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!"#\$%&' ( ) &\* '%+&\* , \$\* - + . '%+&\$# ! / # % - % ( # 0 \$ # 1 % & % & 2 \$ , % 2 1 ' \$ + & \$ ' 1 ( \$ - \* ) 3 \$  
1 % # ' + ) 4 \$ + 5 \$ ' 1 ( \$ / \* / 4 \$ 6 / , \* 7 3 \$ 8 \* ) 3 ( ' 9 \$

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\$%&! ' ( ) \* ( + , ! \$ - . / + - 0 !  
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1 \* . , + ! . / 2 + - / ( 2 . 3 / ( , ! ( 4 3 5 2 . 3 / ! . 6 ! ( ! 7 + ( 8 2 . 9 8 , ! ) 3 / ) + 5 2 ! . / ! 2 \* + 3 - % : ! 2 ! 3 9 2 + / ! , + ( 4 6 ! 2 3 ! 4 ( - ; ! ) 3 / 6 + < 8 + / ) + 6 = !  
> - 3 ? ! . 2 6 ! . / ) + 5 2 . 3 / : ! \* 8 ? ( / ! 2 - ( 9 9 . ) ; . / @ ! \* ( 6 ! + / ( 7 , + 4 ! . / 2 + - / ( 2 . 3 / ( , ! ( 4 3 5 2 . 3 / 6 = ! 1 \* . , + ! 2 \* + ! A / . 2 + 4 ! B 2 ( 2 + 6 !  
( , 3 / + ! ) ( / / 3 2 ! 4 . 6 ? ( / 2 , + ! 2 \* + ! + / 2 . - + ! 7 ( 7 % ! C 7 , ( ) ; ! ? ( - ; + 2 D ! ( / 4 ! 2 \* + ! , . ; + , % ! 7 , ( ) ; ! ? ( - ; + 2 ! 9 3 - ! ) \* . , 4 - + / E 6 !  
3 - @ ( / 6 ! . / 2 + - 2 F . / + 4 ! F . 2 \* ! . 2 : ! 2 \* + ! A = B = ! ) ( / ! - + ? 3 G + ! . 2 6 ! , ( - @ + ! ) 3 / 2 - . 7 8 2 . 3 / = ! ! \$ % ! , . ? . 2 / @ ! 2 \* + ! 9 + 4 + - ( , !  
( 4 3 5 2 . 3 / ! 6 8 7 6 . 4 % ! 2 3 ! 3 / , % ! 4 3 ? + 6 2 . ) ! ( 4 3 5 2 . 3 / 6 : ! 2 \* + ! A / . 2 + 4 ! B 2 ( 2 + 6 ! ) ( / ! + / 6 8 - + ! . 2 ! 3 / , % ! ( . 4 6 ! 6 % 6 2 + ? 6 !  
F . 2 \* . / ! . 2 6 ! ) 3 / 2 - 3 , ! ( / 4 ! ( 4 4 - + 6 6 ! 2 \* + ! / + + 4 6 ! 3 9 ! . 2 6 ! 3 F / ! ) \* . , 4 - + / ! F . 2 \* 3 8 2 ! \* 3 ? + 6 ! ? 3 - + ! + 9 9 + ) 2 . G + , % = ! ! H ( / % !  
3 2 \* + - ! ( 8 2 \* 3 - 6 ! \* ( G + ! ( , 6 3 ! / 3 2 + 4 ! G ( - . 3 8 6 ! \* 8 ? ( / ! 2 - ( 9 9 . ) ; . / @ ! ( / 4 ! 5 3 2 + / 2 . ( , ! 3 - @ ( / ! 2 - ( 9 9 . ) ; . / @ ! ) 3 / ) + - / 6 : !

./!5-+G+/2./@!2\*+!4.,82.3/!39!2\*+.-!-+638-)+6-

A/.3/=!! 1 3-,4! 1 (-!U!,. ;+,%!. /65.-+4!2\*.6!4+),(-2.3/:(6! ? (/%!%38/@!(48,26!+05+-./)+4!9.-62\*(/4!  
2\*+!\*3--3-6!39!\*3F!)\*.,4-+ /!F+-+!2-(2+4=!'!! ' (2\*+-!2\*(/!(!,.62!65+).9%./@!(!)\*.,4E6!-.@\*26!:!2!93)86+4!



39!)\*,.4-+/-D<sup>01</sup>!!Q\*+!S3/G+/2.3/!3/!2\*+! '.@\*26!39!2\*+!S\*.,4!F(6!(4352+4!7%!2\*+!V+/-+-(,!I 66+ ? 7,%!  
./!#]b]-<sup>02</sup>!! f /+!39!2\*+! ? 362!6F.92,%!(4352+4!-(2.9.)(2.3/6:2\*.6!4+),(-(2.3/!(,2+-+4!2\*+!F(%!)\*)\*.4-+/  
(-+!G.+F+4!,+@(!,%ZZ)\*.,4-+!/!F+-+!9./(!,%!@.G+!/(!8/.<8+!6+2!39!-.@\*26-<sup>03</sup>!!Q\*.6!4+),(-(2.3/!(,63!,(.4!  
2\*+!938/4(2.3/!39!2\*+!A/.2+4!T(2.3/6!S\*.,4-+!/!6!>8/4!hATUSX>i;!F\*.)\*)!,(2+-!7+)( ? +!(!5+- ? (/+/2!  
? + ? 7+-!39!2\*+!A/.2+4!T(2.3/6-<sup>06</sup>!!Q\*.6!3-@(/.L(2.3/!\* (6!(,63!())3 ? 5.,6\*+4!(!@-+(2!( ? 38/2!6./)+!  
2\*+!/ ) 1 .92c mB(\*+)0.2(!)-!3/!@-+!

(G(.,(7,+<sup>-13</sup>!!>3-!./62(/)+: I 4352.3/!B+-G.)+!e-3G.4+-6!h I Be6i! ? 862!7+!(.)-+4.2+4!23!+/68-+!2\*+6!  
(@+/.).+6!C ? ++2!)3 ? 5-+\*+/6.G+!9+4+-(,!62(/4(-46!4+6.@/+4!23!+/68-+!2\*(2!2\*+%!35+-(2+!86./@!638/4!  
5-39+66.3/(,!(/4!+2\*.)(!,(4352.3/!5-(.)+6=D<sup>16</sup>!

!

5=k3 -#\$"#+, -#k>4- ?+, -#k@\*-( "22k

U/!2\*+! A/.2+4!B2(2+6:(4352./@!9-3 ?!(! S3/G+/2.3/!62(2+!. /),84+6!6.0!4.62./)2!62+56=<sup>17</sup>!!>.-62:!2\*+!  
(4352.G+!9( ? .,%! ? 862! )\*336+!( /!(55-3G+4! (4352.3/!6+-G.)+! 5-3G.4+-!( /4! 2\*+!/ ! ? 862! 7+! 938/4!  
68.2(7,+!23!(4352!(!)\*. ,4=<sup>18</sup>!!

/8?7+-!39!9+?(,+!3-5\*(/6=26!!1\*.,+!2\*+!3/+P)\*.,4!53,.)%!F(6!(7(/43/+4!.!/"N#^:!2\*+)38/2-%!62.,,!9(+6!2\*+!(92+-? (2\*!F.2\*!.26!3G+-9,3F./@!3-5\*(/(@+6=27!

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5=kkA\*?/%##%I"2k,#k3/,##%kk

kk

XG+!/2\*38@\*!2\*+!+02-+?+!/+4!93-!3-5\*(/(@+6!-36+!(92+-!2\*+!5(66./@!39!2\*+!3/+P)\*.,4!53,.)%:  
3-5\*(/(@+6!\* (G+!+0.62+4!.!S\*/(!+G+-!6./)+!X?5+-3-!18E6!938/4./@!39!2\*+!@3G+-/?+/2P-8/!  
9(.,-2%!./!d"#!I=K=28!!Q\*.6!3-5\*(/(@+!/32!3/,%)(-+4!93-!)\*.4-+!/782!(,63!93-!+,4+-,%!(48,26!F.2\*382!  
)\*.4-+/=39!!Q\*.6!(,2-8.62.)!938/4./@!633/!28-/+4!7-82(,=!U2!\* (6!7++/!4.6)3G+-+4!2\*(2!B\*(/@\*(!  
3-5\*(/(@+6!\* (G+!\*3--.9)(,%,!(786+4!2\*+.-!)\*.4-+!/!. /),84./@!C4+,.7+-(-2+!62(-G(2.3/!23-28-+!(/4!  
6+08(,(66(8,2:!)3/2./8+4!3G+-!(!5+-34!39!?(/%!%+(-6!(/4!,+4!23!2\*+!8// (28-(,!4+(2\*6!39!F+.,!3G+-!  
#:NNN!)\*.4-+!/7+2F++/!#]b^(/4!#]"]"!(,3/+D3!!Q\*+!587,.)!633/!@-+F!)3/)+-/+4!(7382!2\*+6+!  
)\*.4-+!/!(/4!2\*+!@3G+-/?+/2!9(+4!5-+668-+!23!9.0!2\*+!6%62+?.)! (786+!39!2\*+!)\*.4-+/=3/!!  
T+G+-2\*+,+66:!(/%!@3G+-/?+/2!399.)+-6!C;/3F./@,%!6855-+66+4!+G.4+/)+!39!)\*.,4!(786+!(2!2\*+!  
3-5\*(/(@+!:15+-6.62+/2,%!.@/3-+4!2\*+!. /62.282+E6!\*.\*?!?3/2\*,%4+(2\*!9.@8-+6:(/4!.!/#]"]":!<8(6\*+4!  
(/!. /G+62.@(2.3/!. /23!3-5\*(/(@+!5-()2.)+6-D30!!U2!F(6!(6%!93-!2\*+?!23!)3G+-!2\*+.-!2-();6:!(6!2\*+!  
\$8-+(8!39!I99(-6!)38,4!+(6.,%!4.6536+!39!2\*+!\*3--.9%./@!+-02(62(+0.2(/)0.2(+0.2(!)-24.8601.92cmBT502/3(2)0



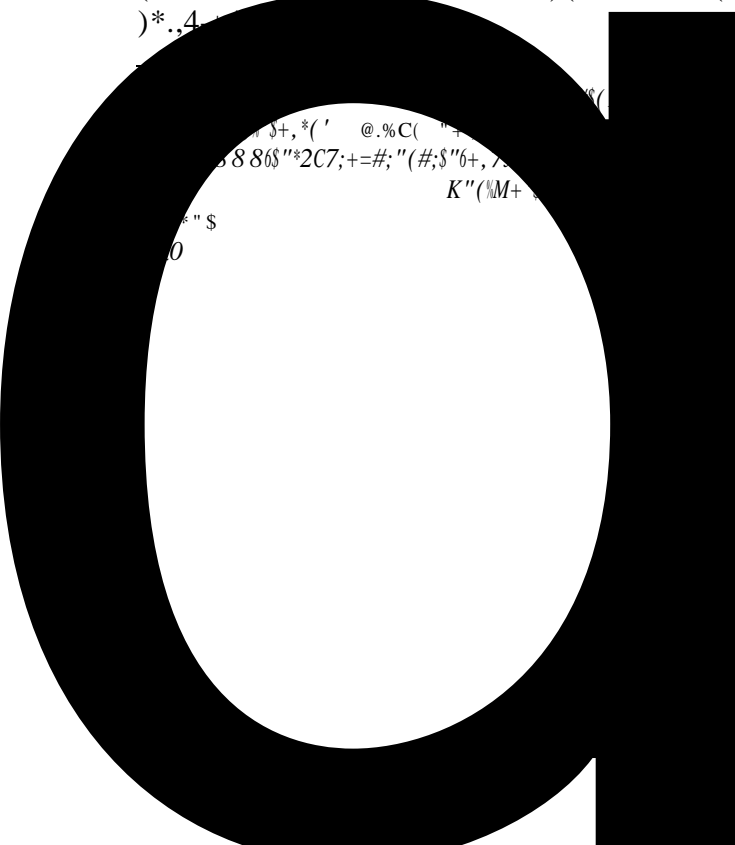
./!2\*+!#] ]N6<sup>-37</sup>!!B3 ? +!)\*,4-+/-+6.4+!./!(!9362+-!)(-+!)3 ? ? 8/.2%!6%62+ ?!(/4!(-+!4.G.4+4!( ? 3/@62!  
\*386+6!./!( ? 3-+!-8-(,)3 ? ? 8/.2%<sup>-38</sup>!!>3-!+0( ? 5,+:(!9362+-!)(-+!)3 ? ? 8/.2%!./!B\*+/%(/@:!S\*./(!  
5,(+6!2F3!)\*.,4-+/-!F.2\*./!+(\*)!\*3 ? +=<sup>69</sup>!! f /+!39!2\*+6+!)\*.,4-+/-!6!+(6.,%! ? 37.,+;!782!2\*+!32\*+-.!6!  
392+/-!4.6(7,+4!(/4!/++46!(66.62(/)+!23! ? 3G+=<sup>6</sup>!!K.6(7,+4!)\*.,4-+/-!68--+/4+-+4!23!2\*+!@3G+-/ ? +/2!

9362+!)(-+!6%62+ ? :! ? (/ %!@3G+/- ? +/2!399.).(,6!(/4!3-5\*( / (@+6!)3/2./8+!23!-+986+!23!2( ;+!)-+4.2!93-!  
2\*+.-!( )2.3/6=7/!

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U/4.(E6!9362+!)(-+!6%62+ ? !.6! ? 3-+!4+)+/2-(.,L+4!)3 ? 5(-+4!23!32\*+!/(2.3/6:!(6!.2!.6!6+2!85!(-38/4!  
4.99+ +/2!G3,8/2(-%!(/4!587,.)!. /62.282.3/6=70!! I ,3/@!F.2\*!3-5\*( / (@+6!(/4!)\*. ,4-+ /E6!\*3 ? +6:!2\*+--+!  
(-+! (,63! /3/P)3/G+/2.3/(, ! /62.282.3/6=71! ! Q\*+! ? 362! 5358,(-! /3/P)3/G+/2.3/(, ! (,2+-(2.G+! .6!  
B(. j -.5(! [ 3 ? +6=72!!U/62+(4!39!(!2-(4.2.3/(, !9( ? ,.%! ? 34+; !2\*+6+!\*3 ? +6!+ /)38-(@+!2\*+!3,4+-!9362+!  
%382\*!23!2( ;+!)(-+!39!2\*+!%38/@+!%382\*=-! 1 \*.,+!2\*+!73%6!(/4!@.-,6!(-+!6+5(-2+4!2\*+%( -+!2(8@\*2!23!  
5-32+)2!+ ) \*!32\*+--!!

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I ,3/@! F.2\*!4.99+ +/2! . /62.282.3/6: !U/4.( ! (,63!\* (6!. ? 5,+ ? +/2+4! ? (/ %!, (F6!23!)3 ? 7(2!)\*. ,4! (786+!  
(/4! /+@,+)2=73!!Q\*+!V8(-4.( /6!( /4! 1 (-46! I )2!39!#b]N!9.-62!6+2!2\*+!7(6.)!482.+6!39!@8(-4.( /6!39!( !  
5+-63/=76!!U2! (,63! +/ ( )2+4! 2\*+! 5-3)+66!93-! 7+)3 ? ./@! @8(-4.( /39! (!)\*. ,4! 32\*+ -F.6+! ; /3F/! (6!  
(4352.3/!3-!68--+/4+-./@!(!)\*. ,4!2\* (2!3/+!\* (6! /32!5-35+-,%!2( ;+! /) (-+!39=77!! I , ? 362!3/+!\*8/4+4!  
%+(-6!, (2+-!Q\*+! [ ./48! I 4352.3/6!( /4!H (. /2+ / ( /) +! I )2!39!#]d^!, (4!382!2\*+!938/4(2.3/!93-!F\*(2!( !  
G(.4!(4352.3/!+ /)3 ? 5(66+6: !F\*3!\* (6!2\*+! (7.,.2%!23!(4352!( !)\*. ,4! ( /4!2\*+!37.,@ (2.3/6!2\* (2!93,,3F!  
(4352.3/=78!!Y+2!2\*+!5-3G.6.3/6!93)86!3/! [ ./486!43 ? .),+4!./!U/4.( :!3/,%!(.,3F./@! [ ./48! ? (,+6!  
(/4!9+ ? (,+6!23!(4352=89!!U/!2(/4+ ? :!Q\*+! 1 3 ? +/!6!( /4!S\*. ,4-+ /!6!U/62.282.3/6!hJ.)+ /6./@! i! I )2!39!  
#]d^!F(6!(,63!+ / ( )2+4=8!! 1 \*.,+ /32!93)86+4!3/!(4352.3/6: !2\* .6! ( )2! ( ? +4!93-!2\*+!7+22+- ? +/2!39!  
F3 ? +/!( /4!)\*. ,4-+ /E6!F+,9(-+!:-+<8.-./@!( !,+ /@2\*%!5-3)+66!93-!./62.282.3/6!)(-./@!93-!2\*+ ? !23!@+2!  
,.)+ /6+4=8!! J (62,%: ! 2\*+! \_8G+ / .,+! \_862.)+! I )2! 39! #]b^! (,63! 4.4/E2! (44-+66! (4352.3/! 4.-+)2,%=-80!!  
U/62+(4: ! .2! 93)86+4! 3/! 2\*+! -+\*(7.,.2(2.3/! 39! /+@,+ )2+4! )\*. ,4-+ /! F\*3! +/4! 85! 5(-2.)5(2./@! ./!  
4+., /<8+ /2! ( )2.G.2.+6=81!!Q\*.6!.6!a862!(6!G.2(,!39!( /!+ / ( )2 ? +/2!(6!2\*+!3 /+6!4.-+)2,%!68--38/4./@!9362+!  
) (-+! 7+)(86+! ? (/ %! 9362+! )\*. ,4-+ /! 43! /32! \* (G+! 2\*+! 68553-2! 2\*+%! /++4! 23! / (G.@(2+! ,.9+!  
' +\*(7.,.2(2.3/! 6!. ? 5+- (2.G+!93-!2\*+6+!)\*. ,4-+ /! (6!2\*+!\* (G+!,. ; ,%! /+G+!\*(4!-3,+! ? 34+ ,6!23!@8.4+!  
2\*+ ? !2\*-38@\*!-.@\*2!( /4!F-3 /@=!! f G+-!2\*+!5(62!2F3!\*8/4-+4!%+(-6:!.2!6!),+(-!2\*+!,+@.6, (28-+!\*(6!7+ /!  
(22+ ? 52./@!23!-+93- ? !2\*+!9362+!)(-+!6%62+ ? ! (/4!2\*+!4.-+!382)3 ? +6!2\*+!5-3@-( ? !)( /!\* (G+!3/!2\*+!  
)\*. ,4



)+\$\$ (2%L+\*J( '4%: "":0, (2%8 "+%8(, (%.,#EOE;(2\$;-#0+I\$(0%  
\$+,\*( ' @.%C( " "  
8 86\$"\*2C7;+=#;"(#;\$"6+, / , 7+\$\$ (29D+\*J('   
K"(%M+ &20# -&=#"(<<: & ( @." \$( &" ,#\*&( \*+: %\$( @&(

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XG+!/F.2\*!G(-.386!5-3@-(?6!23!2-%!23!+/)38-(@+!(4352.3/;!?(a3-!5-37,+?6!62.,!+0.6!F.2\*./!2\*+!  
6%62+?=!I!62(@@+./@!3/+P938-2\*!39!K+,\*E6!\*3?+,+66!(-+!)\*,4-+/:!(/4!3/+!382!39!+G+-%!\*8/4-+4!  
5-362.282+6!.6!(!)\*.,4!8/4+-!2\*+!(@+!39!9.92++/=83!I44.2.3/(,%,?!?(/%!(7(/43/+4!7(7.+6!(-+!,+92!382!  
3/!2\*+!62-++2!23!+.2\*+-!62(-G+!3-!4.+!9-3?!G(-.386!(/.?(,E!(22());6-86!!XG+!/F\*+!/)\*.,4-+!/(-+!  
C(4352+4D!7%!\*3?+6:!(/%!39!2\*+6+!(4352.3/6!28-!/382!23!7+!5(-2!39!(!7,());!?(;-+2!6)\*+?+:!6+,,./@!  
2\*+!7(7.+6!(6!)\*.,4-+!/3-!3-@(/6-87!

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K=

C ? ( ; +!68-+!2\*(2!)\*. ,4-+/. /!) (-+!234(%!43!/32!7+)3 ? +!2\*+!G.)2. ? 6!39!23 ? 3--3F=D!<sup>197</sup>!!S3/6+<8+/2,%:!  
./2+-)38/2-%!(4352.3/!39!)\*. ,4-+/. /!2\*+!T+2\*+-. (/46!.6!/3F!8/(G(.,(7,+=<sup>198</sup>!

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X= ' !

' 866.(E6!9362+-!)(-+!6%62+ ? !.6!7(6+4!(-38/4!3-5\*( / (@+6:!. /!F\*. )!\*!9362+-!9( ? .,+6!)(/!7+)3 ? +!( /!  
./2+@-(,! 5(-2! 39! ? (. /2(. / . / @! 2\*+! )\*. ,4-+ /! (/4! 2\*+! 68553-2! -+<8.-+4! 23! -( .6+! 2\*+ ? =! ! ' 866.( /!  
3-5\*( / (@+6!(-+! ; /3F /!(6!C\$(7%! [ 386+6:D!93-!)\*. ,4-+ /!9-3 ? !2\*-++!23!9.G+:( /4!CK+26;%!K3 ? E6:D!  
93-!)\*. ,4-+ /!( @+6!6+G+ /!23!6.02++ / =! <sup>19</sup>!! 1 .2\*!3G+-! \NN:NNN!3-5\*( /6!)8--+/2,%!.G. / @! . /! ' 866.( :!2\*+!  
/8 ? 7+-!)3/2. /8+6!23!./)-+(6+!7%!###` :NNN!+G+-!%+(-=!!!!Q\*.6/8 ? 7+-!. /),84+6!(7382!]d n !39!63).(,!  
3-5\*( /6: ! ? + ( / . / @! ( ! , .G. / @! 5(-+ /2! 68--+/4+-+4!2\*+ ? !23!2\*+! 62(2+!! XG+ /! .9!)\*. ,4-+ /! (-+! . /!2\*+.-!  
5(-+ /2E6!)(-+!63 ? +2. ? +6!2\*+!@3G+- / ? + /2!(66.@ /6!2\*+ ? !23!3-5\*( / (@+6!.9!2\*+!5(-+ /26!\* (G+!-+986+4!  
23!+ /-3,,!2\*+ ? !. /!( /!+48)(2.3 / (,!. /62.282.3 / =! <sup>1</sup>!!Y+2:163 ? +!39!2\*+6+!3-5\*( / (@+6!3 / ,%!5-3G.4+!)\*. ,4-+ /!  
F.2\*! +48)(2.3 /! 85! 23! 2\*+! 6.02\*! @-(4+! F\*. )\*! + /46! 85! ,. ? .2. / @! 3-5\*( /6! 23! ,3FP+48)(2.3 /!  
3553-28 / .2.+6!3 / )+!2\*+%( @+!382!39!2\*+!6%62+ ? =! <sup>10</sup>!!

!  
5=<>CD2+''< & - . & >E; 2''&

>8-2\*+- ? 3-+! ? ( / %!39!2\*+! ' 866.( /!3-5\*( / (@+6!(-+! ; /3F /!23!7+!C56%)\*363).( ,,%!4+5-.G. / @! ' 866.( /!  
./62.282.3 /6! 2\*(2! 5-3G.4+4! (4+<8(2+! 5\*%6.)(,! -+638-)+6! 782! /32! )3/6.62+/2: ! -+653/6.G+!  
(-+@.G. / @=D!<sup>11</sup>!!

k\*+-1!(/4!4-(@!k\*+-1!7%!2\*+!\*(-=!7!!Q\*+%!(G+!k\*+-1!5.,6!23!)(,?!\*+-!43F/εD!8!!I/32\*+-!%38/@!  
?(/!/32+4!2\*+!62(99!C)3/62(/2,%!@(G+k)\*.,4-+/!./a+)2.3/6:!(/4!2\*+/!2\*+%!6+/2!k2\*+?1!23!2\*+!7+4-33?!  
63!2\*(2!k2\*+%1!F38,4!6,++5=D!9!!  
!

CT(2.3/(, I)2.3/!B2-(2+@%!./!2\*+!U/2+-+626!39!S\*.,4-+!/93-"N#"P"N#\D!F(6!-+)+/2,%!. ? 5,+ ? +/2+4!  
./!(/+993-2!23!-+28-/)!.4-+!/F.2\*!4.6(7.,2.+6!23!2\*+.-!7.-2\*!9( ? ..+6!(/4!5-3G.4+! ? 3-+!./),86.G+!  
)3 ? ? 8/.2.+6!23!5--G+/2!)!.4!(7(/43/ ? +/2=!U/(44.2.3/!2\*+!@3G+-/ ? +/2!6!(,63!62(-2./@!23!5,( )+!  
? 3-+!+ ? 5\*(6.6!3/!9362+-!9( ? ..+6=1/8!! f G+- (.,!2\*+!@3G+-/ ? +/2!7+,.+G+6!2\*.6! F.,! \*+,5! (G3.4!2\*+!  
(786+!2(;./@!5,( )+!F.2\*./!2\*+!3-5\*( / (@+6=!!

!  
1 \*+!/./!9362+-!)(-+!)!.4-+!/F.,!7+!/65+)2+4!7%!(!e6%)\*3,3@3PH+4.)(,Pe+4(@3@.)(,!S3 ? ? .66.3/!  
heHeSi=<sup>109</sup>!!Q\*.6!)3 ? ? .66.3/! F.,!C ? +4.)(,,%!(/4!56%)\*3,3@.)(,,%!+0( ? ./+!)!.4-+!/!.4+/2.9%!  
4+G+,35 ? +/2(,! 4+,(%6!( /4! 93- ? 8,(2+! (! 62-8)28-+4! 5,(/! 93-! (! )\*.4E6! 98-2\*+-! +48)(2.3/! (/4!  
857-./@./@=D!0!!

j 3-+(16+/2!:=!!:=!! j 3-+(!F(6!2\*+!/8 ? 7+-P3+/!6+/4./@!)38/2-%!39!)\*.,4-+!/23!2\*+!A/.2+4!B2(2+6!8/2.,!  
#]jdD!06! ! Q\*+6+! \*.623-.)(! ? 3 ? +/26! F++! 98/4( ? +/2(! 23! ./2+-/(2.3/(! (4352.3/E6! ./)-+(6./@!  
5358,(-.2%!!!!

!  
Y+2!:2\*+! 1 3-,4! 1 (-6!F++!/32!2\*+!3/,%!./9,8+!) +6!3/!./2+-/(2.3/(! (4352.3/6:!(6!2\*+--+!F++! ? (/!  
)+,+7-.2.+6!2\*(2!\*+.@\*2+/+4!2\*+!4+ ? (/4!93-!./2+-/(2.3/(!)\*.,4-+/=!!B3 ? +!39!2\*+!9.-62!) +,+7-.2.+6!23!  
(4352! ./2+-/(2.3/(!,%! F++! H/"& C- ;#4& -.& I ; 2,(E6! \_8, +! I /4-+F6! (/4! H/"& J,#I& %#4& GE6! Y8,!  
\$-+//+=-!07!! Q\*+6+! 9-./46! 732\*! (4352+4! (!5(-! 39!)\*.,4-+!/9-3 ? ! c .+2/( ? !./! 2\*+! #] \N6:!(/4!  
)+,+7-.2.+6!H.(!>(-3F!(/4! I /4-+F!e+,G./!(4352+4!)\*.,4-+!/9-3 ? ! j 3-+(-!08!! [ 3, %F334!(4352.3/6!  
)(-.+4! ./23! 2\*+! 2F+/2%P9.-62! )+/28-%:!(6!6++! /F.2\*! I /@+,./(!\_3, +! (/4! \$-(4! e.22-! ! Q\*.6! )385,+!  
(4352+4!)\*.,4-+!/9-3 ? !S( ? 734.(!X2\*.35.(!H(, (F.:(/4! c .+2/( ? =!19!! 1 \*.,+!) +,+7-.2%!(4352.3/6!  
43!/32! ? ( ;+85!2\*+! ? (66!5+-)/2(@+!39!(4352.3/6: !2\*+%!35+/+4!2\*+!+%+6!39!2\*+! I ? +-.) (/!587,.)!23-!  
2\*+!5366.7.,2%!(/4!(-@8(7,%!) + (2+4!(!C2-+/4D!93-!(4352./@!./2+-/(2.3/(!)\*.,4-+/=!!11!

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>8-2\*+:-!+.,@.3/!\*(6!7++/!(/!. /9,8+!) +13/!./2+-/(2.3/(! (4352.3/!6++/!(6!(!F(!23!65-+(4!9(.2\*!(/4!  
,3G+!23!)38/2-.+6!2\*(2!(-+!5(-2.)8,(-,%!6899+-./@=-!11!>3-!)+2(./!-+.,@.386!6+)23-6:!.2!.6!/32!(!2-+/4:!  
782! (!482%=-!10! ' +@(-4,+66: ! ? (/%! -+.,@.3/6! (/4!)\*8-)\*+6!9./4! 7+(82%! ./!(.,!93- ? 6! 39! (4352.3/!:  
G.+F./@!.2!(6!(!F(!23!5-3G.4+!2\*+!8/ )3/4.2.3/(!,3G+13/,%!(15(-+/2!)(/!@.G+!23!(!)\*.,4=!!U/2+-/(2.3/(!  
(4352.3/!9)+6!6+G+-(,!668+6: !+G+!/2\*38@\*! ? (/%! 39!2\*+ ? ! ? (%!7+!8./2+/4+4=!!B8)\*!5-37,+ ? 6!  
9(./@!./2+-/(2.3/(! (4352.3/!./),84+!8 ? (/!2-(99.);./@!(6!F+.,!(6!532+/2.(!3-@(/!2-(99.);./@!(/4!  
\*(-G+62./@=!!>8-2\*+ ? 3-+!2\*+!./)-+(6+4!93)86!3/!) \*.,4-+!/3G+-6+(6!4.-+)2,%!.@/3-+6!2\*+!)\*.,4-+!/./!  
38-!3F/!43 ? +62.)!9362+!)-(+!6%62+ ? 6=!!!

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I,2\*38@\*! \*8 ? (/! 2-(99.);./@! \*(6! \*.623-.) (.,%! 7++/! (! 5-+G(+/2! ./4862-%:!.2! \*(6! 7+)3 ? +! (!  
)3/)+-././@,%!,(-@+! 5(-2! 39! ./2+-/(2.3/(! (4352.3/6! 48+!23! ? 34+-/P4(%!2+)\* /3,3@%!(/4!+(6+! 39!  
2-(G+,-!! I 6!2\*+!5358,(-.2%!39!./2+-/(2.3/(! (4352.3/6!./)-+(6+4!./!2\*+!,(2+!#]NN6: !2\*+!4+ ? (/4!93-!  
(4352(7,+!)\*.,4-+!/!-36+!(6!F+.,=-!11!!

+0)++4+4!2\*+!(G(.,(7,+!)\*.4-+!/93-(4352.3/!/!2\*+6+)38/2-.+6<sup>-112</sup>!! I 6!)3/2-(+52.G+6!7+)( ? +! ? 3-+!  
-+(4.,%!(G(.,(7,+!(/4!2\*+!62.@ ? (!68--38/4./@!8/F+4! ? 32\*+-6!4+)-+(6+4:!2\*+-+! F+-+!+G+!/9+F+-!  
)\*.4-+!/!(G(.,(7,+!23!(4352!F3-,4F.4+<sup>-113</sup>!!T3F:!(6!)38/2-.+6!5-3@-+66.G+,%!4+)-. ? ./(.L+!(73-2.3/!  
2\*+-+!,. ; +,%!F.,!7+!+G+!/9+F+-!)\*.4-+!/!(G(.,(7,+<sup>-116</sup>!

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U/.2(.,%:(4352.3/!F(6!C4-.G+!/7%!(!\*8 ? (/2(-./!-+653/6+:D!782!5-365+)2.G+!5(-+/26! F\*3! F+-+!  
4+65+-(-2+!23!\*(G+!)\*.4-+!/62(-2+4!5(%./@!68762(/2.(,!( ? 38/26!39! ? 3/+%!23!(<8.-+!)\*.4-+!/=!!Q\*.6!



U/! 3/+! 623-%! 8/)3G+-+4! 7%! S\*(-, +! S862+-! ./! Q I :!(! 9( ? .,%! (4352+4! (!)\*.,4! 9-3 ?!  
S\*./ (= !23!! Q\*+! (4352.G+! 5(-+/26! 62(-2+4! ./G+62.@(2./@! 2\*+! 3-.@./6! 39! 2\*+.-! (4352+4! 4(8@\*2+-! (92+-!  
/32.)./@! 63 ? +! .--@8, (-.2.+6! ./! 2\*+! (4352.3/! 5-3)+66= !26!! 1 \*+ /! 2\*+! 5(-+/26! F+-+! 9./ (, %! (7,+! 23! @+2!  
./! 238)\*! F.2\*! 2\*+! ? (/! F\*3! C938/4D! 2\*+!, .22,+! @.-, :!\*+! (4 ? .22+4! 2\*+!)\*.,4! F(6! 58-)\* (6+4=!! B28//+4:!  
2\*+! 5(-+/26! 2\*+ /! \*+(-4! (7382! 2\*+! 4.-+)23-! 39! 2\*+! 3-5\* (/ (@+! F\*3! 6++ ? +4! 23!)3/9.- ? !2\*+! (4352.3/!  
(@+ /)%! 738@\*2! 2\*+! 7(7%= !27!! U/! (/3! 2\*+.-! ./2+-G.+F! 587,.6\*+4! 7%! Q V :! 2F3! (4352.G+!

5+35,+!C9./4+-6!9++6:D!(!5(% ? +/2!93-!)\*.4-+!/7-38@\*2!23!2\*+.-!(@+/@)%=-!32!!Q-(99.);+-6!392+/-+)-8.2!  
>./4+-6!F.2\*!(!5-3 ? .6+4!5(% ? +/2:!. /)-+(6+4!62(286:!3-!,+66!(786+=!33!

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XG+/@2\*+!@3G+-/? +/2!.6!/32!6(9+!9-3 ?!)3--852.3/:(6! ? (/!@3G+-/? +/2!399.).(,6!\* (G+!2( ; +/!5(-2!./!  
2\*+!6)\*+ ? +=!36!!>3-!./62(/)+!3/+!39!2\*+!C,(-@+62!-./@6!k./!V8(2+ ? (,(!!.6!(,+,@+4,%!\*+(4+4!7%!(!235!  
@3G+-/? +/2! 399.).(,=D!37! ! Q\*+! -./@! ./),84+4! 2\*+! 3-5\*(/(@+! .26+,9:!(6! .2! C<sub>m</sub>7+,3/@+4! 23! 2\*+!  
@3G+-/? +/2:!(/4! ? (/!%!k)\*.4-+!/1!F\*3!F+/2!2\*-38@\*!2\*.6!./62.282.3!/F+-+!6+/2!23!S(/(4(!3-!2\*+!  
A/.2+4!B2(2+6:!.+,+@ (,%,!7+)(86+!2\*+-+! F(6!(/!(@-++ ? +/2!7+2F++/!2\*+!V8(2+ ? (,(/!@3G+-/? +/2!  
(/4!2\*+! 3-5\*(/(@+=D!38!!

@-(2,%!8/4+--+53-2+4=D<sup>166</sup>!!



62-++26=^9!!Q\*+!/(2.3/!633/(4G(/)+4:!(6!./!#^ ^!(!6+G+/P%+(-P3,4!7+)(?+!2\*+!9.-62!-)3@/.L+4!  
9362+-!)\*,4=^9/!!

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B2.,:!(4352.3/!-+@8,(2.3/6!F+--+! /32!. ? 5,+ ? +/2+4!8/2.,!2\*+! ? .4P#bNN6!F\*+!/H(66()\*86+226!5(66+4!  
(!62(282+193)86./@!3/!)\*,4!F+,9(-+!./!2\*+!(4352.3/!5-3)+66=^90!!>3,,3F./@!6\*3-2,%:!S\*(-,+6!J3-./@!  
\$-())+:! 2\*+! 4.-+)23-! 39! 2\*+! T+F! Y3-;! S\*,4-+/E6! I .4! B3).+2%:! 7+@(/! 2\*+! 9362+-!)(-+! 6%62+ ?!  
? 3G+ ? +/2!./!#bd`=^91!!K8+!23!2\*.6!3-@(/.L(2.3/E6!5,(+) + ? +/26:! ? (/!62(2+6!(/4!63).(!(@+/.).+6!  
7+@(/!23!@+2!./G3,G+4!./!2\*+! ? (22+-ZZ98-2\*+-. /@!2\*+!,+@(!5-32+)2.3/6!39!2\*+6+!)\*,4-+/=^92!!Q\*-++!  
62(2+6!,+4!2\*+! ? 3G+ ? +/2!H(66()\*86+226!e+//6%,G(/.(:!(/4!B382\*!K(; 32(=^93!!H(66()\*86+226!7+@(/!  
6876.4.L./@!9( ? ..,+6!F\*3!233;!./!(!9362+-!)\*,4:!(/4!B382\*!K(; 32(!7+@(/!6876.4.L./@!2\*+!S\*,4-+/E6!  
[ 3 ? +!B3).+2%=^96!!e+//6%,G(/.(!5(66+4!(!9362+-!,.)+6./@!,(F:! ? (;./@!.! ? (/4(23-%!23!372(./!(!  
.,)+/6+!7+93-+!9362+-./@! ? 3-+!2\*(/!3+/!)\*,4=^97!!U2!F(6/E2!8/2.,!2\*+!#]NN6!2\*(2!@3G+-/ ? +/2!(@+/.).+6!  
7+@(/!23! ; +5!-)3-46!3/!9362+-!)\*,4-+/:!5+-93- ? !\*3 ? +!./G+62.@(2.3/6!(/4!4+2+ ? ./+!2\*+!7+62!  
./2+-+62!39!2\*+!)\*,4=^98!!

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XG+/(92+-!%+(-6!39!. ? 5,+ ? +/2(2.3/!2\*+!9362+-!)(-+!62.,!9()+6! ? (a3-!.668+6-! 1 .2\*(7382!MM` :NN!  
9362+-!)(-+!)\*,4-+/:!./!2\*+!A/.2+4!B2(2+6!2\*+!/8 ? 7+-6!\*(G+)3/2./8+4!23!-.6+!3G+-!2\*+!,(62!2+/  
%+(-6=^9!!

23!6899+!9-3 ? !4-8@!(786+:!2\*-++!2. ? +6! ? 3-+!,. ;+,%!23!7+!5-+6)-.7+4!56%)\*32-35.)! ? +4.) (2.3/6:!(/4!  
2F.)+!(6!,. ;+,%!23!6899+!9-3 ? !5362P







(6! ? (/%! (4352.G+!9( ? ..+6!\* (G+!23!,+(-/!(,3/@!2\*+!F(%=/10!!e-3G.4./@!859-3/2!,+@(!-+<8.-+ ? +/26!  
)38,4!\*+,5!9( ? ..+6! (/4!)\*.,4-+!/7+!)3//+)2+4! ? 3-+!<8.);,%:!(/4!\*+,5!2\*+!9( ? ..%!5,(/!93-!2\*+!  
9./(/).(!-+<8.-+ ? +/26=>8-2\*+:-! ? (/%!9362+-!9( ? ..+6! (-+!8/(F(-+!39!2\*+!2-(8 ? (!9362+-!)\*. ,4-+!/!  
\*(G+! 9()+4! (/4! \*3F! .2! )38,4! (99+)2! 2\*+ ? =/11! ! e-3G.4./@! ? 3-+! )3 ? 5-+\*+/6.G+! 2-(././@! (/4!  
+48)(2.3/(,!-+638-)+6!23!2\*+!532+/2.(,! (4352.G+!9( ? ..+6!F38,4!./93- ? !2\*+ ? !3!/F\*(2!23!+05+)2!3/)+!  
2\*+%!\* (G+!(!)\*.,4!./!2\*+.-!\*3 ? +=/12!

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1 \*.,+!\* (6!7++/!(!2-+ /4!23!(4352!./2+-/(2.3/(,%,!+G+-!6./)+!2\*+! 1 3-,4! 1 (-6:!2\*+--+!(-+! ? (/%!F(%6!  
23!@.G+!2\*+!587,.)! ? 3-+!/6.@\*2!23!F\*(2!)\*.,4-+!/43F /!2\*+.-!62-++26!(-+!9()./@=!! I 4G+-2.6./@:!F\*.,+!

9( ? ,%!) \* (-)2+- .62.)6:!( /4! 32\*+-! 9()23-6! 2\*(2! 5,(%! . /23! (4352.3 / =! ! H( /%! (-2.9.) .(! . /2+ , , @+ / )+!  
2+)\* /3,3@. +6!\* (G+!7++ /!86+4!23!4+G+,35! ? (2)\*. /@!6.2+6!93-!) \*.,4-+ /!( /4!9( ? ..,+6:!6. ? ..,(-!23!4(2. /@!  
6.2+!6+-G.)+6=-/2!!U/G+62. /@!. /!2\*+6+!2%5+6!39!5-3@-( ? 6!)38,4!,+(4!23! ? 3-+!) \*.,4-+ /!7+ /@!5,( )+4!  
F.2\*!9( ? ..,+6!633 /+-=!

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I /32\*+-!F(%!23! ? ( ; +!2\*+!5-3)+66! ? 3-+!+99.) .+ /2!F38,4!7+!23!4+G32+!-+638-)+6!23!)-+(2. /@!( ! ? 3-+!  
)3 ? ? 8/ .2%P7(6+4! 9362+-! )(-+! 6%62+ ? =! ! S-+(2. /@! 5(-2 /+-6\* .56! 7+2F++ /! 2\*+! 62(2+! 9362+-! )(-+! 3-!  
(4352.3 /! (@+ /) .+6! ( /4!5-.G(2+!)3 ? ? 8/ .2%! 3-@ ( / .L(2.3 /6! ,+(46!23!G(-.386!7+ /+9.26!93-!2\*+!9362+-!  
) \*.,4-+ /!( /4!9( ? ..,+6=-/2!!T32!3 / ,%!43+6! .2! \*3,4!2\*+!62(2+6! ( )38/2(7,+! F\*+ /!+ /@(@. /@! F.2\*!2\*+!  
)3 ? ? 8/ .2.+6! ( /4!5-.G(2+!3-@ ( / .L(2.3 /6: !782! .2! (,63!@.G+6!2\*+!62(2+! ( )+66!23!,3) (, .L+4!4(2(=!Q\* .6!  
\*+,56!(@+ /) .+6! . ? 5-3G+! ? ( / (@+ ? + /2: !.4+ /2.9%) \*.,4-+ /!(2!-.6; !39!+ /2+- . /@!2\*+!6%62+ ? :!( /4!+G(,8(2+!  
2\*+!+99+)2.G+ /+66!39!2\*+.-!5-3@-+66=-/20!!

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U /!"N#\ :!Q+0(6!F(6!2\*+!9.-6!23!399.) .(, ,%!7+@. /!2\* .6!-+93- ? (2.3 /!F\*+ /! .26!,+@.6,(28-+!5(66+4!B+ / (2+!  
\$.,,! ##=-/21!!Q\* .6! 7.,,! 5-3G.4+4! 93-! 2\*+! 2- ( /6.2.3 /! 39! 2\*+! S\* .,4! e-32+)2.G+! B+-G.)+6! hSeBi: ! 2\*+!

Q\*+!A/.2+4!B2(2+6!43+6!/32!\*(G+!2\*+!53F+-!23!)3/2-3,!32\*+!)38/2-.+6E!(4352.3/!6%62+ ? 6:!782!.2!43+6!  
\*(G+!2\*+!53F+-!23!)3/2-3,!26!3F/=! !'+@(-4,+66!39!2\*+!A/.2+4!B2(2+6!+)3/3 ? %E6!7+!+9.26!9-3 ?!  
./2+-/(2.3/(,! (4352.3/6:!2\*+!587,.)!./2+-+62!(/4!)3/)+-!/93-!)\*.4-+/E6!6(9+2%!6\*38,4!+0)++4!(/%!  
./2+-+62!./!5-39.26=(/27!!>8-2\*+- ? 3-+;!48+!23!