

ORIGINAL

ABSTRACT

The invention provides fermentative methods for producing n-propanol. The methods of the invention involve providing a suitable carbon source, a microorganism expressing the dicarboxylic acid pathway, reducing equivalents, and at least one gene coding for an enzyme that catalyzes the conversion of propionate/propionyl-CoA into n-propanol. The methods further involve contacting the carbon source and reducing equivalents with the microorganism under conditions favorable for the production of n-propanol. Also provided are methods for producing propylene and polypropylene from the n-propanol and microorganisms suitable for use in the methods of the invention.

FIGURE 4

WE CLAIM:

1. A method for producing n-propanol comprising:
 - (a) providing a suitable carbon source for fermentation by a microorganism expressing the dicarboxylic acid pathway, reducing equivalents, in the form of NAD(P)H, and at least one gene coding for an enzyme that catalyzes the conversion of propionate/propionyl-CoA into n-propanol;
 - (b) contacting the carbon source and reducing equivalents in the form of NAD(P)H with the microorganism under conditions favorable for the production of n-propanol by the microorganism; whereby a fermentation broth is produced; and
 - (c) recovering n-propanol from the fermentation broth.
2. The method of claim 1, wherein the microorganism has been genetically engineered to express one or more enzymes, whereby the microorganism is capable of converting propionate/propionyl-CoA to n-propanol.
3. The method of claim 2, wherein the microorganism is selected from the group consisting of: *Propionigenium* spp., *Propionispira arboris*, *Propionibacterium* spp., and *Selenomonas*.
4. The method of claim 2, wherein the enzyme is selected from the group consisting of:
 - aldehyde dehydrogenases that are capable of using propionic acid as a substrate;
 - aldehyde dehydrogenases that are capable of using an acyl-CoA intermediate as a substrate;
 - alcohol dehydrogenases that catalyze the conversion of an aldehyde to its corresponding primary alcohol; and
 - multifunctional enzymes that possess both aldehyde/alcohol dehydrogenase domains.
5. The method of claim 4, wherein the enzyme has alcohol dehydrogenase protein domain with e-value threshold below 1e-2.

6. The method of claim 4, wherein the enzyme has aldehyde dehydrogenase protein domain with e-value threshold below 1e-2.
7. The method of claim 4, wherein the aldehyde dehydrogenases are capable of using propionic acid as a substrate are selected from the group consisting of: *Mus musculus* (GenBank Accession No. AC162458.4); *Clostridium botulinum* A str. American Type Culture Collection (ATCC) No. 3502 (GenBank Accession No. AM412317.1); and *Saccharomyces cerevisiae* (GenBank Accession No. EU255273.1).
8. The method of claim 4, wherein the aldehyde dehydrogenases that are capable of using acyl-CoA intermediate as a substrate are selected from the group consisting of: *Rhodococcus opacus* (GenBank Accession No. AP011115.1); *Entamoeba dispar* (GenBank Accession No. DS548207.1); and *Lactobacillus reuteri* (GenBank Accession No. ACHG01000187.1).
9. The method of claim 4, wherein the alcohol dehydrogenases that catalyze the conversion of an aldehyde to its corresponding primary alcohol are selected from the group consisting of: *Aspergillus niger* (GenBank Accession No. AM270229.1); *Streptococcus pneumoniae* Taiwan19F-14 (GenBank Accession No. CP000921.1); and *Salmonella enterica* (GenBank Accession No. CP001127.1).
10. The method of claim 4, wherein the multifunctional enzymes that posses both aldehyde/alcohol dehydrogenase domains are selected from the group consisting of: *Lactobacillus sakei* (GenBank Accession No. CR936503.1); *Giardia intestinalis* (GenBank Accession No. U93353.1); *Shewanella amazonensis* (GenBank Accession No. CP000507.1); *Thermosynechococcus elongatus* (GenBank Accession No. BA000039.2); *Clostridium acetobutylicum* (GenBank Accession No. AE001438.3); and *Clostridium carboxidivorans* ATCC No. BAA-624T (GenBank Accesion No. ACVI01000101.1).
11. The method of claim 1, wherein the fermentation broth further comprises ethanol and/or isopropanol.

12. The method of claim 11, wherein ethanol and/or isopropanol are recovered from fermentation broth.
13. The method of claim 1, wherein the microorganism has the expression of its gene encoding for an enzyme acetate kinase (E.C. 2.7.2.1) altered so as to diminish its activity.
14. The method of any one of claims 1-13, wherein the reducing equivalents comprise NAD(P)H.
15. The method of claim 14, wherein the NAD(P)⁺ is reduced to NAD(P)H comprising the use of electrodes and a mediator molecule, an overpressure of H₂, or a microorganism expressing a NAD⁺-dependent formate dehydrogenase in the presence of formate.
16. The method of claim 14, further comprising contacting the fermentation broth with electrodes and a mediator molecule.
17. The method of claim 16, wherein mediator molecules are benzyl viologen, methyl viologen, anthraquinone 2,6-disulfonic acid, neutral red, cobalt sepulchrate, 1,4 dihydroxy-2-naphthoic acid (DHNA) and flavins.
18. The method of claim 16, wherein mediator molecules are compounds present in yeast extract and *Propionibacterium* spp. extract.
19. The method of any one of claims 1-18, wherein the carbon source is sugarcane juice, sugarcane molasses, hydrolyzed starch, hydrolyzed ligno-cellulosic materials, glucose, sucrose, fructose, lactate, lactose, xylose or glycerol in any form or a mixture thereof.
20. A microorganism for using in the method as defined in any one of claims 1 to 19.

21 A method of claim 1 further comprising:
dehydrating the n-propanol produced by the method as defined in any one of claims 1 to 19 to produce propylene.

22. A method of claim 1 further comprising:
dehydrating in the same reactor n-propanol and isopropanol and/or ethanol produced by the method as defined in any of claims 1 to 19 to produce propylene.

23. A method of claim 1 further comprising:
polymerizing the propylene produced by the method as defined in any one of claims 21 and 22 to produce polypropylene.

Dated this 3rd April, 2012



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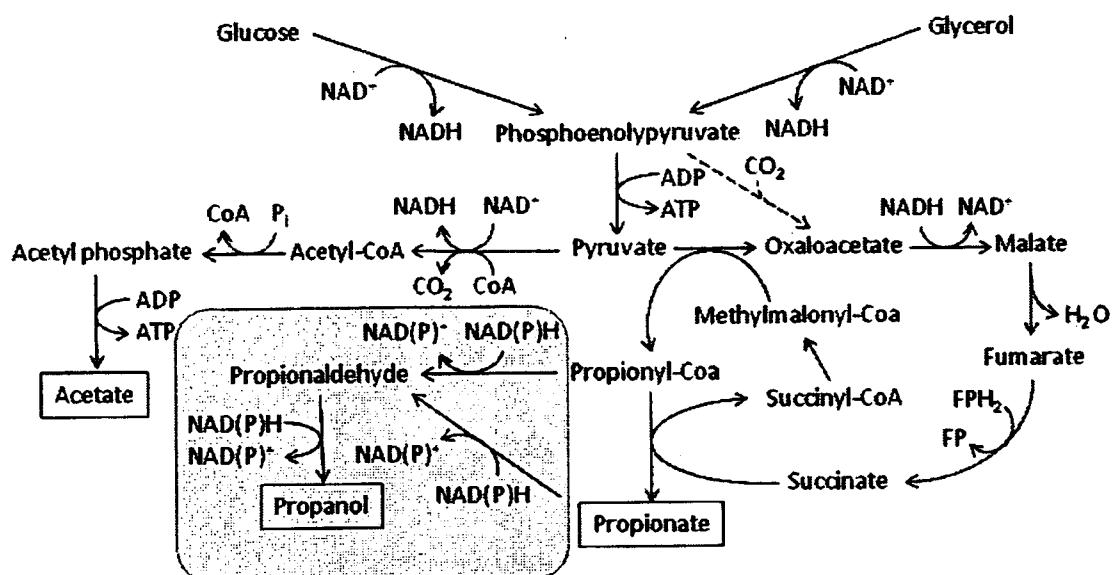


FIGURE 1

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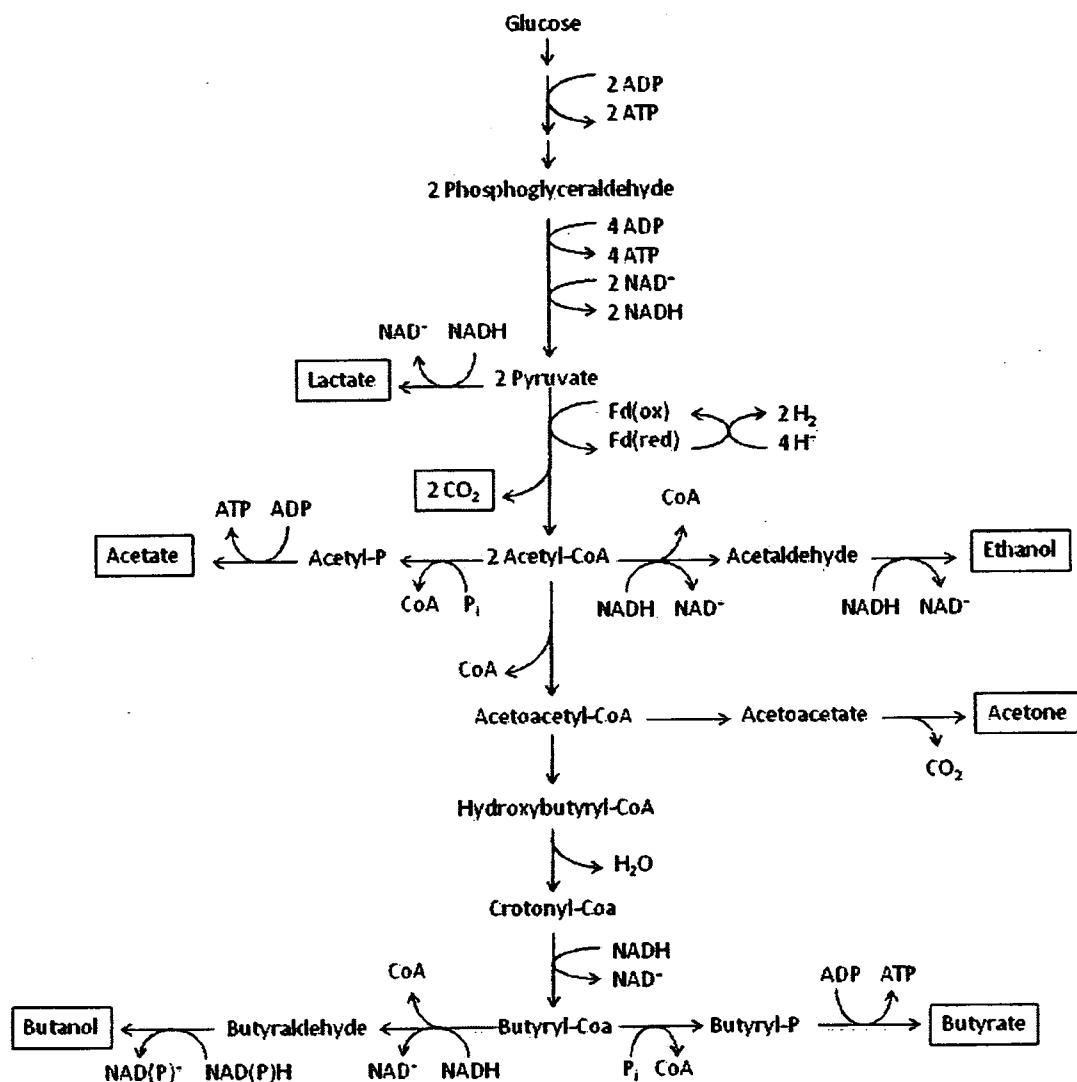


FIGURE 2

Sneha
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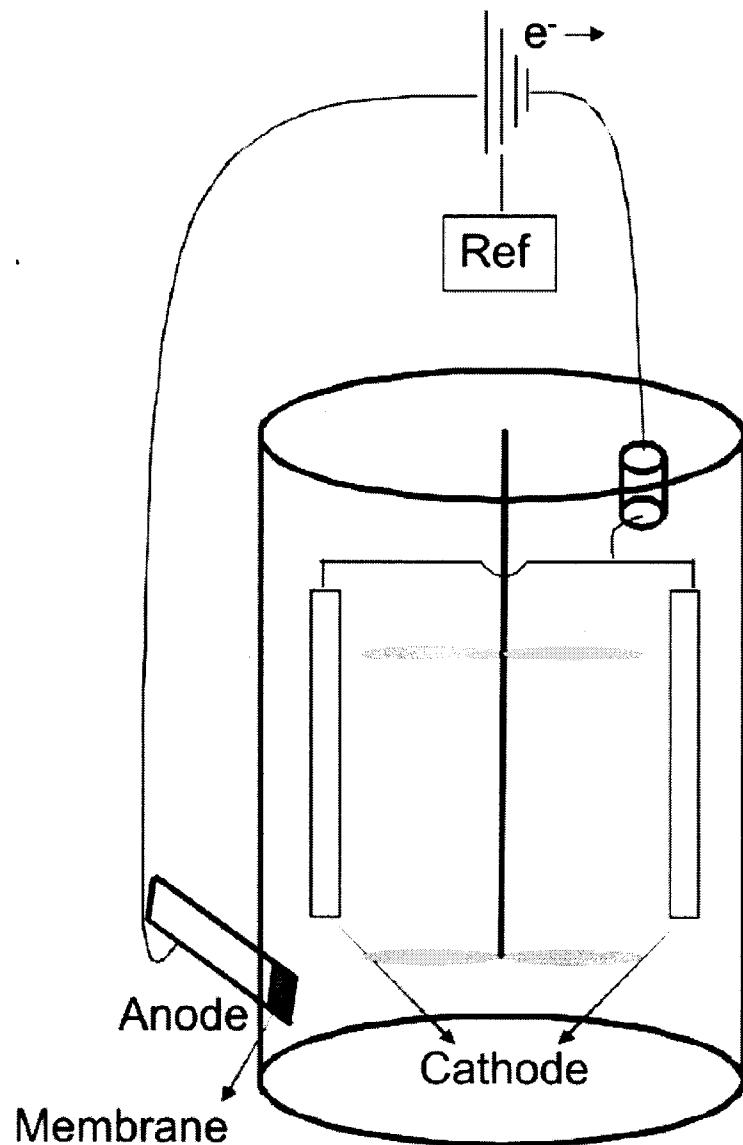


Figure 3

Sneha
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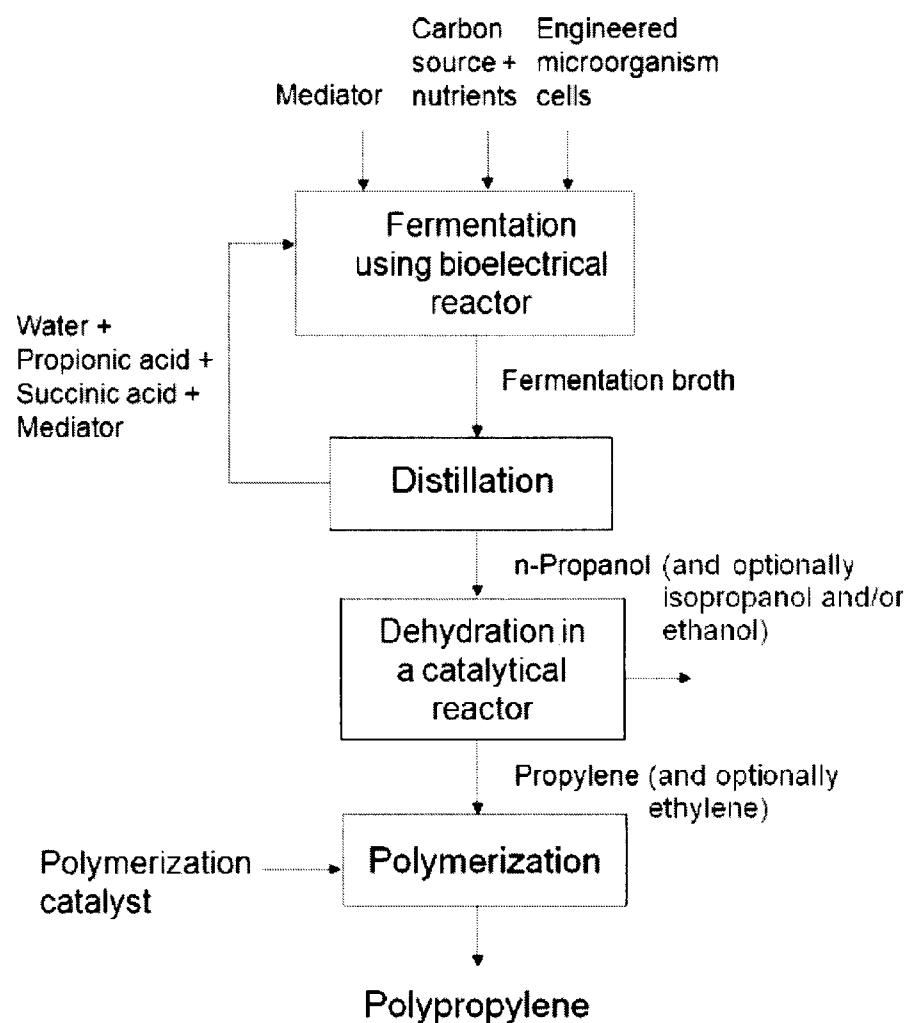


Figure 4

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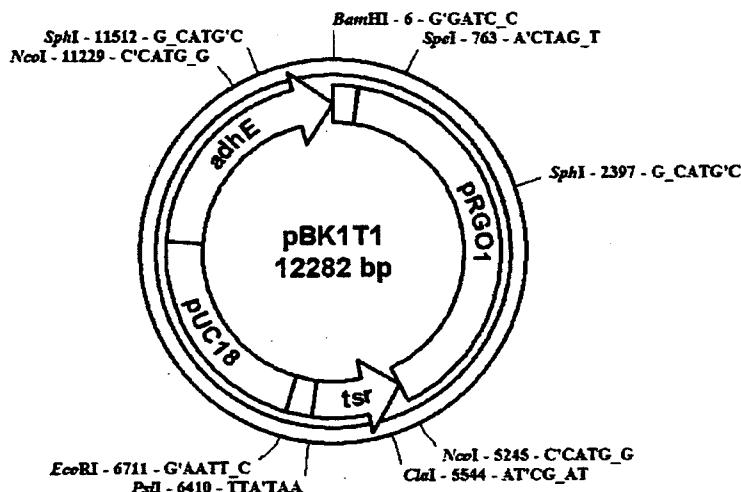


Figure 5

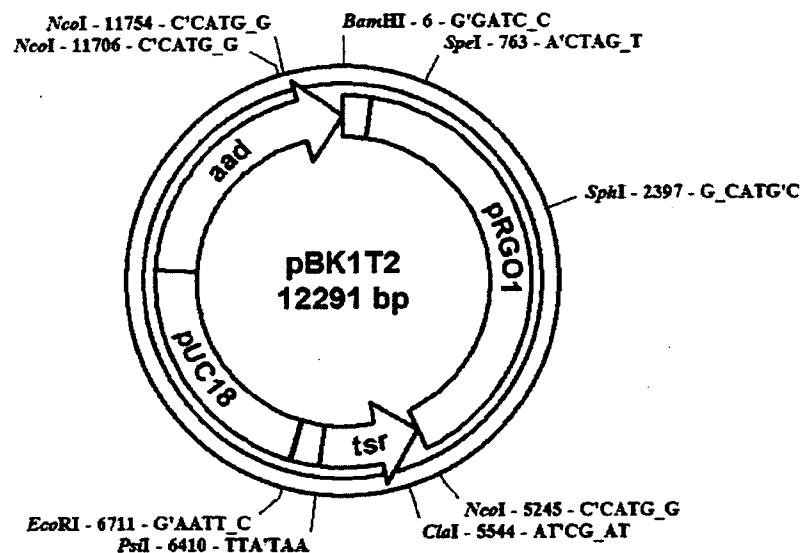


FIGURE 6

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1 GATGACATCC ATGGGTGTCC CATTCTCAC AATCCCGGGG TGGGATTGTC
51 GCGTTTCCCA CAGGAATCGG CGCGGGGATC TGGAGGGTGC TGGCACACGC
101 CCATATTTG AACGATGTT AGTGCCTCAA CCTCGACACCC AGTGCCTGAAAC
151 TTGTCCGTCG CGGGTGCAAG GATTGGACCC ATGAGTCCGC GAAAGATTGG
201 CGTTACCGAG CTGGCGCTCC GCGACGGCGA TCAGAGCCTG ATTGCAACCC
251 GG(AAG)ACTGA GTTGGACACC ATCGCAATC CGTCCGAATC CGCGGTGCAAG
301 CGGATCATCG ATGTCACCAA GCCGTCGCGA TCCAACATAA AGACAACGTT
351 GATCGAGGAC GTGAGGCCCTC ATGCACTAG CATCGCGGCC GGGGTGGAGT
401 TCATCGAGGT CTACGGCAGC GACAGCAGTC CTTTCCATC TGAGTTGCTG
451 GATCTGTGCG GGCAGCAGAA CATAACGGTC CGCCTCACTG ACTCCTCGAT
501 CGTCAACCAG TTGTTCAAGG GGGAGCGGAA GGCAAGACA TTCGGCACTG
551 CCCGCGTCCC TCGCCCGGCC AGGTTCGGCG ATATCGCAGG CGGGCGTGGG
601 GACGTGTCG TTCTCGACGG GGTGAAGATC GTGGGGAAACA TCGGCGCGAT
651 AGTACGCCAGC TCGCTCGCGC TCGGAGCGTC GGGGATCCTC CTGGTCGACA
701 GTGACATCAC CAGCACTCGCG GACCGGGCGTC TCCAAGGGC CAGCCGAGGT
751 TACGTCTCTTCCCGT CGTTCTCTCC GGTGCGGAGG AGGCCATCGC
801 CTTCATTCGG GACAGCGGTA TGCACTGAT GACGCTCAAG GCGGAAGGGC
851 ACATTTCCGT GAAGGAACTC GGGGACRATC CGGATCGGCT GGCCTTGCTG
901 TICGGCAGCG AAAAGGGTGG GCCTTCCGAC CTGTTGAGG AGGCGTCTC
951 CGCCTCGGT ICCATCCCCA TGAIGAGCCA GACCGAGTCT CTCAACGTT
1001 CCGTTTCCCT CGGAATCGCG CTGCACCGAGA GGATCGACAG GAAATCGCG
1051 GCCAACCGA(TAA) TCAGGCTG AGAACGACCT GATCCCGCAC TCGGGAACT
1101 CCGGACGCCG CGTCCCTCG GGGGCGCGC GTCTGCATG TCCGGCGCA
1151 GGGGCAAGGC AGGCCTCCTA CTTAAACG ATC

FIGURE 7


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1 GAGTTCTAGA GTGTGCCATT TCTCACAATC CCGGGGTGCG ATTGTGCGGT
51 TTCCCACAGG AATCGCCGGG GGGATCTGGA GGGTGTGCG ACACGCCAT
101 ATTTTGAACG ATGTTCACTG CGTCAACCTC GACCCCCAGTG CTGAACCTTGT
151 CCGTCGGGGG TCGAAGGATT GGACCCATGA GTCCCGCGAAA GATTGGCGTT
201 ACCGAGCTCG CGCTCCCGGA CGCGCATCAG AGCCTGATTG CAACCCGG(AI
251 G)AAGGTCAACC AACGTGAGG AGCTGATGAA GAAGAATGCAG GAGGTGCGAGA
301 ACGCCAGAA GAAGTTCGGC TCCTTCACCC AGGAGCAGGT CGACGAGATC
351 TTCCGCCAGG CCGCGCTGGC CGCGAACTCG GCCCGCATCG ACCTGGCCAA
401 GATGGCCGTC GAGGAGACCA AGATGGGCAT CGTCGAGGAC AAGGTGATCA
451 AGAACCACTT CGTCGCCGAG TACATCTACA ACAAGTACAA GAACGAGAAG
501 ACCTGCGGCA TCCTGGAGGA GGACGAGGGC TCCGGCATGG TCAAGATCGC
551 CGAGCCGGTC GGCCTCATCG CCGCGGTCA CCCGACCACC AACCCCACCT
601 CCACCGCCAT TTCAAGGCC CTCCCTGGCC TCAAGACCCG CAACGGCATC
651 ATCTTCTCCC CGCACCCCGCG CGCCAAGAAG TGCAACCATCG CCGCGGCCAA
701 GCTGGTGTCTC GACGCCGCGG TGAAGGCCGG CGCCCGAAG GGCATCATCG
751 GCTGGATCGA CGAGCCCTCC ATCGAGCTGT CGCAGATCGT CATGAAGGAG
801 GCGACATCA TCCTGGCCAC CGGGGGCCCC GGCATGGTGA AGGCCCGCTA
851 CTCGTCCGGC AAGCCCGCCA TCGCGTCGG CCCCCGGCAAC ACCCCCCGCC
901 TGATCGACGA GTCCGCCGAC ATCAAGATGG CCGTCAACTC CAICCTGCTG
951 TCCAAGACCT TCGACAAACGG CATGATCTGC GCCTCCGAGC AGTCGGTGGT
1001 CGTCGTGAC TCGATCTACG AGGAGGTGAA GAAGGAGTTC GCCCACCGCG
1051 GCGCTAACAT CCTGTCCAAG GACGAGACCA CCAAGGTGCG CAAGAACCTC
1101 CTGGTCAACG GCACCCCTGAA CGCCGGCATC GTCCGGCAGT CGGCCTACAA
1151 GATCGCCGAG ATGGCCGGCG TGAAGGTCCC GGAGGACGCC AAGGTGCTCA
1201 TCGGCCGAGGT CAAGTCGGTG GAGCACTCCG AGGAGCCGT CTCCCCACGAG
1251 AAGCTCTCGC CGTGTCTGGC CATGTACCGC GCCAAGAACT TCGACGAGGC
1301 CCTGCTCAAG GCCGGCCGCC TCGTCGAGCT GGGCGGGATG GGCCACACCT
1351 CGGTCTGTG CGTCAACGCC ATCACCGAGA AGGTGAAGGT GGAGAAGTTC
1401 CGCGAGACCA TGAAGACCGG CCGCACCCG ATCAACATGC CCTCCGCCA
1451 GGGCGCCATC GGCGACATCT ACAACTCAA GTCGCCCCC TCCCTGACCC
1501 TCGGCTGCGG CTCTGGGGC GGCAACTCCG TGTCCGAGAA CGTGGGCCCG
1551 AAGCACCTGC TGAACATCAA GTCGGTGGCC GAGCGCCGCG AGAACATGCT
1601 GTGGTTCCGC GTGCCGGAGA AGGTCTACTT CAAGTACGGC TCCCTCGGCG
1651 TCGCCCTCAA GGAGCTCGAC ATCCTCGACA AGAAGAAGGT GTICATCGTG

FIGURE 8 (Sheet 1 of 2)


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1701 ACCGACAAGG TGCTGTACCA GCTGGGCTAC ATCGACCGCG TCACCAAGAT
1751 CCTCGAGGAG CTCAAGATCT CCTACAGAT CTTCACCGAC GTCGAGCCCG
1801 ACCCCACCCG GCCAACCGCC AAGAAGGGCG CCGAGGAGCT GCTGTCCTTC
1851 AACCCCCGACA CCATCATCGC CGTGGGCGGG GGCTCCGCCA TGGACGCCGC
1901 CAAGATCATG TGGGTGATGT ACGAGCACCC GGAGGTGCGC TTGAGGAGCC
1951 TCGCCATGCG CTTCATGGAC ATCCGCAAGC GCGTCTACAC CTTCCCARG
2001 ATGGGGCGAGA AGGCCATGAT GATCTCGGTG GCCACCTCGG CGGGCACCGG
2051 CTCGGAGGTC ACCCCCTTCG CGCGCATCAC CGACGAGAAG ACCGGCGCCA
2101 AGTACCCCCG GCCGACTAC GAGCTGACCC CGAACATGGC CATCATCGAC
2151 GCCGAGCTCA TGATGGGCAT GCCGAAGGGC CTCACCGCCG CGTCCGGCAT
2201 CGACGCCCTG ACCCACGCGA TCGAGGCCTA CGTGTGATC ATGGCCTCCG
2251 AGTACACCAA CGGCCTGGCC CTGGAGGCCA TCCGCCTGAT CTTCAAGTAC
2301 CTCCCGATCG CCTACTCGGA GGGCACCAAC TCCATCAAGG CCCGCGAGAA
2351 GATGGCCCAC GCCTCGACCA TCGCCGGCAT GGCCTTCGCC AACGCCCTCC
2401 TCGGCGTCTG CCACTGATG GCCCACAAAGC TGGGCTCGAC CCACCACTGC
2451 CCCCCACGGCA TCGCCAACGC CCTGCTGATC AACGAGGTGA TCAAGTCAA
2501 CGCCGTCGAG AACCCCCGCA AGCAGGCCGC CTTCGGCAG TACAAGTACC
2551 CGAACATCAA GAAGCGCTAC GCCCACATCG CCGACTACCT CAACCTCGGC
2601 GGCTCGACCG ACGACGAGAA GGTCCAGCTC CTGATCAACG CCATCGACGA
2651 GCTCAAGGCC AAGATCAACA TCCCGGAGTC CATCAAGGAG GCGGGCGTCA
2701 CCGAGGAGAA GTTCTACGCC ACCCTCGACA AGATGTCGGA GCTGCCCTC
2751 GACGACCAGT GCACCGCGC CAACCCGCGC TACCCGCTCA TCTCCGAGAT
2801 CAAGCAGATG TACGTGAACG CCTTC (TGA) TG ATCAGGCTGA GAACGACCTG
2851 ATCCGCCACT CGCGGAACTC CGGACGCCGC GTCCCTCGG GGGCCGGCG
2901 TCCTOCATGT CCGGGCOCAG GGGCAAGGCA GGCCTCCTAC AAGCTTGA

FIGURE 8 (Sheet 2 of 2)


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1 GAGTCTAGA GTGTGCCATT TCTCACAATC CCGGGGTGCG ATTGTGCGGT
51 TTCCCACAGG AATCGGCGCG GGGATCTGGA CGGTGCTGCG ACACGCCCCAT
101 ATTTTGAACG ATGTTCACTG CGTCAACCTC GACCCAGTG CTGAACCTGT
151 CCGTCGCGGG TGCAAGGATT GGACCCATGA GTCCGCGAAA GATTGGCGTT
201 ACCGAGCTCG CGCTCCGCGA CGCCCATCAG AGCCTGATTC CAACCCGG (AT
251 G)AAGGTCAACC ACCTGCAAGG AGCTGGACGA GAAGCTCAAG GTCATCAAGG
301 AGGCCCAGAA GAAGTTCTCG TGCTACTCGC AGGAGAATGGT GGACGAGAATC
351 TTCCGCAACG CGCGAATGGC CGCGAATCGAC GCCCGCATCG AGCTCGCCAA
401 GGCCGCGGTC CTGGAGACCG GCATGGGCT CGTCAAGGAC AAGGTGATCA
451 AGAACCACTT CGCCGGCGAG TACATCTACA ACAAGTACAA GGACGAGAAG
501 ACCTGCGGCA TCATCGAGCG CAACGAGCCG TACGGCATCA CCAAGATCGC
551 CGAGCCCACAT CGCGTCGTGCG CGCGCATCAT CCCCGTCACC AACCCGACCT
601 CCACCAAGAT CTTCAAGTGC CGTATCTCGC TCAAGACCCG CAACGGCATC
651 TTCTTCTCGC CGCACCCGCG CGCCAAGAAG TCGACCATCC TGGCCGCGAA
701 GACCACTCTG GACGCCGCGG TCAAGTCGGG CGCCCCCGAG AACATCATCG
751 GCTGGATCGA CGAGCCCTCG ATCGAGCTGA CCCAGTACCT GATGCAGAAG
801 GCGGACKTCA CCCTCGCCAC CGGGGGGGCC TCGCTCGTCA AGTCGGCCTA
851 CTCGTCCGGC AAGCCCGCCA TCGGCGTGGG GCCGGGCAAC ACCCCCGTCA
901 TCATCGACGA GTCCGGCCAC ATCAAGATGG CGTCTCTCTC CATCATCTC
951 TCCAAAGACCT ACGACAACGG CGTCATCTGC GCCTCGGAGC AGTCCGTGAT
1001 CGTCCTCAAG TCGAATCTACA ACAAGGTCAA GGACGAGTT CAGGAGCGCG
1051 GCGCTACAT CATCAAGAAG AACGAGCTGG ACAAGGTGCG CGAGGTCAIC
1101 TTCAAGGACG GCTCGGTGAA CCCCAAGAIC GTGCGCCAGT CGGCCTACAC
1151 CATCGCCGCG ATGGCCGGCA TCAAGGTCCC GAAGACCAAG CGCATCTCTCA
1201 TCGGCGAGGT CACCTCCCTG GGCGAGGAGG AGCCCTTCGC CCACGAGAAG
1251 CTCTCGCCCG TCTGGCCAT GTACGAGGCC GACAACCTCG ACGACGCCCT
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1351 GCATCTACGC CGACGAGAAT AAGGCCCGCG ACAAGATCGA CCGCTCTCC
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1451 CGCCCTCCGGC GACCTGTACA ACTTCGCGAT CCCGCCCTCC TTCACCCCTCG
1501 GCTGCGGGCTT CTGGGGGGGC AACTCCGTCT CGGAGAACGT GGGCCCGAAG
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1601 GTTCCGCGTC CCCCCACAAAGG TCTACTTCAA GTTCCGGTTC CTCAGTTCG
1651 CCCTCAAGGA CCTCAAGGAC CTCAAGAAGA AGCGCGCCCTT CATCGTCACC

FIGURE 9 (Sheet 1 of 2)


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1701 GACTCGGACC CCTACAACCT GAACTACGTC GACTCCATCA TCAAGATCCT
 1751 CGAGCACCTC GACATCGACT TCAAGGTCTT CAACAAGGTG GGCCGCGAGG
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 2751 GACCAAGTGCA CGGGCGCCAA CCCGCGCTTC CGCCTCACCT CCGAGATCAA
 2801 GGAGAATGTAC ATCAACTGCT TCAAGAAGCA GCCC (TGA) TGA TCAGGCTGAG
 2851 AACGACCTGA TCCGCCACTC GCGGAACCTCC GGACGCCCG TCCCCCTCGGG
 2901 GGCGCGCGT CCTGCATGTC CGGGCGCAGG GGCAAGGCAG GCCTCCTACA
 2951 AGCTTGAGT

FIGURE 9 (Sheet 2 of 2)


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1 CTAGAGGATC CGGCGGAAC TCACTGCTG GCGGTGGAGT TGGCGGGCGC
 51 GTTCCAGCCG TTCTCCAGC ACGGTGATCC GGCCTCCAG ACGCTCACGC
 101 TCACCCCTGCT CCAGGTGCCG GGTACCCGTC ACCGTCCGCA CGGGCCGGGC
 151 CTCGGCTTGG GCGGCCCGGC GTTCCCTACT GGCCCGCTTC CGGCAATCGT
 201 CGGAACACCA CACCCGGGGC CGACCCCGCC CACCGTGGGC CTCCACCGGC
 251 GCCCCGCACT GGGGACACGC CGCAGCGCC GACGCATCCT CATCCAAGGC
 301 CATCACCGGG TCAGGAATCCA TACCCGAAAC CATATCGTCC GGACGATGAA
 351 CTGCGCCAGA CAGCTAAGAA TGCACGAGGT GTGTCTCCGA TTCTCAGGAA
 401 ACGCTCAGCA TTTCGAGA CGTTCGGCGC ACGCACACAC CCCCACAGA
 451 ACCGACCCGC CCAGCAGTCG CCGACACGTC GATCCGCACC CGCGATGGGC
 501 TGGCCGAGGC CGACTACGAC CGCTAGTCAG CACCTGCGCT GATCTACCGT
 551 CGCCCTGACC GACTCTCCCG TCGGGATTGT CGCCGGCGC TGCCAGCAIG
 601 GACCTGCGGC CCCGCCCCCT CGCCCTGCAA CTGAGGGAG GCGGGCCGT
 651 CCACCCCCCA CACCACCCCG ACACCGTGAT GCGCCCATGT CGCCTAACGG
 701 GTTGGCCGAC CTCCCCGACA TCAAGAAAC CTGACACCGT CGCCGCAAGC
 751 GCTACACTGA CTACTAGTAG TCAGGAGGTG CGTGATGACC ATCGCCACAT
 801 CGGTGAAACT CTCCGAAGAG ACCGGCCGCA AACTCGATGA ACTAGCCGG
 851 GCCACCGGGC GATCCAAGTC CTACTACCTG CGCGAGGCCA TCGAGGACCA
 901 CAICGACCAG ATGGTCCACG ACTACGCCAT CGCCCGACTC GCCGACGACG
 951 TCGAGCCGG CGGGCCCGCC ACCTACAGCG CCGACGAAGT GGACCAGATC
 1001 TTGGCCTTGG ACGATTGAGT ACACCGACCC CGCCGTCAAA GCACTGCGCA
 1051 AACTCGACCG AGCCCAGGCC CGCCGCATCA CGCCCTACAT ACGTGAGCTC
 1101 ACCGGCCTGG ACGATCCCCA CCAACGCGGG AAAGGCCTCA CGGGGCCCCCT
 1151 GGCGGGACTC TGGCGCTACC GCGECGGGGG CTACCGGATC ATCTGCGACC
 1201 TGAACGCGA CGGCTGGCC ATCATGCCCG TGACCATCGA GCACCGATCC
 1251 CAGGECTAAC GCTGACACGC AACCCCGCAC CCTCGGCCAA GACGTACAC
 1301 ACCACCCGCC CCACCGAGCA CTGAGGAATG CAACTCGCCC GAGCCGGCT
 1351 GCGGGCGTC TTACGGGTIG TCTTGGCGGG CGGGGTGTCT TTGCCCTGGC
 1401 CCAGCAGGCC CACGATCTCC CGCAGCGTGT CGCGGGTGGC GGCGTCCCAG
 1451 GCGCGCTGAC GCTCCGCCTC CGCCCTGGCC TGCCTGGCTG CCTGCGCCCG
 1501 ATCTCCGCG GCGGCAGGCCT GCTCCCTCGC CTGGGCCAGC TCGCCGGTCA
 1551 GGGCCTCGAC CGGGCCCTGC ACCTGCCCCA GGCGCGCCCTC CGCCTCTG
 1601 TGCACCTGCT CGGGCCGGGC CTCCGCTGG TCCCGGGCCG CCTCGGCCTC
 1651 GGCCCGGTGC TGATCCGCCA GGCGCCGCCCTC GGCGACCGCT TCGGCCTGCC

FIGURE 10 (Sheet 1 of 7)


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1701 CATCCACCGC CTGCTGGCC CGAGCCCCGA ACTCCTCGCG GGCAGCATCA
 1751 CTCGCCTGAC GCCACGCCGC CGCCCACACC AGACCCAACG GCTCCGACAG
 1801 ATCCGGCGGG GCGGGCGTCT GGACCGACGC CGAGACGTG CGCAGGAACC
 1851 CCGCCGCAGC GTGGGTGGAG CACCCCGCTT CCGCCTCAA CGACCGCACC
 1901 GTCAACCGCC GACCCGCACC GCTCAACCGC GCATAGGCCG CCGCCAACCT
 1951 TGACCCATTC GACTCCAIGA CCCACCTCC CATTCTGTAC CCTGTACCTG
 2001 TTCTCTAGGTA CGTCTCTAAT GTACCTCACC GGATGCAGAA CCCGCAACCC
 2051 CCCTCACACT CCCCTGCAC GGGGCCCCGC CCCTGCACCC CCGCTGCCGC
 2101 GCGCGCTCTT GCGTCGCGGC CTGCCCCCTG CCCAACGCCG GGCAGGGGG
 2151 CAGCCCCACCA GAGGCTCTGT GAGACGTGCG CGCCCCCGTC CACCTACCC
 2201 AAAGACCAAC CGGGCGTGGGA AACGTCTGTG AGGAGCCTTG TAGGAGTTCC
 2251 CAGGACAAGC CAGCAAGGCC GGGCTGACG GCCCGGAAAG GAAGTCGCTG
 2301 CGCTCTACG AAGAAGCCCC TCTGGGGACC CCCAGACCCC GGAACATATCT
 2351 GATTTGGTTT AGCGGGCTAC TTCCGTCTATA CCGGAATTTA TGGCAIGCTG
 2401 TGGTCATGGC GACGACGACG GTCGATGAGC AGTGGGAGCA GGTGTGGCTG
 2451 CCCCCGCTGGC CCCCTGGCTC CGACGACCTG GCAGCGGGCA TCTACCGGAT
 2501 GGCCCCCCCC TCGGCGCTGG GGGTCCGATA CATCGAGGTG AACCCCCAAG
 2551 CCAATCAGCAA CCTCTCTGTG GTCGACTGCG ACCACCCCGA CGCTGCCAIG
 2601 CGCGCCGCTT GGGACCGCCA CGACTGGCTG CCCAACGCCA TCGTCGAGAA
 2651 CCCCCGACAAAC GGCCACGCC ACGCCGTGTG GGCCTGGAA GCAGCCATCC
 2701 CGCGCACCGA GTACGCCAC CGCAAGGCCA TCGCTACGC CGCCGGCGTC
 2751 ACCGAGGGCC TGGCCCGATC CGTCGACGGA GACGCCCTCT ACGCCGGCCT
 2801 GATCACCAAG AACCCCCAAC ACCCCGCTTG GAACACCACC TGGTCGACCG
 2851 ACCACCTCTA CGGCTGGCC GAGCTCGACA CCCACCTGGA TGGCCGGCGC
 2901 CTCTATGCCCG CCCCCCTCTG GCGACGCCACC CGCCGGCGCA ACCCCGTCGG
 2951 CCTGGGCGCG AACTGCGCCA TCTTCGAGAC CGCCCGCACC TGGGCTTAC
 3001 GCGACGCCCG CGCGCATCCGA CAACGCCACG AATACCCGAC CGCCGAGGAC
 3051 TCGGCCGACCG TGGCACGCCGT CATGCCCTCC ACCGTGAGGG CGCTAACGC
 3101 CGGCTACAGC GAACCCCTGC CGGCCCGCGA GGGCCGCCGGC ATCGCCGCCA
 3151 GCATCCACCG ATGGATCACC CACCGTTCT ACGGCTGGAT CGACTCCCAC
 3201 ACCGTCAACG AGGCCACTT CTCCACCATC CAGAGCTACA GAGGACACAA
 3251 GGGAGCCGGC AAGGCTCGTC CTCTGTGCCCG CCGTGTGCT TCTATCACCG
 3301 ATGGGGAGGC ATGATGGCTG ACGTCCAGCA CGCGGTGAAG CGTCGGGGCA
 3351 CGGCCCGCGA GGCCGCAGAA CGTGTAGGGG CCTCCATCCG AACCGCCCCAG

FIGURE 10 (Sheet 2 of 7)


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3401 CGGTGGACCT CCATCCCCCG TGAGGAATGG ATCACTCAGA AGGCCGTCGA
3451 GCGTGAGGAG ATCCGGGCCT ACAAGTACGA CGAGGGGCAC ACGTGGGGCG
3501 AGACCTCGCG CCACTTCGGG ATCGCGAAGA CCACCGCCCA GGAGCGGGCC
3551 CGGGCGGGCTC GAAGGGAGCG GGCGGCCGAA GCGGAGAAGG CTGCCGAGGA
3601 GGCGGAGGCC GCGCTCGTC CGACACTCTT CGAGGGCCAG GAGCAAGGTT
3651 CTGCATGAGC AACCCCGAGT CCTCGGGTAG ACCGCTGTC CCGACGTTAA
3701 GCATGGCTGA AGCGCCCGT GCCTGTGGGG TTTCAGTGTGTC CACGGTGAGG
3751 CGTCACCGTG ATGCCCTGGT GGCCCCACGGT GCTACCCGTC ATGACGCGTC
3801 ATGGGTGATA CCCCTATCAG CGTITGATTTC ATGCGGTTTG ATGCCCCGGG
3851 TGACACCCCC TGATGCCCCG TCACCCAAATA ACGTGGCGCC TGCCATGACG
3901 TCCCACGGTG ACGCCCCCTT GACGGGGGAA GTCCAAGAGC TGCGCGAGCG
3951 ACTGGCCAAC GCTGAGCATC GAGCCGAGCT AGCCGAAGCC ATCGCGGCCG
4001 AGCGACAAAC CACGATCGAC GCCCAGCGCA TCGCCTTACG GGCTTAAAGAA
4051 CCCGGCTCGA CCCATAACAG CCCGGCAACC GATGAGCCGG CTACCGCTCG
4101 CGAGCAACCT CCCGGTCCAG AACCCAGCGA CTCCAGGCCA CACCGCCGG
4151 GTTGGTGGCG TCGGCTGACT GGTGGCGCCT GACCGGGCCCC GGTGCTCTTC
4201 GAGGGGAACC TCTCGCTCG GAGAGGACAC AGCAGCCGGC TGTGCTGGTA
4251 GGGCATCCCA GCACGACACC CCTCTGACGC GAGAAGTTCA AGGACTACGC
4301 GAATTGCTGA CTACCGCCGA GCGGCAGCAC ACGATCGAGA TGCTAACGA
4351 ACCGCACIAC GCGGCCCTAG AAGGCCCAA GGCACGCTCA CCTACACCGT
4401 GGATCACCAC CGATCGGCGC CGACAGCTAT GGACCCCAAC GCAAGATCAA
4451 AACCCCTGAG CAGCCATCGC ACCGAGCGCC CGGCACGCCG GAAGAAGCTC
4501 CGACGCCCT GCTGTCCGGA CACGGCCTAA CGCGTCCAGA CCAGAACCG
4551 TGCTCCGATC TAAACCGAAG GCCCTTCAIG TGAGAGCATA GTCGTGACGT
4601 CGGCACAGTA GTCGTGGCCCG GCGGGGGTAA CGCTACACAA CGCTTAAAAA
4651 GCATCGGAGC AAGCTAACAC AAGGGGGACTG ATGAACAAAA CACACAAAT
4701 GGCACGGTG GTAACTGGCG CGAICTTGGC CGCCGGAATG ACCGCACCAA
4751 CTGCCTATGC AGATTCTCCT GGAAACACCA GAATTACAGC CAGCGAGCAA
4801 AGCGTCCTA CCCAGATACT CGGCCACAAA CCTACACAAA CTGAATATAA
4851 CCGATACGTT GAGACTTACG GAAAGCGTACG GACCGAAGCA GACATCAACG
4901 CATATATAGA AGCGTCTGAA TCTGAGGGAT CATCAAGTCA AACGGCTGCT
4951 CACGATGACT CGACATCACC CGGCACGAGT ACCGAAATCT ACACGCAGGC
5001 AGCCCCCTGCC AGGTTCTCAA TGTCCCCCT GTCCCGGAACCT TGGATCACTA
5051 GGAGTGGTGT AGTATCGCTC TCCCTGAAGC CAAGGAAGGG TGGTATTGGC

FIGURE 10 (Sheet 3 of 7)


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5101 AACGAGGGGG ACCAGCGTAC CTGGAAGACT GTATACGACA AATCCATAA
5151 CGCTGGCAA TGGACACGAT ACAAGAACAA CGGCCTAGAC GCCAGCATGA
5201 AAAAGCAGTA CATGTGCCAC TTCAAGTACG GGATGGTGAAC GACGCCATGG
5251 GTGTGCCATT TCCTACAATC CCGGGGTGCG ATGTCGCGT TTCCCACAGG
5301 AATCGGCGCG GGGATCTGGA GGGTGCTGCG ACACGCCAT AITTTGAACG
5351 ATGTTCACTG CGTCAACCTC GACCCAGTG CTGAACTTGT CCGTCGCGGG
5401 TGCAAGGATT GGACCCATGA GTCCCGAAA GATIGGCGTT ACCGAGCTCG
5451 CGCTCCGCGA CGCGCATCAG AGCCTGATTG CAACCCGGAT GACTGAGTTG
5501 GACACCATCG CAAATCCGTC CGATCCCGCG GTGCAGCGGA TCATCGATGT
5551 CACCAAGCCG TCGCGATCCA ACATAAAGAC AACGTTGATC GAGGACGTCG
5601 AGCCCCCTCAT GCACAGCAATC GCGGCGGGGG TGGAGTTCAI CGAGGTCTAC
5651 GGCAGCGACA GCAGTCCTTT TCCATCTGAG TTGCTGGATC TGTGCGGGCG
5701 GCAGAACATA CCGGTCCGCC TCATCGACTC CTCGATCGTC AACCAGTTGT
5751 TCAAGGGGGG GCGGAAGGCC AAGACATTCG GCATCGCCCG CGTCCCTCGC
5801 CCGGCCAGGT TCGCGATAAT CGCGAGCCGG CGGGGGGACG TCGTCGTTCT
5851 CGACGGGGTG AAGATCGTCG GGAACATCGG CGCGATAGTIA CGCACGTCG
5901 TCGCGCTCGG AGCGTCGGGG ATCATCTGG TCGACAGTGA CATCACCAGC
5951 ATCGCGGACC GGCGTCTCCA AAGGGCCAGC CGAGGTTACG TCTTCTCCCT
6001 TCCCCTCGTT CTCTCCGGTC GCGAGGAGGC CATCGCCTTC AITCAGGGACA
6051 GCGGTATGCA GCTGATGACG CTCAAGGCCG ATGGCGACAT TTCCGTGAAG
6101 GAACTCGGGG ACAATCCGGA TCGGCTGGCC TTGCTGTTG GCAGCGAAAA
6151 GGGTGGGCCT TCCGACCTGT TCGAGGAGGC GTCTCCGCC TCGGTTTCCA
6201 TCCCCATGAT GAGCCAGACC GAGTCTCTCA ACGTTTCCGT TTCCCTCGGA
6251 ATCGCGCTGC ACGAGAGGAT CGACAGGAAT CTGCGGGCCA ACCGATAATC
6301 AGGCTGAGAA CGACCTGATC CGCCACTCGC GGAACCTCCGG ACGCCCGTC
6351 CCCCTGGGGG CGCGCGTCC TGCATGTCG GGCAGGGGG CAAGGCAGGC
6401 CTCTTACTTA TAATTGTCCC ATACGCGTCA TACTGGTTAG TCGCTGGAGA
6451 TCCAGACGTT TGGGACTTCT ATCGTTCTT ATGGTGGATT CCAGTGGCTT
6501 TTCTAGGAAT AGTTCAATA GTACTGATGG CTAGCAGTAG AGGTGGGGGA
6551 CGACGTCTCG GCGACTCCGG AGAACACCAA GTCAAGGTCT CATGAGTGTG
6601 CGATAGCTTG AGCTGCTAC CAACTGGAT ATAGCTATAAT CGGTCGTTTG
6651 TGTCTGATTC GCCAGTGAGC CAACGGCGGG GGCAGACACGC GGTGGCGAAA
6701 CCCCCCTGGCA GAATTCGTAA TCATGGTCAT AGCTGTTCC TGTGTGAAAT
6751 TGTATCCGC TCACAAATCC ACACAAACATA CGAGCCGGAA GCATAAAGTG

FIGURE 10 (Sheet 4 of 7)


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6301 TAAAGCCTGG GGTGCCTAAT GAGTGAGCTA ACTCACAITA ATTGCGTTC
 6851 GCTCACTGCC CGCTTTCCAG TCGGGAAACC TGTCGTGCCA GCTGCATTAA
 6901 TGAATCGGCC AACGCGCGGG GAGAGGCCTG TTGCGTATTG GGCGCTCTTC
 6951 CGCTTCCTCG CTCACTGACT CGCTGCCTC GGTCGTTCGG CTGCGGCAG
 7001 CGGTATCAGC TCACCTCAAAG GCGGTAATAC GGTTATCCAC AGAACTCAGGG
 7051 GATAACGCAG GAAAGAACAT GTGAGCAAAA GGCCAGCAAA AGGCCAGGAA
 7101 CCGTAAAAAG GCCGCGTTGC TGGCGTTTT CCATAGGCTC CGCCCCCTG
 7151 ACGAGCATCA CAAAAATCGA CGCTCAAGTC AGAGGGTGGCG AAACCCGACA
 7201 GGACTATAAAA GATACCAGGC GTTTCCCCCTT GGAAGCTCCC TCGTGCCTC
 7251 TCCTGTTCCG ACCCTGCCGC TTACCGGATA CCTGTCGCCCTT TTCTCCCTT
 7301 CGGGAAAGCGT GGCGTTTCTT CAAAGCTCAC GCTGTAGGTA TCTCAGTTCG
 7351 GTGTAGGTG TGCGCTCAA GCTGGGCTGT GTGCACGAAC CCCCCGTTCA
 7401 GCCCCGACCCG TGGCGCTTAT CCGGTAACTA TCGTCTTGAG TCCAACCCGG
 7451 TAAGACACGA TTATCGCCA CTGGCAGCAG CCACIGGTAA CAGGATTAGC
 7501 AGAGCGAGGT ATGTAGGCAG TGCTACAGAG TTCTTGAAGT GGIGGGCTAA
 7551 CTACGGCTAC ACTAGAACAA CAGTATTG TGCTGCGCT CTGCTGAAGC
 7601 CAGTTACCTT CGGAAAAAGA GTGGTAGCT CTGATCCGG CAAACAAACC
 7651 ACCGCTGGTA CGGGTGGTTT TTGTTGTC AAGCAGCAGA TTACGGCAG
 7701 AAAAAGGA TCTCAAGAAG ATCCCTTGAT TTCTTCTACG GGGCTGACG
 7751 CTCAGGGAA CGAAAACCTCA CGTAAAGGGA TTGTTGTCAT GAGATTATCA
 7801 AAAAGGAATCT TCACCTAGAT CCTTTAAAT TAAAAATGAA GTTTIAAATC
 7851 AATCTAAGT ATATAATGAGT AAACCTGGTC TGACAGTTAC CAATGTTAA
 7901 TCAGTGAGGC ACCTAATCTCA GCGAATGTC TATTCGTTC ATCCATAGTT
 7951 GCCTGACTCC CCGTCGTGTA GATAACTACG ATACGGGAGG GCCTACCATC
 8001 TGGCCCCAGT GCTGCAATGA TACCGCGAGA CCCACGCTCA CCGGCTCCAG
 8051 ATTTATCAGC AATAAACCAG CCAGCCGGAA GGGCCGAGCC CAGAAGGIGGI
 8101 CCTGCAACTT TATCCGCTC CATCCAGCT ATTAATTGTT GCCGGGAAGC
 8151 TAGAGTAAGT AGTTGCCCAG TTAAATAGTTT GCGCAACGTT GTTGCCATTG
 8201 CTACAGGCAT CGTGGGTGTC CGCTCGTCGT TTGGTATGGC TTCAATTAGC
 8251 TCCGGTTCCC AACGATCAAG GCGAGTTACA TGATCCCCCA TGTGTCGAA
 8301 AAAAGCGGTT AGCTCCTTCG GTCCCTCCGAT CGTTGTCAGA AGTAAGGTGG
 8351 CCGCAGTGGT ATCACTCAIG GTTATGGCAG CACTGCAIAA TTCTCTTACT
 8401 GTCATGCCAT CCGTAAGATG CCTTTCTGTG ACTGGTGAGT ACTCAACCAA
 8451 GTCATCTGA GAATAGTGTA TGCAGCGACG GAGTTGCTCT TGGCCGGCGT

FIGURE 10 (Sheet 5 of 7)


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9501 CAATACGGGA TAATACCGCG CCACATAGCA GAACCTTAAA AGTGCTCATC
9551 ATGGAAAAC GTTCTCGGG GCGAAAACTC TCAAGGATCT TACCGCTGTT
9601 GAGATCCAGT TCGATGTAAAC CCACTCGTGC ACCCAACTGA TCTTCAGCAT
9651 CTTTACTTT CACCAAGCGTT ICTGGGTGAG CAAAACAGG AAGGCAAAAT
9701 GCCGCRAAAA AGGGAAATAAG GGCGACACGG AAATGTGAA TACTCATACT
9751 CTTCCTTTT CAATATTATT GAAGCATTIA TCAGGGTTAT TGTCATGAA
9801 GCGGATAACAT ATTTGAATGT ATTTAGAAAA ATAAACAAAT AGGGGTTCCG
9851 CGCACATTTC CCCGAAAAGT GCCACCTGAC GTCTAAGAAA CCATTATTAT
9901 CATGACATTA ACCTATAAAA ATAGGCGTAT CACGAGGCC 111CGTCTCG
9951 CGCGTTTCGG TGATGACGGT GAAAACCTCT GACACATGCA GCTCCGGAG
9001 ACGGTACAG CTTGCTGTAA AGCGGAIGCC GGGAGCAGAC AAGCCCGTCA
9051 GGGCGCGTCA GCAGGGTGTG GCGGGTGTG GGGCTGGCTT AACTATGCGG
9101 CATCAGAGCA GATTGTAATG AGAGTGCACC ATATGCGGTG TGAAAATACCG
9151 CACAGATGCG TAAGGAGAAA ATACCGCAIC AGGCGCCATT CGCCATTACAG
9201 GCTGCGCAAC TGTGGGAAG GGCGATCGGT GCGGGCCTCT TCGCTATTAC
9251 GCCAGCTGGC GAAAGGGGA TGTGCTGCAA GGCGATTAAG TTGGGTAACG
9301 CCAGGGTTT CCCAGTCACG ACGTTGTAAA ACACGGCCA GTGCCACTAG
9351 AGTGTGCCAT TTCTCACAAT CCCGGGGTGC GATTGTCGCG TTTCCCACAG
9401 GAATCGGCAC GGGGAICTGG AGGGTGTG GACACGCCCA TATTTGAAC
9451 GATGTTCACT GCGTCAACCT CGACCCCACT GCTGAACCTG TCCGTCGCGG
9501 GTGCAAGGAT TGGACCCATG AGTCCGCGAA AGATGGCGT TACCGAGCTC
9551 GCGCTCCCGC ACGCGCATCA GAGCCTGATT GCAACCCGGA TGAAGGTAC
9601 CAACGTGAG GAGCTGATGA AGAAGATGCA GGAGGTGCAAG AACGCCAGA
9651 AGAAGITCGG CTCCTTCACC CAGGAGCAGG TCGACGAGAT TTTCCGCCAG
9701 GCCGCGCTGG CCGCGAACTC GGCCCACATC GACCTGGCCA AGATGGCGT
9751 CGAGGAGACC AAGATGGGCA TCGTCGAGGA CAAGGTGATC AAGAACCACT
9801 TCGTCGCCGA GTACATCTAC AACAACTACA AGAACGAGAA GACCTGCGGC
9851 ATCTGGAGG AGGACGAGGG CTTCGGCATG GTCAAGATCG CCGAGCCGGT
9901 CGCGTCATC GCCGCCTCA TCCCGACAC CAACCCACC TCCACCGCCA
9951 TCTTCAAGGC CCTCTGGCC CTCAAGACCC GCAACGGCAT CATCTCTCC
10001 CGCGACCCGC GCGCCAAGAA GTGCACCAIC GCGCGGGCCA AGCTGGTGCT
10051 CGACGCCCGC GTGAAGGCCG GCGCCCCGAA GGGCATCATC GGCTGGATCG
10101 ACGAGCCCTC CATCGAGCTG TCGCAGATCG TCAATGAAGGA GGCGACATC
10151 ATCTGGCCA CGGGCGGGCCC CGGCATGGTG AAGGGCGCGT ACTCGTCCGG

FIGURE 10 (Sheet 6 of 7)


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10201 CAAGCCCCGCC ATCGGCGTCG GCCCGGGCAA CACCCCCGCC CTGATCGACG
10251 AGTCCCGCCGA CATCAAGATG GCGCTCAACT CCATCCTGCT GTCCAAGACG
10301 TTCGACAACG GCATGATCTG CGCCCTCCGAG CAGTCGGTGG TCGTCGTCGA
10351 CTGGAACCTAC GAGGAGGTGA AGAAGGGAGTT CGCCCCACCGC GGCCTACAA
10401 TCCCTGTCAA GGACGAGACG ACCAAGGTG GCAAGAACCT CCTGGTCACG
10451 GGCACCCCTGA ACGCCGGCAT CGTCGGCCAG TCGGCTACAA AGATCGCCGA
10501 GATGGCCGGC GTGAAGGTCC CGGAGGACGC CAAGGTGCTC ATCGGCAGG
10551 TCAAGTCGGT GGAGCACTCC GAGGAGCCGT TCTCCACGA GAAGCTCTCG
10601 CCCGTCTGG CCAIGTACCG CGCCAAGAAC ITTCGACGAGG CCTCTGCTCAA
10651 GGCCGGCCGC CTCTGTCGAGC TGGGCGGGAT GGGCACACCC TCGGTCTGT
10701 ACGTCAACGC CATCACCGAG AAGGTGAAGG TGGAGAAGTT CCGCGAGACG
10751 ATGAAGACCG GCCGCACCCCT GATCAACATG CCTCTCCGCC AGGGCGCCAT
10801 CGGCGACATC TACAACCTCA AGCTCGCCCC CTCCCTGACC CTCTGGCTGCG
10851 GCTCTGGGG CGGCAACTCC GTGTCCGAGA ACGTGGGCCG GAAGCACCTG
10901 CTGACATCA AGTCGGTGGC CGAGCGCCGC GAGAACATGC TGTGGTTCCG
10951 CGTGGCCGGAG AAGGTCTACT TCAAGTACGG CTCCCTCGGC GTGCCCCCTCA
11001 AGGAGCTCGA CATCCTCGAC AAGAAGAAGG TGTTCATCGT GACCGACAAG
11051 GTGCTGTACC AGCTGGGCTA CATCGACCCG GTCACCAAGA TCTCTGAGGA
11101 GCTCAGATC TCTTACAAGA TCTTCACCGA CGTCGAGGCC GACCCACCC
11151 TGGCCACCGC CAAGAAGGGC GCGGAGGAGC TGCTGCTTI CAACCCCGAC
11201 ACCATCATCG CGCTGGGCGG GGGCTCCGCC ATGGACGCCG CCAAGATCAT
11251 GTGGGTGATG TACGAGCACC CGGAGGTGCG CTTCGAGGAC CTGGCCATGC
11301 GCTTCATGGA CATCCGCAAG CGCGTCTACA CCTTCCCGAA GATGGGGAGG
11351 AAGGCCATGA TGAATCTCGGT GGCCACCTCG GCGGGCACCG GTCGGAGGT
11401 CACCCCTTC GCGTCATCA CGACGAGAA GACCGGGCACC AAGTACCCCC
11451 TGGCCGACTA CGAGCTGACC CGGAACATGG CCATCATCGA CGCCGAGCTC
11501 AIGATGGGCA TGGCGAAGGG CCTCACCGCC GCGTCCGGCA TCGACGCCCT
11551 GACCCACCGC ATCGAGGCCT ACGTGTGAT CATGGCCTCC GAGTACACCA
11601 ACGGCCTGGC CCTGGAGGCC AICCGCCTGA TCTTCAAGTA CCTCCGATC
11651 GCCTACTCGG AGGGCACCCAC CCTCCATCAG GCGCGCGAGA AGATGGCCCA
11701 CGCCTCGACC ATCGCCGGCA TGGCCTTCGC CAACGCCCTC CTGGCGCT
11751 GCCACTCGAT GGGCCACAAG CTGGGCTCGA CCCACCCACGT CCCCCACGGC
11801 ATCGCCRAAGC CCTGCTGAT CAACGAGGTG ATCAAGTTCA ACAGCGTCGA
11851 GAACCCCCGC AAGCAGGGCG CCTTCCCGCA GTACAAGTAC CGAACATCA
11901 AGAAGCGCTA CGCCCGCCTAC CGCGACTTAC TCAACCTCGG CGGCTCGACC
11951 GACGAGGAGA AGGTCCAGCT CCTGATCAAC GCCATCGACG AGCTCAAGGC
12001 CAAGATCAAC ATCCCCGGAGT CCATCAAGGA GCGCGCGTC ACCGAGGAGA
12051 AGTTCTACGC CACCCCTCGAC AAGAATGTCGG AGCTCGCCCT CGACGACCGAG
12101 TGCACCCGGCG CCAACCCCGCG CTACCCGCTC ATCTCCGAGA TCAAGCAGAT
12151 GTACGTGAC GCCTCTGAT GATCAGGCTG AGAACGACCT GATCCGCCAC
12201 TCGCGGAACG CGGGACGCCG CGTCCCCCTCG GGGSCGCGGC GTCTGCAIG
12251 TCCGGCGCA GGGGCAAGGC AGGCCTCTCA CA

FIGURE 10 (Sheet 7 of 7)


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1 CTAGAGGAAT CGGCAGGAAT TCACGTCTG GCGGTGGAGT TGGCGGGCGC
 51 GTTCCAGCCG TTCCCTCCAGC ACGGTGATCC GGGCCTCCAG ACGCTCACGC
 101 TCACCCCTGCT CCAGGTGCCG GGTCACCGTC ACCGTCGCCA CGGGCCGGGC
 151 CTCGGCCTGG CGGGCCGGC GTTCCCTCACT GGCCCGCTTC CGGCAATCGT
 201 CGGAACACCA CACCCGGGGC CGACCCCGCC CACCGTGGGC CTCCACCGGC
 251 GCCCCGAGT GGGGACACGC CGCGAGCGCC GACCGATCCT CATCCAAGGC
 301 CATCACCGGG TCGGAATCCA TACCCGAAAC CATATCGTCC GGACGATGAA
 351 CTGCGCCAGA CAGCTAAGAA TGCACGAGGT GTGTCTCCGA TTCTCAGGAA
 401 ACGCTCAGCA TTTTCCGAGA CGTTCGGCCG ACCGACACAC CCCCACAAAGA
 451 ACCGACCCGC CCAGCATCCG CGCACACGTC GATCCGCACC CGCGATGGGC
 501 TGGCCGAGGC CGACTACGAC CGCTAGTCAG CACCTGCCT GATCTACCGT
 551 CGCCCTGACC GACTCTCCCG TCGGGATTGT CGCCGGCCGC TGCCAGCATG
 601 GACCTGCAGG CCCGCCCCCT CGCCCTGCAA CTGAGGGAG CGGGGGCGT
 651 CCACCCCCCA CACCACCCCG ACACCGTGAT CGGCCCATGT CGCCTAACGG
 701 GTTGGCCGAC CTCCCCGACA TCAAGAAAAC CTGACACCGT CGCCGCAAGC
 751 GCTACACTGA CTACTAGTAG TCAGGAGGTG CGTGATGACC ATCGCCACAT
 801 CGGTGAAACT CTCCGAAGAG ACCGGCCCA AACTCGATGA ACTAGCCCG
 851 GCGACCCGGC GATCCAAGTC CTACTACCTG CGCGAGGCCA TCGAGGACCA
 901 CATCGACCCAG ATGGTCCACG ACTACGCCAT CGCCCGACTC CGCGACGACG
 951 TGCGAGCCGG CGGGGCCGCC ACCTACAGCG CCGACGAAGT GGACCAAGATC
 1001 CTTGGCCTGG ACCATTGAGT ACACCGACCC CGCCGTCAA GCACTGCGCA
 1051 AACTCGACCG AGCCCAAGGCC CGCCGCATCA CGCCCTACAT ACGTGAGCTC
 1101 ACCGGCCTGG ACGATCCCCA CCAACGCCGG AAAGGGCTCA CGGGGGCCCT
 1151 GGCGGGACTC TGGCGCTACC GCGTCGGGGA CTACCGGATC ATCTGCGACC
 1201 TGAACGCCGA CGGCCCTGGCC ATCATCGCCC TGACCATCGA GCACCGATCC
 1251 CAGGGCTTAC GCTGACACGC AACCCCGCAC CCTCGGCCAA GACGTACAC
 1301 ACCACCCGCC CCACCGAGCA CTGAGGATGT CAACTCGCCC GAGCCGGCCT
 1351 GCGCGCCGTC TTACCGGTTG TCTTGGCCGG CGGGGTGTCT TTGGCCCTGGC
 1401 CCAGCAGGCC CACGATCTCC CGCACCGTGT CGCGCGTGGC CGCGTCCCGG
 1451 GCGCGCTGAC GCTCCGCCTC CGCCCTGGCC TGCTCGCGTC CCTCGCCCG
 1501 ATCCCTCCCGC CGGGCGGCCT GCTCCCTCGC CTGGCCAGC TCACCGGTCA
 1551 GGGCCTCGAC CGGGCCCTGC ACCTGCCCA GGCGCCGCTC CGCCCTCTGC
 1601 TGACACCTGCT CGGGCCGGGC CTCCGGCTGG TCCCGGGCCG CCTCGGCCTC
 1651 GGGCCGGTGC TGATCCGCCA GGGCCGCCCT GGCCACCGCT TCGGGCTGCC

FIGURE 11 (Sheet 1 of 7)


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1701 CATCCACCGC CTGCTCGGCC CGAGCCCCGA ACTCCTCGCG GGCCCCATCA
1751 CTCGCTGAC GCCACGCCGC CGCCCCACACC AGACCCAACG GCTCCGACAG
1801 ATCCGGCGGG GCCCGCGTCT GGACCGACCG CGAGACGTG CGCAGGAACC
1851 CGCCCGCAGC GTCCGTGGAG CACCCCGCT CGCCCTCAA CGACCGCACC
1901 GTCACCCGCC GACCCGCACC GCTCAACCGC GCATAGGCCG CGCCCAACCT
1951 TGACCCATTG GACTCCATGA CCCACCCCTC CATTCTGTAC CCTGTACCTG
2001 TTCCCTAGGTA CGTTCTTAAT GTACCTCACC GGATGCAGAA CCCGCAACCC
2051 CCCTCACACT CCCCTGCAC GGGGCCCCGCC CCCTGCACCC CCGCTGCCGC
2101 GCCCCGCTCT GCGTCGCGGGC CTTGCCCCCTG CCCAACGCCG GGCCGGGGGG
2151 CAGCCCCACCA GAGGCTCTGT GAGACGTCGG CGCCCCCGTC CACCTACCT
2201 AAAGACCAAC CGGGCGTGGG AACGTCTGTG AGGAGCCTTG TAGGAGTTCC
2251 CAGGACAAGC CAGCAAGGCC GGGCCTGACG GCCCCGAAAG GAAGTCGCTG
2301 CGCTCCTACG AAGAAGCCCC TCTGGGGACC CCCAGACCCC CGAACTATCT
2351 GATTTGGTTT AGCGGCGTAC TTCCGTATA CGCGAATTAA TGGCATGCTG
2401 TGGTCATGGC GACGACGACG GTCGATGAGC AGTGGGAGCA CGTGTGGCTG
2451 CCCCCGCTGGC CCCTGGCCTC CGACGACCTG CGACGGGGCA TCTACCGGAT
2501 GGGCCGGCCCC TCGGCCTGGG GGGTCCGATA CATGAGGTC AACCCCCAAG
2551 CCATCAGCAA CCTCCTCGTG GTCGACTGCG ACCACCCGA CGCTGCCATG
2601 CGGGCCCGTCT GGGACCGCCA CGACTGGCTG CCCAACGCCA TCGTCGAGAA
2651 CCCCCGACAAAC GGCCACGCCG ACGCCGTGT GGGCCTGGAA CGAGCCATCC
2701 CGCCGACCGA GTACGCCCCAC CGCAAGCCCA TCGCCTACGC CGCCGGCGTC
2751 ACCGGAGGGCC TGCGCCGATC CGTCGACGGA GACGCCCTCT ACGCCGGCCT
2801 GATCACCAAG AACCCCCAAC ACCCCGCTG GAACACCACC TGGTGCACCG
2851 ACCACCTCTA CCGGCTGGCC GAGCTCGACA CCCACCTGGA TGGCGCCGGC
2901 CTCATGGCCG CCCCTCCCTG GCGACCGACCG CGCCGGCGCA ACCCCGTCGG
2951 CCTGGGGCCG AACTGCGCCA TCTTCGAGAC CGCCCGCACC TGGGCCCTACC
3001 GCGACGGCCCG CGGCATCCGA CAACGCCACG AATACCCGAC CGCCGAGGAC
3051 TCGGGCCGACC TGCACGCCGT CATCGCTCTC ACCGTCGAGG CGCTAACGC
3101 CGGCTACAGC GAACCCCTGC CGGGCCGCGA GGCCGCCGGC ATCGCCGCCA
3151 GCATCCACCG ATGGATCACC CACCGTTCT ACGGCTGGAT CGACTCCAC
3201 ACCGTCAACG AGGCCACTTT CTCCACCATC CAGAGCTACA GAGGACACAA
3251 GGGAGCCGGC AAGGCTCGTC CTCGTGGCCG CGTGTCTGCT TCTATCACCG
3301 ATTGGGAGGC ATGATGGCTG ACGTCCAGCA CGCGTGAAG CGTCGGGGCA
3351 CGGGCCGGGA GGCCCCAGAA CGTGTAGGGG CCTCCATCCG AACCGCCCCAG

FIGURE 11 (Sheet 2 of 7)


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3401 CGGTGGACCT CCATCCCCG TGAGGAATGG ATCACTCAGA AGGCCGTCGA
 3451 GCGTGAGGAG ATCCGGGCCT ACAAGTACGA CGAGGGGCAC ACGTGGGGCG
 3501 AGACCTCGCG CCACTTCGGG ATCGCGAAGA CCACCGCCCA GGAGCGGGCC
 3551 CGGCAGGCTC GAAGGGAGCG GGCAGGCGAA CGGAGAAGG CTGCGAGGA
 3601 GGCGAGGCC CGCGTGCCTC CGACACTCTT CGAGGGCCAG GAGCAAGGTT
 3651 CTGCATGAGC AACCCCGAGT CCTCGGGTAG ACCGTCTGGC CCGACGTTAA
 3701 GCATGGCTGA AGCGGCCCCGT GCCTGTGGGG TTTCAGTGTGTC CACGGTGAGG
 3751 CGTCACCGTG ATGCCCTGGT GCGCCACGGT GCTACCCGTC ATGACGGCTC
 3801 ATGGGTGATA CCCCTATCAG CGTTGATTTG ATGCGGTTTG ATGCCCGGG
 3851 TGACACCCCC TGATGCCCCG TCACCCAAATA ACGTGGCGCC TGCCATGACG
 3901 TCCCACGGTG ACGCCCCCT GACGGGGGAA GTCCAAGAGC TGGCGAGCG
 3951 ACTGGCCAAC GCTGAGCATC GAGCCGAGCT AGCCGAAGCC ATGCGGCCG
 4001 AGCGACAACA CACGATCGAC GCGGAGCCCA TCGCCTTACG GGCCTTAGAA
 4051 CCCGGCTCGA CCCATAACAG CCCGGCAACC GATGAGCCGG CTACCGCTCG
 4101 CGAGCAACCT CCCGGTCCAG AACCCAGCGA CTCCAGGCCA CACCGCCCGA
 4151 GTTGGTGGCG TCGGCTGACT GGTGGCGCCT GACCGGGCCC GGTGCTCTTC
 4201 GACGGGAACC TCTCGCCTGC GAGAGGACAC AGCAGCCGGC TGTGCTGGTA
 4251 GGCGATCCCA GCACGACACC CCTCTGACGC GAGAAGTTCA AGGACTACGC
 4301 GAATTGCTGA CTACCGCCGA GCGGAGCAC ACGATCGAGA TGCTAACGA
 4351 ACCCGACTAC GCGGCGCTAG AAGGGCCAA GCGACGCTCA CCTACCACT
 4401 GGATCACCAC CGATCGGCGC CGACAGCTAT GGACCCCATC GCAAGATCAA
 4451 AACCCCTGAG CAGCCATCGC ACCGAGGCC CGGCACGCCG GAAGAAAGCTC
 4501 CGACGGCCCT CCTGTCCGGA CACGGCCTAA CGCGTCCAGA CCAGAACAG
 4551 TGCTCCGATC TAAACCGAAG GCGCTTCATG TGAGAGCATA GTCGTGACGT
 4601 CGGCACAGTA GTCGTGGCCG GCGGGGGTAA CGCTACACAA CGCTTAAAAAA
 4651 GCATCGGAGC AAGCTAACAC ACGGGGACTG ATGAACAAAA CACACAAAAT
 4701 GCGGACGCTG GTAATTGCCG CGATCTTGGC CGCCGGAATG ACCGCACCAA
 4751 CTGCCTATGC AGATTCTCCT GGAAACACCA GAATTACAGC CAGCGAGCAA
 4801 AGCGTCCTTA CCCAGATACT CGGCCACAAA CCTACACAAA CTGAATATAA
 4851 CCGATACGTT GAGACTTACG GAGCGTACG GACCGAAGCA GACATCAACG
 4901 CATATATAGA AGCGTCTGAA TCTGAGGGAT CATCAAGTCA AACGGCTGCT
 4951 CACGATGACT CGACATCACC CGGCACGAGT ACCGAAATCT ACACGCAGGC
 5001 AGCCCCTGCC AGGTCTCAA TGTTTTCCCT GTCCGGAACT TGGATCACTA
 5051 GGAGTGGTGT AGTATCGCTC TCCTTGAAGC CAAGGAAGGG TGGTATTGGC

FIGURE 11 (Sheet 3 of 7)


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5101 AACGAGGGGG ACGAGCGTAC CTCGAAGACT GTATACGACA AATTCCATAA
5151 CGCTGGCAA TGGACACGAT ACAAGAACAA CGGGTAGAC GCCAGCATGA
5201 AAAAGCAGTA CATGTGCCAC TTCAAGTACG GGATGGTGAA GACGCCATGG
5251 GTGTGCCATT TCTCACAATC CCGGGGTGCG ATTGTGCGGT TTCCCACAGG
5301 AATCGGGCGC OGGATCTGGA CGGTGCTGCG ACACGCCAT ATTGAAACG
5351 ATGTTCAAGTG CGTCAACCTC GACCCCAGTG CTGAACTTGT CCGTCGCGGG
5401 TGCAAGGATT GGACCCATGA GTCCCGAAA GATTGGCGTT ACCGAGCTCG
5451 CGCTCCGCGA CGCGCATCAG AGCCTGATTG CAACCCGGAT GACTGAGTTG
5501 GACACCATCG CAAATCCGTC CGATCCCGCG GTGCAGCGGA TCATCGATGT
5551 CACCAAGCCG TCGCGATCCA ACATAAAGAC AACGTTGATC GAGGACGTCG
5601 AGCCCCATC GCACACATC GCGGCCGGGG TGGAGTTCAT CGAGGTCTAC
5651 GCGAGCGACA GCAGTCCTT TCCATCTGAG TTGCTGGATC TGTGCGGGCG
5701 GCAGAACATA CCGGTCGGCC TCATCGACTC CTCGATCGTC AACCAAGTTGT
5751 TCAAGGGGGG GCGGAAGGCC AAGACATTG GCATCGCCCG CGTCCCTCGC
5801 CCGGCCAGGT TCGGCGATAT CGCGAGCCGG CGTGGGGACG TCGTCGTTCT
5851 CGACGGGGTG AAGATCGTCC CGAACATCGG CGCGATAGTA CGCACGTCGC
5901 TCGCGCTCGG AGCGTCGGGG ATCATCCTGG TCGACAGTGA CATCACCGC
5951 ATCGCGGACC CGCGCTCCA AAGGGCCAGC CGAGGTTACG TCTTCTCCCT
6001 TCCCCTCGTT CTCTCCGGTC GCGAGGAGGC CATCGCCTTC ATTGCGGACA
6051 GCGGTATGCA GCTGATGACG CTCAGGGCGG ATCGCGACAT TTCCGTGAAG
6101 GAACTCGGGG ACAATCCGGA TCGGCTGGCC TTGCTGTTCG GCAGCGAAAA
6151 GGGTGGGCCT TCCGACCTGT TCGAGGAGGC GTCTCCGCC TCGGTTCCA
6201 TCCCCATGAT GAGCCAGACC GAGTCTCTCA ACGTTTCCGT TTCCCTCGGA
6251 ATCGCGCTGC ACGAGAGGGAT CGACAGGAAT CTCGCGGCCA ACCGATAATC
6301 AGGCTGAGAA CGACCTGATC CGCCACTCCG GGAACCTCCG ACGCCCCGTC
6351 CCCTCGGGGG CGCGCGCTCC TGCATGTCCG GGGCAGGGG CAAGGCAGGC
6401 CTCCTACTTA TAATTGTCCC ATACGCGTCA TACTGGTTAG TCGCTGGAGA
6451 TCCAGACGTT TGGGACTTCT ATCGTTCTTT ATCGTTGGATT CCAGTGGCTT
6501 TTCTAGGAAT AGTTCAATA GTACTGATGG CTAGCAGTAG AGGTTGGGA
6551 CGACGTCTCG GCGACTCCGG AGAACACCAA GTCAGGGTCT CATGAGTGTG
6601 CGATAGTTG AGCTGTCTAC CAATCTGGAT ATAGCTATAT CGGTCGTTTG
6651 TGTCTGATTC GCCAGTGAGC CAACGGCGGG GGCAGACACGC GGTGGCGAAA
6701 CCCCCCTGGCA GAATTGTTAA TCATGGTCAT AGCTGTTTCC TGTGTGAAAT
6751 TGTATCCGC TCACAAATTCC ACACAAACATA CGAGCCGGAA GCATAAAGTG

FIGURE 11 (Sheet 4 of 7)


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6801 TAAAGCTGG OGTGCCTAAT GAGTGAGCTA ACTCACATTA ATTGCCTTGC
6851 GCTCACTGCC CGCTTTCCAG TCGGGAAACC TGTCGTGCCA GCTGCATTAA
6901 TGAATCGGCC AACCGCGCGG GAGAGGCGGT TTGGCTATTG GGCGCTCTTC
6951 CGCTTCCCTCG CTCACTGACT CGCTCGCTC GGTCGTTCGG CTGCGGCGAG
7001 CGGTATCAGC TCACTCAAAG GCGGTAATAC GGTTATCCAC AGAATCAGGG
7051 GATAACCGAG GAAAAGAACAT GTGAGCAAAA GGCCAGCAAA AGGCCAGGAA
7101 CCGTAAAAAG GCCGCCTTGC TGGCGTTTT CCATAGGCTC CGCCCCCTG
7151 ACGAGCATCA CAAAAATCGA CGCTCAAGTC AGAGGTGGCG AAACCCGACA
7201 GGACTATAAA GATAACCGAGC GTTTCCCCCT GGAAAGCTCCC TCGTGCCTC
7251 TCCTGTTCCG ACCCTGCCGC TTACCGGATA CCTGTCGCC 3' TTTCTCCCTT
7301 CGGGAAACGT GGGCCTTCT CAAAGCTCAC GCTGTAGGTA TCTCAGTTCG
7351 GTGTAGGTG TTGCGCTCCAA GCTGGGCTGT GTGACAGAAC CCCCCGTTCA
7401 GCGCGACCGC TGCGCCTTAT CGCGTAACCA TCGTCTTGAG TCCAACCCGG
7451 TAAGACACGA CTTATCGCCA CTGGCAGCAG CCACTGGTAA CAGGATTAGC
7501 AGAGCGAGGT ATGTAGGGCGG TGCTACAGAG TTCTGAGT GGTGGCCTAA
7551 CTACGGCTAC ACTAGAAGAA CAGTATTG TGCTGCGCT CTGCTGAAGC
7601 CAGTTACCTT CGGAAAAAGA GTTGGTAGCT CTTGATCCGG CAAACAAACC
7651 ACCGCTGGTA CGGGTGGTT TTTTGGTTGC AAGCAGCAGA TTACCGCGAG
7701 AAAAAAAGGA TCTCAAGAAG ATCCCTTGAT CTTTCTACG GGGTCTGAGC
7751 CTCAGTGGAA CGAAAACCTCA CGTTAAGGGA TTTTGGTCAT GAGATTATCA
7801 AAAAGGATCT TCACCTAGAT CTTTTAAAT TAAAATGAA GTTTTAAATC
7851 AATCTAAAGT ATATATGAGT AAACCTGGTC TGACAGTTAC CAATGCTTAA
7901 TCAGTGAGGC ACCTATCTCA GCGATCTGTC TATTTCTGTC ATCCATAGTT
7951 GCCTGACTCC CGTCGTGTA GATAACTACG ATACGGGAGG GCTTACCATC
8001 TGGCCCCAGT GCTGCAATGA TACCGCGAGA CCCACGCTCA CCGGCTCCAG
8051 ATTTATCAGC AATAAACCGAG CCAGCCGGAA GGGCCGAGCG CAGAAGTGGT
8101 CCTGCAACTT TATCCGCCCTC CATCCAGTCT ATTAATTGTT GCCGGGAAGC
8151 TAGAGTAAGT AGTCGCCAG TTAATAGTT GCGCAACGTT GTGCCATTG
8201 CTACAGGCAT CGTGGTGTCA CGCTCGTGT TTGGTATGGC TTCATTCAAC
8251 TCCGGTTCCC AACGATCAAG GCGAGTTACA TGATCCCCA TGTGTCGAA
8301 AAAAGCGGTT AGCTCCTTCG GTCCCTCCGAT CGTGTGAGA AGTAAGTTGG
8351 CCGCAGTGTG ATCACTCATG GTTATGCGAG CACTGCATAA TTCTCTTACT
8401 GTCATGCCAT CGGTAAGATG CTTTCTGTG ACTGGTGAGT ACTCAACCAA
8451 GTCATTCTGA GAATAGTGTG TGCGGGGACCGAGTTGCTCT TGCCCGCGT

FIGURE 11 (Sheet 5 of 7)


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9501 CAATACGGGA TAATACCGCG CCACATAGCA GAACTTTAAA AGTGCTCATC
9551 ATTGGAAAAC GTTCTTCGGG GCGAAAACTC TCAAGGATCT TACCGCTGTT
9601 GAGATCCAGT TCGATGTAAC CCACTCGTGC ACCCAACTGA TCTTCAGCAT
9651 CTTTTACTTT CACCAAGCGTT TCTGGGTGAG CAAAAACAGG AAGGCAAAAT
9701 GCGGAAAAAA AGGGATAAG GCGGACACGG AAATGTTGAA TACTCATACT
9751 CTTCCCTTTT CAATATTATT GAAGCATTTA TCAGGGTTAT TGTCTCATGA
9801 GCGGATACAT ATTTGAATGT ATTTAGAAAA ATAAACAAAT AGGGGTTCCG
9851 CGCACATTTG CCCGAAAAGT GCCACCTGAC GTCTAAGAAA CCATTATTAT
9901 CATGACATTA ACCTATAAAA ATAGGGTAT CACGAGGCC CTTCGTCTCG
9951 CGCGTTTCGG TGATGACGGT GAAAACCTCT GACACATGCA GCTCCCGGAG
9001 ACGGTACACAG CTTGTCTGTA AGCGGATGCC GGGAGCAGAC AAGCCCGTCA
9051 GGGCGCGTCA GCGGGTGTG GCGGGTGTG GGGCTGGCTT AACTATGCGG
9101 CATCAGAGCA GATTGTAATG AGAGTGCACC ATATGCGGTG TGAAATACCG
9151 CACAGATGCG TAAGGAGAAA ATACCGCATC AGGCGCCATT CGCCATTCA
9201 GCTGCGCAAC TGTTGGGAAG GCGGATCGGT GCGGGCCTCT TCGCTATTAC
9251 GCCAGCTGGC GAAAGGGGA TGTGCTGAA GCGGATTAAG TTGGGTAACG
9301 CCAGGGTTTT CCCAGTCACG ACGTTGTAAGG ACGACGGCCA GTGCCACTAG
9351 AGTGTGCCAT TTCTCACAAT CCCGGGGTGC GATTGTCGGG TTTCCACAG
9401 GAATCGGCGC GGGGATCTGG AGGGTGTG GACACGGCCA TATTTGAAC
9451 GATGTTCACT CGGTCAACCT CGACCCCCAGT GCTGAACCTG TCCGTCGG
9501 GTGCAAGGAT TGGACCCATG AGTCCGCGAA AGATTGGCGT TACCGAGCTC
9551 GCGCTCCCG ACAGCGCATCA GAGCCTGATT GCAACCCCGA TGAAGGTAC
9601 CACCGTCAAG GAGCTGGACG AGAAGCTCAA GGTCAATCAAG GAGGCCAGA
9651 AGAAGTTCTC GTGCTACTCG CAGGAGATGG TGGACGAGAT CTTCCGCAAC
9701 CCCGCGATGG CCGCGATCGA CGCCCCGATC GAGCTCCCA AGGCCCGGT
9751 CCTGGAGACC GGCATGGGCC TCGTCGAGGA CAAGGTGATC AAGAACCACT
9801 TCGCCGGCGA GTACATCTAC AACAAAGTACA AGGACGAGAA GACCTGCGGC
9851 ATCATCGAGC GCAACGADCC GTACGGCATC ACCAAGATCG CCGACCCAT
9901 CGCGCTCGTC GCGCGATCA TCCCCGTAC CAACCCGACC TCCACCACGA
9951 TCTTCAGTC GCTGATCTCG CTCAAGACCC GCAACGGCAT CTTCTCTCG
10001 CGCGACCCCG GCGCCAAGAA GTCGACCATC CTGGCCGCGA AGACCATCCT
10051 GGACGCCCGCG GTCAAGTCGG GCGCCCCCGA GAACATCATC GGCTGGATCG
10101 ACGAGCCCTC GATCGAGCTG ACCCAGTACC TGATGCAAGAA GGCGACATC
10151 ACCCTCGCCA CGGGCGGGCC CTCGCTCGTC AAGTCGGCCT ACTCGTCCGG

FIGURE 11 (Sheet 6 of 7)


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10201 CAAGCCGCC ATCGCGTGG GCGCGGGCAA CACCCCGTC ATCATCGACG
10251 AGTCCGCCA CATCAAGATG GCGGTCTCT CCATCATCCT CTCCAAGACC
10301 TACGACAACG CGTCATCTG CGCCTCGGAG CAGTCCGTGA TCGTCCTCAA
10351 GTCGATCTAC AACAAAGGTCA AGGACGAGTT CCAGGAGCGC GGGCCTACA
10401 TCATCAAGAA GAAGGAGCTG GACAAGGTC GCGAGGTAT CTTCAAGGAC
10451 GGCTCGGTGA ACCCCAAGAT CGTCGGCCAG TCUGGCTACA CCATCGCCGC
10501 GATGGCCGCC ATCAAGGTCC CGAAGACCAC CGCAGATCCTC ATCCGGAGG
10551 TCACCTCCCT GGCGGAGGAG GAGCCCTTCG CCCACGAGAA GCTCTCGCCC
10601 GTCCCTGGCA TGTACGAGGC CGACAACTTC GACGACGCCC TCAAGAAGGC
10651 CGTCACCCCTG ATCAACCTCG GCGGGCTGGG CCACACCTCC GGCACTCTACG
10701 CCGACGAGAT CAAGGGCCGC GACAAGATCG ACCGCTTCTC CTCGGCCATG
10751 AAGACCGTCC GCAACCTTCGTA CAACATCCCC ACCTCCAGG GCGCCTCCGG
10801 CGACCTGTAC AACTTCCGCA TCCCGCCCTC CTTCAACCTC GCGTCCGGCT
10851 TCTGGGGGGG CAACCTCCGTC TCGGAGAACG TGGGCGGAA GCAACCTGCTG
10901 AACATCAAGA CGGTGGCCGA GCGGGCGAG AACATGCTGT GGTTCGGCGT
10951 CCCCCACAAG GTCTACTTCA AGTTCCGGCTG CCTCCAGTT CCCCCTCAAGG
11001 ACCTCAAGGA CCTCAAGAAG AAGCGCGCT TCATCGTCAC CGACTCGGAC
11051 CCCTACAACC TGAACCTACGT CGACTCCATC ATCAAGATCC TCGACCCACCT
11101 CGACATCGAC TTCAAGGTCT TCAACAAAGT GGGCCCGAG GCGGACCTCA
11151 AGACCATCAA GAAGGCCACC GAGGAGATGT CGTCCTTCAT GCGCGACACC
11201 ATCATCGCCG TGGCGGGAC CCGGAGATG TCCTCCGCA AGCTGATGTG
11251 GGTCCCTAC GAGCACCCCG AGGTCAAGTT CGAGGACCTG GCCATCAAGT
11301 TCATGGACAT CGCGAACCGC ATCTACACCT TCCCCAAGCT GGGCAAGAAG
11351 GCGCATGCTCG TGGCCATCAC CACGTCGGCC GCGTCCGGCT CGGAGGTCAC
11401 CCCCTCGCC CTCGTGACCG ACAACAAACAC CGGCAACAAG TACATGCTCG
11451 CGGACTACGA GATGACCCCC AACATGGCCA TCGTGGACGC CGAGCTCATG
11501 ATGAAGATGC CGAAGGGCCT CACCGCCTAC TCGGGCATCG AGGCCCTGGT
11551 CAACTCGATC GAGGCTTACA CCTCCGTCTA CGCCTCCGAG TACACCAACG
11601 GCCTCGCCCT CGAGGCCATC CGCCTGATCT TCAAGTACCT CCCGGAGGCC
11651 TACAAGAACG GCGCGACCAA CGAGAAGGCC CGCGAGAAGA TGGCCCACGC
11701 GTCCACCATG GCCGGCATGG CGTCCGCCAA CGCCTTCCTC GCGCTCTGCC
11751 ACTCCATGGC CATCAAGCTG TCCTCCGGAC ACAACATCCC CTCCGGCATC
11801 GCGAACGGCCG TCCTCATCGA GGAGGTATC AAGTCAACG CGTGGACAA
11851 CCCGGTGAAG CAGGCCCCCT GCGCGACGTA CAAGTACCCCC AACACCATCT
11901 TCCGCTACGC CGCGATCGCC GACTACATCA AGCTGGCGG GAACACCGAC
11951 GAGGAGAAGG TCGACCTCT CATCAACAAG ATCCACGAGC TCAAGAAGGC
12001 CCTCAACATC CGGACCTTCA TCAAGGACGC CGCGCTGCTG GAGGAGAACT
12051 TCTACTCCCT CCTGGACCGC ATCTCGGAGC TCGCCCTGGA CGACCAGTGC
12101 ACCGGCGCCA ACCCGCGCTT CGCGCTCACC TCCGAGATCA AGGAGATGTA
12151 CATCAACTGC TTCAAGAACG AGCCCTGATG ATCAGGCTGA GAAACGACCTG
12201 ATCCGCCACT CGCGGAACCTC CGGACGCCGC GTCCCGCTGG GGGCGCGGCC
12251 TCCTGATGT CGGGCGCGAG GGGCAAGGCA GCGCTCCATC A

FIGURE 11 (Sheet 7 of 7)

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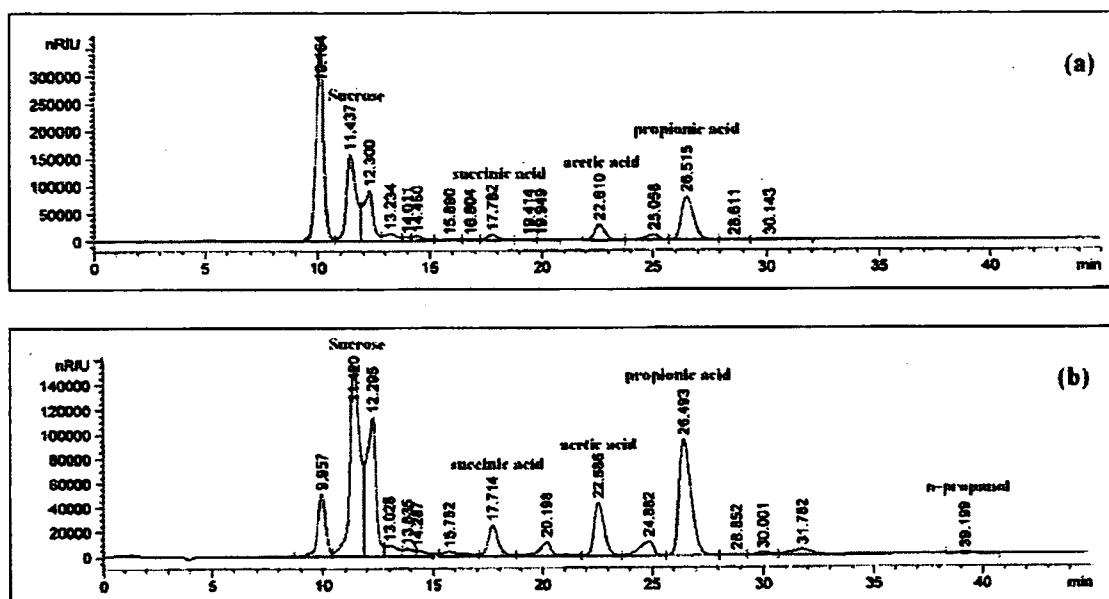


FIGURE 12


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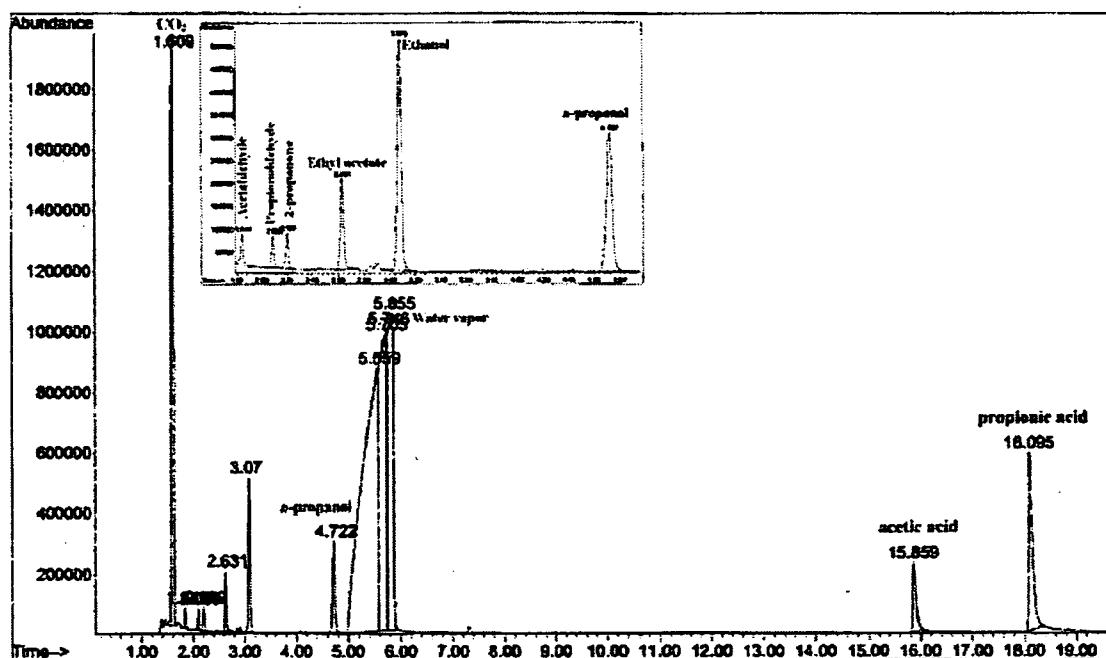


FIGURE 13


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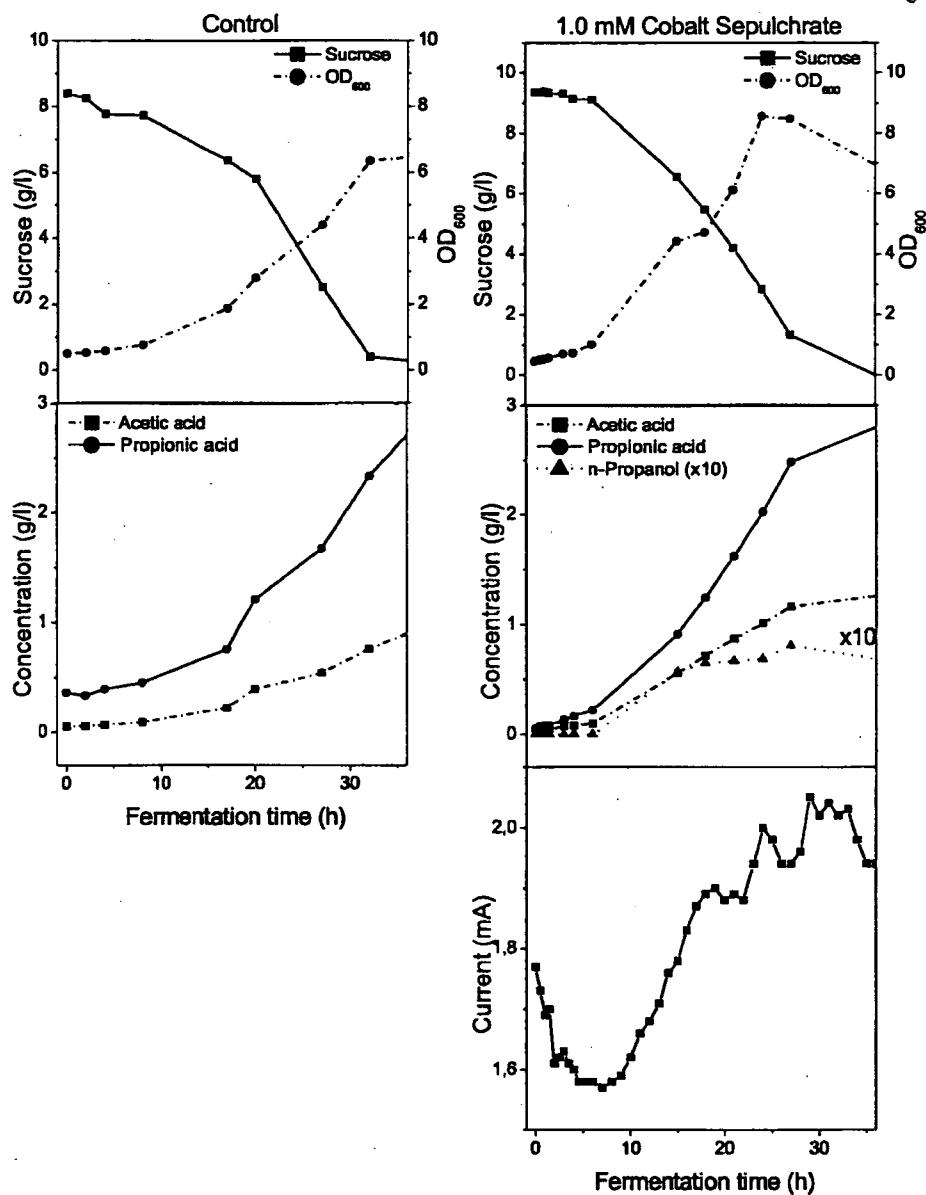


FIGURE 14

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FIELD OF THE INVENTION

The present invention relates to a process of bioconverting a biobased substrate (such as sugarcane juice, hydrolyzed starch, hydrolyzed cellulose or glycerol) into n-propanol using genetically modified microorganisms combined with a process for supplying reducing equivalents in the form of NAD(P)H during fermentation. The biobased n-propanol thus obtained could be dehydrated to propylene and polymerized to polypropylene to yield a bioplastic.

BACKGROUND OF THE INVENTION

n-Propanol (1-propanol, primary propyl alcohol, propan-1-ol) is a non-hazardous solvent that is freely miscible with water and other common solvents, with numerous applications in industry, such as printing inks, coatings, cleaners, adhesives, herbicides, insecticides, pharmaceuticals, de-icing fluids and as a chemical intermediate for the production of esters, propylamines, halides and thermoplastic resins. The use of n-propanol in fuel blends has also been suggested (U.S. Pat. No. 6,129,773), as this alcohol has the same capacity of ethanol to be used to increase as an antiknock additive and increase the octane number of gasoline according to Barannik V. P. et al. 2005, Chemistry and Technology of Fuels and Oils 41(6): 452-455.

n-Propanol is one of the main constituents of “fusel oils” or “potato oils”, which are the higher-order alcohols by-products of ethanol fermentation by the yeast *Saccharomyces cerevisiae* (Hazelwood et al. 2008. The Ehrlich Pathway for Fusel Alcohol Production: a Century of Research on *Saccharomyces cerevisiae* Metabolism. *Applied and Environmental Microbiology* 74(8): 2259-2266). In the past, n-Propanol was obtained by fractional distillation of fusel oil, but nowadays it is manufactured from fossil feedstocks in a two-stage process known as Oxo Process, comprising ethylene hydroformylation at 80-120°C and 2.0 MPa in the presence of cobalt or rhodium carbonyl followed by hydrogenation of the resulting propionaldehyde on a copper-chromium, nickel-chromium or porous cobalt catalyst (U.S. Pat. No. 4,263,449 and U.S. Pat. No 5,866,725).

Worldwide interest in organic compounds produced from renewable feedstocks has increased considerably in recent years, especially for compounds that can be used as fuels or as bulk chemicals for the petrochemical industry. The latter are particularly interesting, since these compounds could be fixed in highly durable materials that can be recycled,

thus effectively mitigating atmospheric CO₂ (Rincones et al. 2009. The golden bridge for nature: the new biology applied to bioplastics. *Polymer Reviews* 49: 85-106). Thus, the use of the chemical products obtained from renewable feedstocks is becoming increasingly accepted and widespread as a viable alternative aiming at decreasing our society's dependence on fossil carbon sources. Products obtained from green sources can be certified as to their renewable carbon content according to the methodology described by the technical norm ASTM D 6866-06: "Standard Test Methods for Determining the Biobased Content of Natural Range Materials Using Radiocarbon and Isotope Ratio Mass Spectrometry Analysis".

The production of short-chain organic solvents (mainly reduced alcohols) through microorganism fermentation has been extensively studied. The most dramatic example is the production of ethanol as a commodity chemical, which is a major industrial process reaching nearly 90 million m³/year and occurring by the fermentation of renewable carbon sources (mainly cornstarch and sugarcane juice) by the yeast *Saccharomyces cerevisiae*. This process is extremely efficient and has been refined to the point where ethanol distilled from the fermentation broth is obtained at 90-95% of the theoretical yield. The ethanol thus produced is used as an industrial solvent, as the main additive for gasoline in fuel blends and, in Brazil, is used as the sole fuel for small vehicles. Another use of a biobased ethanol is the manufacture of bio-ethylene to be used as a monomer in the polyethylene manufacture, through a dehydration reaction as described by Morschbäcker A. L. 2009, Bio-Ethanol Based Ethylene, *Journal of Macromolecular Science, Part C: Polymer Reviews*, 49:79–84.

Other well-known examples of solvent production by fermentation are the Acetone-Butanol-Ethanol (ABE) and the Isopropanol-Butanol-Ethanol (IBE) fermentations performed by some bacterial species of the genus *Clostridium*, yielding more than 35% by weight of the solvent mixture (U.S. Pat. No. 5,192,673). In addition, fermentation of 2,3-butanediol from carbohydrates by enteric bacteria of the genera *Klebsiella* and *Enterobacter* yields up to 47% by weight (Ji et al., 2009, *Bioresource Technology* 100:3410-3414). A recent success is the fermentative production of 1,3 propanediol from glucose in a single microorganism with high yield (35% w/w) and titer (129 g/L) (U.S. Pat. No. 7,169,588 B2; U.S. Pat. No. 7,067,300 B2; U.S. Pat. No. 5,686,276). The establishment of an industrial process for the production of this low cost

