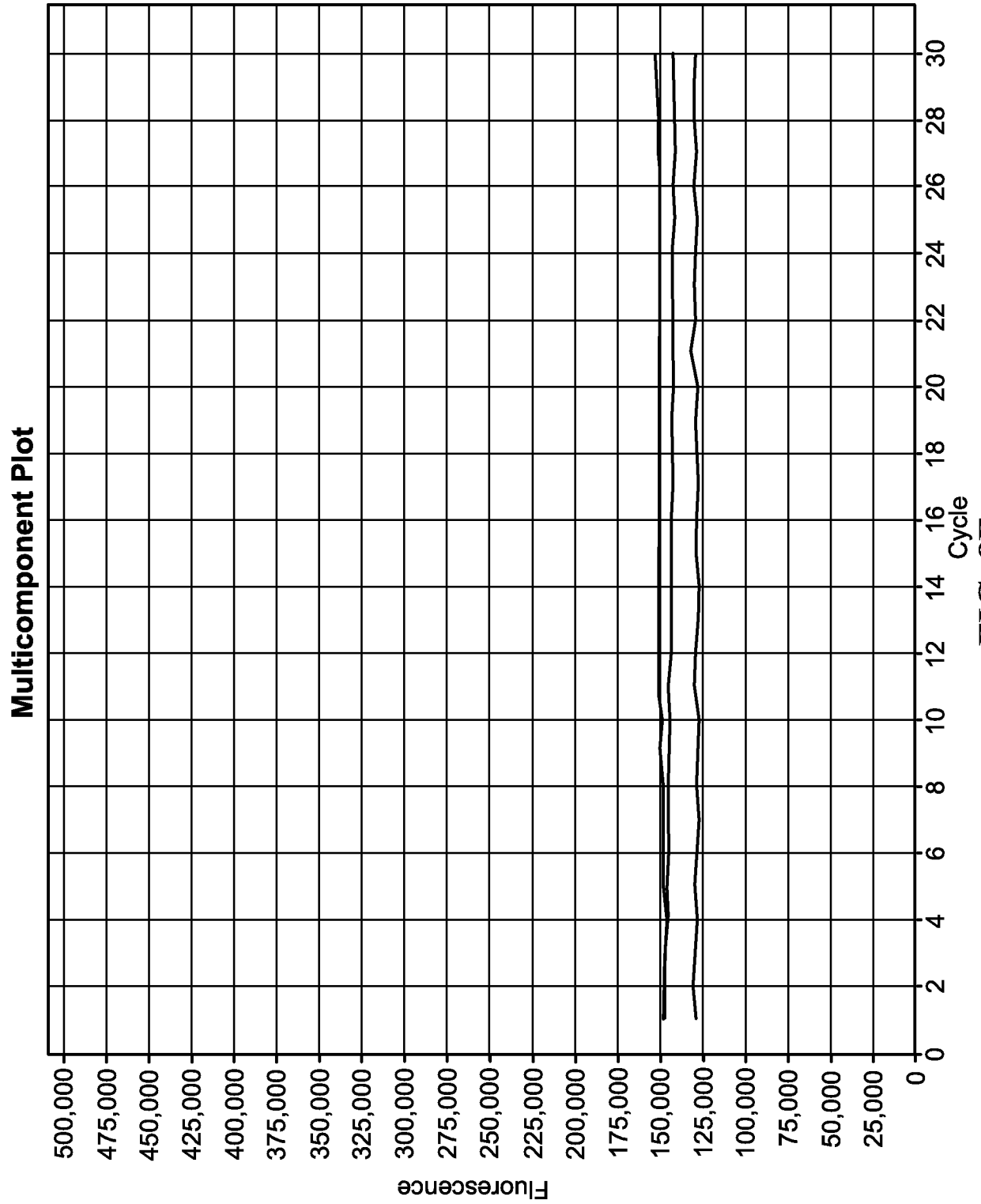
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**FIG. 8E**

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**FIG. 8F**

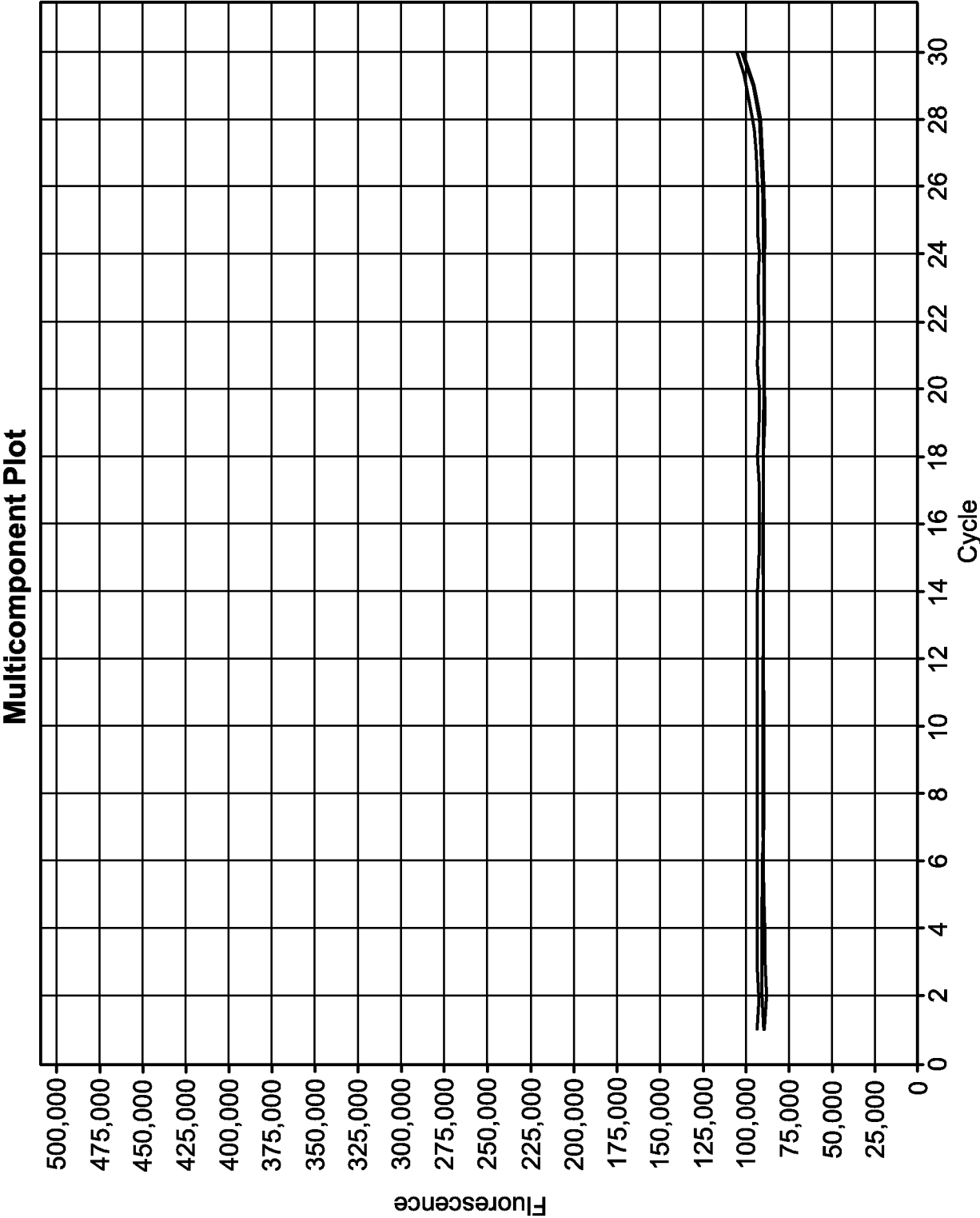


FIG. 8G

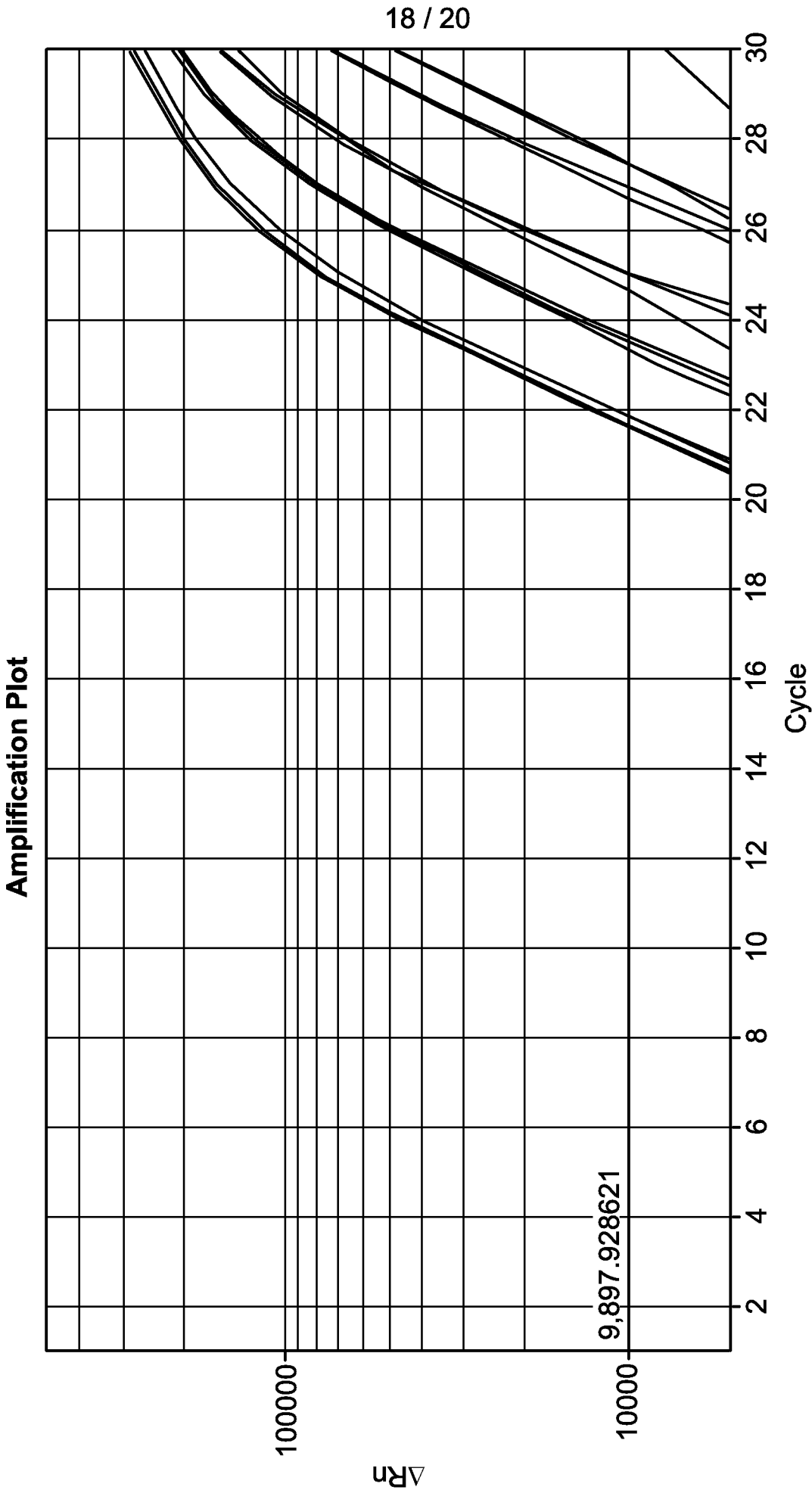


FIG. 9

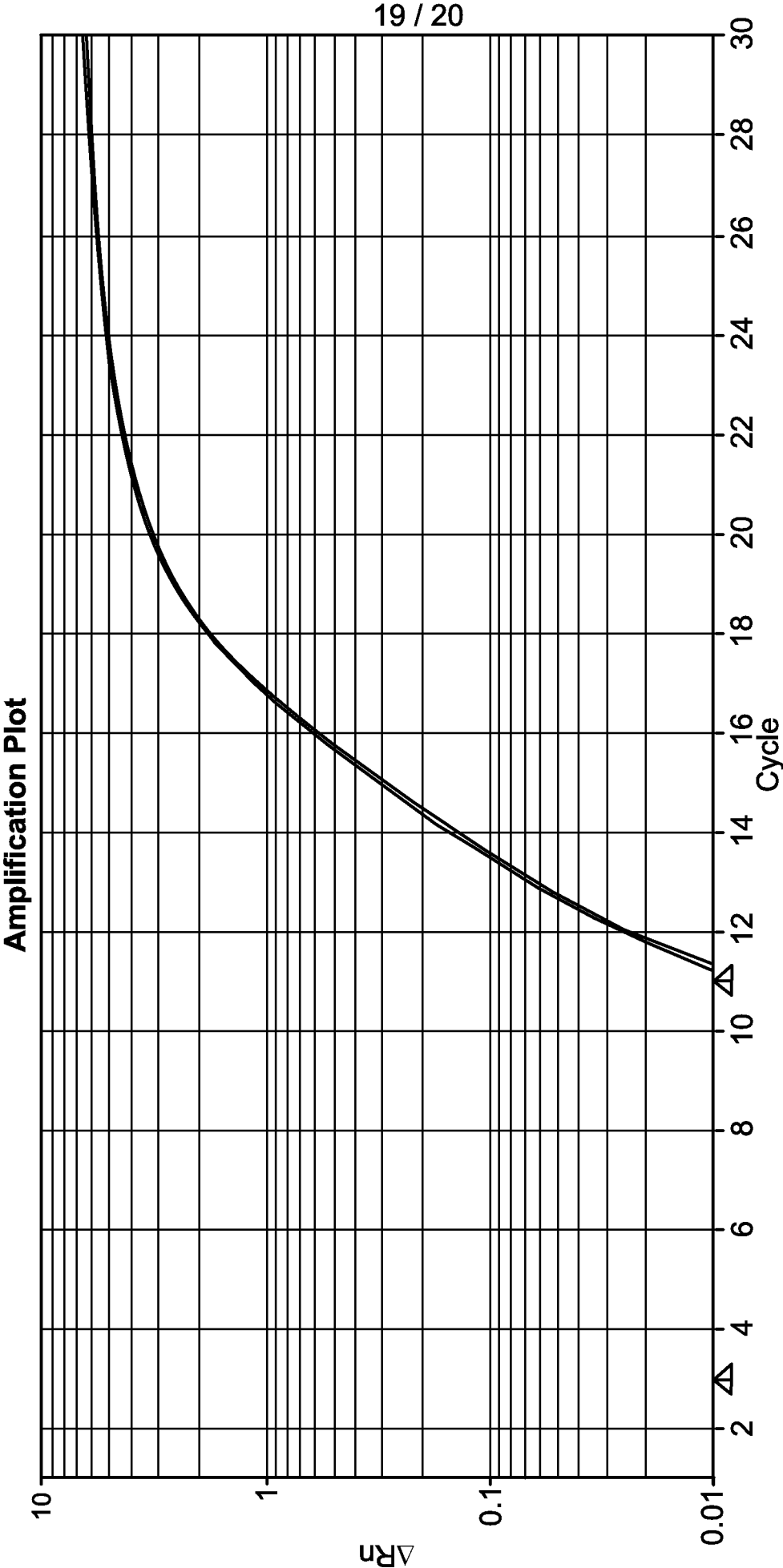


FIG. 10A

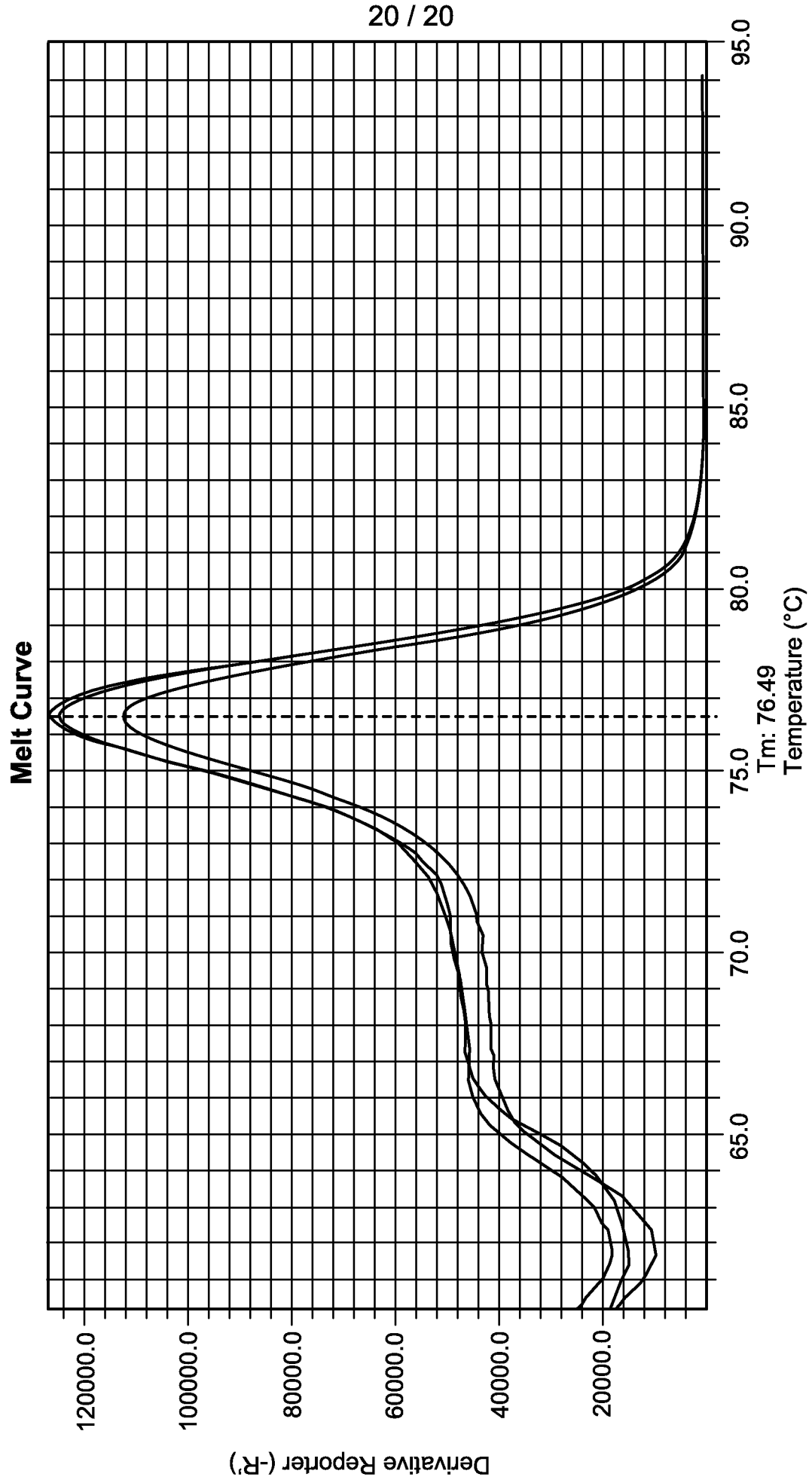


FIG. 10B

Amplification Plot

