

?i `hi fY``Y GWX ÀhnY j cb ? mchc

9bhXYW_Yb'G]Y'X]Y'_i `hi fY``Yb'GW\AhnY'? mchcg.'HYa dY`ž _i`]bUf]gW\Y'A Af_hY'i bX'UhYa VYfUi VYbXY'K UbXYfi b[Yb Yfk UfhYb'G]Y"



?mchc` Y]bY'GhUXhž']b'XYf'JYf[Ub[Yb\Y]h'i bX'; Y[Ybk Ufh'Ui ZnUi VYf\UZhY'K Y]gY'j YfgW\a Y`nYb"'<]Yfž'nk]gW\Yb'XYb a UYgh\Ah]gW\Yb'HYa dY`b'i bX'fi gh]_U`Yb'<c`n\\Ai gYfbž'j YfghYW_Ybg]W\'_i `hi fY``Y'GW\\AhnYž'X]Y'XUfUi Z'k UfhYbž'j cb'X]f'YbhXYW_h'ni k YfXYb"'<Ugh'Xi 'gW\cb'Y]ba U`'j cb'XYb'j YfVcf[YbYb'\$i k Y`Yb[Y\\Ofhž'X]Y'UVgY]hg'XYf'Ui g[YhfYhYbYb'DZUXY'`]Y[Yb3'8]YgYk Yb][Yf'VY_UbbhYb'HYa dY`'i bX'GW\fY]bY'g]bX'_`Y]bY K i bXYfk Yf_Y'XYf'5fW\]hY_hi f'i bX'Gd]f]hi U`]h\Ahz'X]Y'X]W\']b'Y]bY UbXYfY'K Y`hYbhZØ\fYb"

8 c W. ? mc hc `\ Uh b c W. `a Y\ f`ni `V]YhYb ``@Ugg`X]W. `j c b `XYb j Yf`c W_Yb XYb `5 fca Yb `XYf `hf U X]h]c b Y``Yb `A Àf_hY `j Yf ZØ\ fYb `i b X Yf`YVY `Y]b Y __i `]b Uf]g W. Y `9 b h X Y W_i b [gfY]g Y ž `X]Y `XY]b Y; Yg W. a U W_g_b c g d Yb `j Yf n Ui V Yf h " I b X `k Ybb `Xi `XUg `; Y ZØ\``ZØf X]Y `B Uhi f `b] W. h `j Yf`]Y fYb `a ÒW. h Yghž g W. b U d d `X]f `XY]b Y

K UbXYfgW\i\Y'i bX'YbhXYW_Y'UhYa VYfUi VYbXY'@UbXgW\UZhYbž']bXYbYb'X]Y'?i`hi f'XYf'GhUXh'Ui Z'X]Y'GW\Òb\Y]h'XYf'BUhi f'hf]ZZh''

6YfY]h'ZØf'Y]b'i bj Yf[Ygg`]W\Yg'5VYbhYi Yf3'@Ugg'i bg'X]Y'nY]h`cgYbGW\Òb\Y]h'i bX'X]Y'j YfVcf[YbYb'GW\ÀhnY'?mchcg'Yf_i bXYb°

JYfVcf[YbY'ik Y`Yb. '9bhXYW_Y'X]Y'k Yb][Yf VY_UbbhYb'HYa dY`ibX'GWXfY]bY'?mchcg

K Yf'X]Y'_i `hi fY``Yb'GW\AhnY'? mchcg'Yf_i bXYb'a ÒW\hYžgc``hY i bVYX]b[h'Ui W\'UVgY]hg'XYf'VY_UbbhYb'DZUXY'k UbXYfb"'8]Y'GhUXh]gh'VY_Ubbh'ZØf']\fY'a U'YghÀh]gW\Yb'HYa dY`i bX'GW\fY]bYžXcW\]a 'J YfVcf[YbYb'gW\`i a a Yfb'k U\fY'\si k Y`Ybž'X]Y'cZh']a 'GW\UhhYb]\fYf'VYfØ\a hYfYb'BUW\VUfb'ghY\Yb"'9]b'6Y]gd]Y``\]YfZØf']gh'XYf' < cbYb!]bž'Y]b'_`Y]bYf'HYa dY`ž'XYf'6Ygi W\Yf'a]h'gY]bYa 'fi \][Yb 5a V]YbhYi bX'Y]bYf'VYY]bXfi W_YbXYb'; UfhYb`UbXgW\UZh Ya dZ\b[h''K \and \fYbX'XYg': fØ\`]b[g'j Yfk UbXY`h'g]W\'X]YgYf'Cfh']b Y]b'A YYf'Ui g'nUfhYb'?]fgW\V`ØhYbž'i bX'XYf'`Y]gY'?`Ub['XYg D`\and \fYbg'XYg'K UggYfg'\\and \fYhXhXUni 'Y]bž']bbYni \U`hYb'i bX'ni a YX]h]YfYb"

9]b k Y]hYfYf; Y\Y]a h]dd]gh XYf G\cfYb!]b ž XYf gck c\``]b gY]bYa \]ghcf]gW Yb K Yfh U`g Ui W]b gY]bYf GW Òb\Y]h [`Àbnh" <]Yf _ObbYb FY]gYbXY b]W h bi f X]Y _i bghj c ``Yb ?]fY]!; ÀfhYb VYk i bXYfb ž gcbXYfb Ui W X]Y Fi \Y [Yb]Y » Yb ž X]Y X]Y gYf C fh Ui gghfU\`h" C Zh hfY ZZYb \]Yf bi f k Yb][Y 6Ygi W Yf Ui ZY]bUbXYf ž k Ug Y]b ; YZØ\``XYf 5V[YgW]YXYb\Y]h i bX XYg dYfg Ob`]W Yb 9f YVYbg gW UZZh" 8 Yf NYb[UfhYb ž Ub[Y Y[h]a '%' "'* J\f\i bXYfh ž V]YhYh Y]bY gh]``Y ?i `]ggY ZØf XYb 6Ygi W Yf ž i a 'X]Y Y][YbY GYY Y i bX X]Y B Uhi f]b '9]b_`Ub['ni 'Vf]b[Yb"

6YgcbXYfg`\Yfj cfni \YVYb`]gh`XYf`8U]_U_i !^]žY]b`k Y]h`Ài Z][Yf HYa dY`_ca d`Yl ž'XYf`XYb`6Ygi W\Yfb`Y]bY`ZUgh`a mgh]gW\Y 5ha cgd\ÀfY`V]YhYh"`8]YgYf`Cfh`]gh`b]W\h`bi f`Y]b`8f]j Y!H\fi `ZØf?i`hi f]bhYfYgg]YfhYž'gcbXYfb`Ui W\`Y]b`FØW_ni [gcfh`ZØf`X]Y 9]b\Y]a]gW\Yb"`8cfh`_Ubb`a Ub`ni a `6Y]gd]Y``Y]bY`HUggY`A UhW\U]b`Y]bYa `XYf`hfUX]h]cbY``Yb`HYY\Ài gYf`[Yb]Y»Yb`i bX`[`Y]W\nY]h][XYb`6`]W_`Ui Z'XYb`UhYa VYfUi VYbXYb`GYY`]a `<YfnYb`XYg

 $HYa dY`[Y`\grave{A}bXYg`k YfZYb"`8]Y`?]fgW\V`ØhY`\]Yf`]gh`VYgcbXYfg gU[Yb\UZhž`XU`g]W\`X]Y`6`ØhYb`gd]Y[Y`bX`]a `K UggYf`dfÅgYbh]YfYb"$

9]bY'9f_i bXi b[ghci fini 'X]YgYb'k Yb][Yf'VY_UbbhYb'C fhYb']gh
b]Wkh'bi f'Y]bY'FY]gY'Xi fWk'X]Y'; YgWk]WkhYž'gcbXYfb'Ui Wk'Y]bY
9bhXYW_i b['XYg'U``hÀ[`]WkYb'@YVYbg']b'?mchc'''C Zh'VY[Y[bYh'a Ub
ZfYi bX`]Wk'`ÀWkY`bXYb'9]b\Y]a]gWkYbž'X]Y'VYfY]h'g]bXž
; YgWk]WkhYb'Ui g'j Yf[Ub[YbYb'NY]hYb'ni 'hY]`Yb'cXYf'XYb'K Y['ni
k Y]gYb'''8]Y'5V[YgWk]YXYb\Y]h'X]YgYf'HYa dY`'i bX'GWkfY]bY'V]YhYh
b]Wkh'bi f'Y]bYb'F@W_ni ['j cb'XYf'<Y_h]_'XYf'GhUXhž'gcbXYfb'Ui Wk
X]Y'A Ò[`]Wk_Y]hž'X]Y''UdUb]gWkY'Gd]f]hi U`]hÀh']b']\fYf'fY]bghYb
: cfa 'ni 'Yf`YVYb''

5`gcždUW_Y`XY]bY`GW\i\Y`ZØf`XUg`5VYbhYiYf`ibX``UggY`X]Y
[fc»Yb`Hcif]ghYbghfÒaY`\]bhYf`X]f"`HUiW\Y`Y]b`]b`X]Y`gh]``Y`DfUW\h
XYf`jYfghYW_hYb`<Y]`][hØaYf`?mchcg`ibX`YbhXYW_Y`X]Y`GYY`Y
Y]bYf`GhUXhž`X]Y`ØVYf`\$U\f\ibXYfhY`\]bkY[`bcW\`]aaYf`]\fY
_i`hifY``Y`\\XYbh]h\Ah`VYkU\fh`\Uh"

?i`]bUf]gWXY'?Ògh`]WX_Y]hYb.'9]b ; Ybi ggfY]gY'Xi fWX'X]Y'hfUX]h]cbY``Yb'A Àf_hY

M XcZi . DfcV]YfYb G]Y i bVYX]b[h'M XcZi ž'Y]bYb
Y]bZUWXYbž'UVYf'_Ògh`]WXYb HcZi ž'XYf']b '\Y]» Ya 'K UggYf
[Y_cWXh'i bX'a]h'Y]bYf'5i gk U\`'Ub Gc» Yb gYfj]Yfh'k]fX"
8 [YgYf'?`Ugg]_Yf']gh'VYgcbXYfg']b 'XYb'_À`hYfYb'A cbUhYb

Y]b; Ybi gg"

- ? U]gY_]. :: Øf'Y]b'k]f_`]W\'i bj Yf[Ygg`]W\Yg'9f`YVb]g'gc``hYbG]Y'Y]b'hfUX]h]cbY``Yg'? U]gY_]!8]bbYf']b'Y]bYa 'XYf'_`Y]bYbFYghUi fUbhg'[Yb]Y» Yb"'8]YgY'a Y\f[Àb[][Y'A U\`nY]hž'X]Y_i bghj c``'Ub[Yf]W\hYh'k]fXž']gh'Y]b'A Y]ghYfk Yf_ 'UdUb]gW\Yf'? ØW\Y"
- B]g\]_]'GYba U]ni _Y.'@UggYb'G]Y'g]W\'XUg'GYba U]ni _Y
 b]W\h'Ybh[Y\Ybž'Y]bY'_Ogh`]W\Y'5i gk U\`'Ub'Y]b[Y`Y[hYa
 ; Ya ØgYž'XUg'XYb'dYfZY_hYb'GbUW_'ZØf'nk]gW\YbXi fW\
 XUfghY``h'i bX'Ui W\'\Yfj cffU[YbX'U`g'A]hVf]b[gY`'[YY][bYh]gh"

GWX`YbXYfh'a Ub'Xi fWX'X]Y; UggYb'XYg'A Uf_hYgž'f]YWXh'a Ub'X]Y j YfZØ\fYf]gWXYb'5fca Yb'j cb'Zf]gWX'[Y[f]``hYa 'MU_]hcf]'i bX [YfÒghYhYb'9XUa Ua Y"'8]Y'ZfYi bX`]WXYb'<ÀbX`Yf'g]bX'ghYhg'VYfY]hž]\fY'DfcXi _hY'ni 'dfcV]YfYb' 'U`gc'gWXYi Yb'G]Y'g]WX'b]WXhž'Y]b GhØW_'GU_Y!6cbVcb'ni '_cghYb'cXYf'Ui WX'Y]bYb'GWX`i W_'Ui g'XYb nU\``cgYb'GU_Y!5`hYfbUh]j Yb"'

9]b'k Y]hYfYf'j YfghYW_hYf'_i `]bUf]gWXYf'GWXUhn']gh'XYf' \oplus c_Ug\]fU A Uf_hž'k Yb][Yf'VY_Ubbhž'UVYf'b]WXh'k Yb][Yf'ZUgn]b]YfYbX"'<]Yf Yf\U`hYb'G]Y'Y]bYb'Ui h\Ybh]gWXYb'9]bV`]W_']b'XUg'5``hU[g`YVYb'XYf?mchYf"'8]Y'GhÀbXY'g]bX'ZØf']\fY'\UbXk Yf_`]WX'[YZYfh][hYb DfcXi _hY'i bX'fY[]cbU`Yb'?Ògh`]WX_Y]hYb'VY_Ubbh'''?cghYb'G]Y i bVYX]b[h'XUg'[Y[f]``hY'GWXk YfhZ]gWX!GUbXk]WX'cXYf'X]Y gU]gcbU`Yb'GØ»][_Y]hYbž'X]Y'cZh'a]h'`c_U`Ya 'A UhWXU'ni VYfY]hYh k YfXYb"

BUhi f'hf]ZZh'?i `hi f. K UbXYfi b[Yb'Xi fWX X]Y UhYa VYfUi VYbXYb @UbXgWX UZhYb'? mchcg 9]b[YVYhhYhink]gWXYbigUbZhYbi<0[Yibii bXiØdd][YbiK ÀiXYfbV]bYhYhi?mchcib]WXhibifY]bYi: ØiYiUbi_i ihifYiYbiGWXÀhnYbžgcbXYfbiUi WXiY]bYiVYY]bXfi W_YbXYiBUhifiUbXgWXUZhii9]bUVgciihYgiAiggiZØfiK UbXYfZfYibXYi]ghiXYfiK Y[iniai?ifUaU!6Yf[žiXYfiÒghi]WXijcbi?mchcii]Y[hii8]YiK UbXYfib[iVY[]bbhi]a_Y]bYbi8cfZi?ifUaUžiXUgiVY_Ubbhi]ghiZØfigY]bYiNY]»YbiEiYiiYbiiK À\fYbXiXYgi5iZgh]Y[giniaiHYadYii?]ZibY!i]bYiNXiifWXeiYfYbG]YiX]WXhYi6UaVigk ÀiXYfiibXi_ObbYbiXUgi; YdiAhgWXYfiY]bYg_iUfYbi6UWXgiNOfYbžiXYfiG]YiUiZi\fYaiKY[iVY[iY]hYhii8]YgYfiN][Yi5hacgdNAfYiiAXhiXUniiY]bžiX]Yi<Y_h]_iXYgiGhUXhiYVYbg

9]b k Y]hYfYf; Y\Y]a h]dd]gh XYf D\] cgcd\Ybk Y[žY]b
a U`Yf]gWXYf GdUn]Yf[Ub['Ybh`Ub['Y]bYg gWX a U`Yb ? UbU`gž XYf
j cb ?]fgWXVÀi a Yb [YgÀi a h`]gh" 8 Yf K Y['YfghfYW_h`g]WX 'ØVYf
Yhk U`nk Y]??]`ca YhYf i bX ZØ\fh V]g ni a ;]b_U_i ! ^Jž XYa
G]`VYfbYb DUj]``cb" \(\daggerap \text{ XYf 6 `ØhYnY]h XYf ?} \]fgWX V`ØhYb ']gh X]Yg Y]b
k U\fYg DUfUX]Yg" 5 VYf Ui WX 'Ui » Yf\U`V X]YgYf GU]gcb ']gh X]Y
K UbXYfi b['Y]bY : fYi XY ZØf X]Y G]bbY 'XYf 8 i Zh'j cb Zf]gWX
[YVfØ\hYa 'A UhWX Už XYf 'Ui g XYb 'Ub[fYbnYbXYb 'HYY[ÀfhYb
\YfØVYfk Y\hz i bX 'X]Y 'gWX `]WX hY '9`Y[Ubn XYf 'HYa dY`z X]Y 'g]WX
\Ufa cb]gWX ']b 'X]Y '@UbXgWX UZh'Y]b ZØ[Ybž k YfXYb '\Lambda bYb
i bj Yf[Ygg`]WX '\9f]bbYfi b[Yb 'VYgWXYfYb"

 $: \emptyset f'k Yb][Yf'; Y\emptyset VhYžX]Y'hfchnXYa 'X]Y'?ca V]bUh]cb'Ui g'?i'hi fib X'BUhi f'Yf'YVYb'k c'`YbžYa dZ]Y\`h'g]W\'X]Y'Fib XY'i a 'XYb': i g\ a]'=bUf]!HU]g\ U'''8]Y'VYfØ\a hYbžfch'`UW_]YfhYb'Hcf]]!HcfYn]Y\Yb'g]W\'XYb'6Yf[\Ub['\]bUi Z'i bX'V]'XYb'Y]b'Y]bXfi W_gj c'`Yg @UVmf]bh\'''<]Yf'gdUn]YfYb'G]Y'b]W\h'bi f'Xi fW\'X]Y'; YgW\]W\hYž gcbXYfb'Ui W\'Xi fW\'Y]bY'UhYa VYfUi VYbXY'I a [YVi b[žX]Y'j cb XYb'\Y]`][Yb'6Yf[Yb'?mchcg'[YdfÀ[h']gh''5i Z'XYa 'K Y['VY[Y[bYb=\bYb'nU\`fY]W\Y'_`Y]bY'GW\fY]bYž'; Y]ghYf[YgW\]W\hYb'i bX'`c_U`Y @Y[YbXYbžX]Y'Y]bYa 'XUg'; YZØ\`'[YVYbž']b'Y]bY'UbXYfY'NY]h j YfgYmh'ni 'k YfXYb''$

Ni gÀhn`]W\ni 'XYb'K UbXYfi b[Yb'g]bX'X]Y'_`Y]bYfYbž'k Yb][Yf $VY_UbbhYb'K UbXYfdZUXY']b'XYb'5fUg\]mUa U!6Yf[Yb'Y]b'YW\hYg \Rightarrow k Y`"'8]Y'FY[]cb']gh'VY_Ubbh'ZØf']\fY'VYY]bXfi W_YbXY'BUhi fž$

[YfU\a hij cb XYb gWkbYYVYXYW_hYb;]d ZY`b]a 'K]bhYf'i bX XYa j c``Yb'; fØb XYf'K À`XYf']a '< cWkgca a Yf" 6Ygi WkYb 'G]Y 'XUg' 5fUg\]mUa U!6Ua Vi gk U`Xž'k c 'X]Y \c\Yb '6Ua Vi gghÀa a Y 'Y]bY a U YghÀh]gWkY '?i `]ggY 'V] XYb" '<]Yf'_ÒbbYb 'G]Y 'h]Y ZYf']b 'X]Y 'fi \][Y 5ha cgd\ÀfY 'Y]bhUi WkYb i bX'j]Y ``Y]WkhY]b 'dUUf'A ca YbhY 'XYf Gh]``Y '[Yb]Y» Ybž'k À\fYbX 'X]Y 'gUbZhYb 'K]bXY 'X]Y '6Ua Vi gV`ÀhhYf ni a 'FUgWkY`b 'Vf]b[Yb"

I a '⇒fY'K UbXYfi b[Yb'ni 'VYfY]WXYfbž'gc``hYb'G]Y'Yg'b]WXh
j YfgÀi a Ybž']b'Y]bYa 'XYf'_`Y]bYb'HYY\Ài gYf'<U`h'ni 'a UWXYb"
DfcV]YfYb'G]Y'hfUX]h]cbY``Y'GbUW_g'i bX'[Yb]Y» Yb'G]Y'Y]bY'HUggY
Zf]gWX'ni VYfY]hYhYb'A UhWX U!HYYŽ'K À\fYbX'G]Y'X]Y'5i gg]WXh'Ui Z
X]Y'i a `]Y[YbXYb'6Yf[Y'VYK i bXYfb"'?mchc']gh'b]WXh'bi f'X]Y'GhUXh
XYf'HYa dY`ž'gcbXYfb'Ui WX'Y]b'Cfhž'Ub'XYa 'BUhi f'i bX'?i `hi f']b
dYfZY_hYf'<Ufa cb]Y'a]hY]bUbXYf'j YfgWXa Y`nYb"

 $8] Y _i `hi fY``Yb `GW. ÅhnY `? mc hcg `g] b X `k] Y `Y] b `gcf[ZÅ`h][`[Y \setminus \emptysethYhYg ; Y \setminus Y] a b] gž X Ug `X Uf Ui Z k Uf hYhž j cb `b Yi [] Y f][Yb `9b h X Y \w_Yf b Yb h \ \Ø``h `ni `k Y f X Y b " K Yb b `\Rightarrow f Y : Ø \widetildow Y \widetildow Y \widetildow Y \widetildow Y f Y b `i b X `X Y f `8 i Z h 'j cb `Z f] g \widetildow ni \widetildow f Y b '\widetildow f Y b `i b X `X Y f `8 i Z h 'j cb `Z f] g \widetildow ni \widetildow f Y h '\widetildow f Y b '\widetildow$

? mc hc]gh b] W h bi f Y] b N] Y Y g]gh Y] b 9 f Y V b] gž X Ug] b \Rightarrow f' < Y fn Y] b X f] b[Y b ii b X \Rightarrow f Y G Y Y Y V Y f Ø\ f Y b ik]f X " @Ugg Y b G] Y ig] W ij c b X Y b j Y f V c f[Y b Y b \Rightarrow k Y Y b ž X Y b [Y g W a U W_ `] W Y b 8 Y `] _ U h Y gg Y b i b X ` X Y f `] b g d] f] Y f Y b X Y b B U hi f 'j Y fn U i V Y f b " K Y b b ` X] Y g Y f 5 f h] _ Y ` G] Y] b g d] f] Y f h ` U h ž `] g h ` X Y f ` Y f g h Y ` G W f] h h ` V Y f Y] h g `[Y h U b " D U W_ Y b ` G] Y \(\delta \) f Y ? c ZZ Y f 'i b X ` V Y [Y V Y b ` G] Y ` g] W ` U i Z Y] b 'i b j Y f[Y gg `] W Y g 5 V Y b h Y i Y f `] b ` X U g ` g d] f] hi Y ` ` Y 'i b X ` _ i `] b U f] g W Y ' < Y f n ` \delta U d U b g ` ? mc h c Y f k U f h Y h ` G] Y ` a] h ` c ZZ Y b Y b ` 5 f a Y b 'i b X 'i b n À \`) [Y b '; Y g W X] W h Y b ž X] Y X U f U i Z ` k U f h Y b ž ' j c b ` \delta b Y b ` Y b h X Y W h 'n i ` k Y f X Y b "

6Ygi WXYb G]Y i bg Ui Z Y]bY!fY]gY "XY