

GhY][YbXYg=bhYfYggY. < YX[YZcbXggYhnYbjYfghÀf_hUiZ6]hWc]b!9H:g

=bgh]hi h]cbY``Y`5b`Y[Yf`gYhnYb`j YfghÀf_h`Ui Z`6]hWc]b!9H: g"
K Y`WXY`<YX[YZcbXg`dfcZ]h]YfYb`i bX`k Ug`VYXYi hYh`XUg`ZØf
XYb`A Uf_h3</pre>

=a '>Jbi Uf'\Uh'X]Y'I G!6ÒfgYbUi Zg]W\h'[fØbYg'@]W\h'ZØf'6]hWc]b!Gdchl 9H: g'[Y[YVYbž'k Ug'Y]bY'Zi bXUa YbhU`Y'K YbXY'ZØf']bgh]hi h]cbY``Y =bj YghcfYb'k Uf"'8]YgY'9bhgW\Y]Xi b['\Uh'Yg'[fc»Yb'5b`U[YZcbXg Yfa Ò[`]W\hž'X]fY_h']b'XYb'?fmdhca Uf_h'Y]bni hfYhYbž'k Ug'Y]bYa _`UfYb'NY]W\Yb'ZØf'XUg'k UW\gYbXY'=bhYfYggY'Ub'X][]hU`Yb K À\fi b[Yb'[`Y]W_ca a h"

8 Yf '6]hWc]b!?i fg `\ Uh'gY]hXYa 'GW\ k Ub_i b[Yb'Yf`YVhž'UVYf`XUg 9b[U[Ya Ybh'XYf']bgh]hi h]cbY``Yb'5b`Y[Yf'nY][h'k Y]hYf\]b'Y]bYb dcg]h]j Yb'HfYbX"'@Ui h'GUa '6U_Yfž'5bU`mgh'XYf'6]hWc]b! gdYn]U`]g]YfhYb':]fa U'F]j Yfž'\U`hYb'a]hh`Yfk Y]`Y'*\$'DfcnYbh'XYf'&) [fò» hYb'I G! < YX[YZcbXg'6]hWc]b!9H: g"'8]YgY': cbXg'\UVYb']a nk Y]hYb'Ei UfhU`']\fY'6YghÀbXY'b]W\h'bi f'[Y\U`hYbž'gcbXYfb'Ui W\k Y]hYfY'?Ài ZY'[YhÀh][hž'k Ug'XUg'J YfhfUi Yb']b'XYb'A Uf_h'ghÀf_h"

GhUf_Yg 9b[U[Ya Ybh XYf < YX[YZcbXg

 $5b`XYf`Gd]hnY`XYf`6]hWc]b! \pm j\;YghcfYb`ghY \ Yb`X]Y`<YX[\;YZcbXg A]``Ybb]i a \; \check{z}`GWXcbZY`X`GhfYYh`5Xj]gcfg`i bX`; G`5ggYh A UbU[\;Ya\;Ybhž`X]Y`VYXYi hYbXY`6YghÅbXY`\U`hYb"`A]``Ybb]i a `ZØ\fh a]h`&+"&*' `6]hWc]bž`[YZc`[h'j cb`GWXcbZY`X`a]h`*"+' (`6]hWc]b`i bX ; G`5ggYh`A UbU[Ya Ybh`a]h`*"&$&`6]hWc]b"`=a `; Y[YbgUhn`XUni \UVYb`: cbXg`k]Y`6U`mUgbm`i bX`6`i YWfYgh'bi f`gYWXg`Vnk "`bYi b 6]hWc]b`]b`]\fYb`DcfhZc`]cgž`k Ug`nY][hž`XUgg`b]WXh`U``Y`: cbXg`[`Y]WX ghUf_`Ui Z`XYb`6]hWc]b!Ni [`Ui Z[Ygdfi b[Yb`g]bX"$

7]hUXY`ž'XYf'[fÒ» hY'< YX[YZcbXg'XYf'K Y`hž'\Uh'_Øfn`]W\'(%'6]hWc]b ni 'gY]bYb'6YghÀbXYb'\]bni [YZØ[hž'k ca]h'g]W\'X]Y'U_hi Y``Y'5bnU\`Ui Z', %&'6]hWc]b'Yf\Ò\h'\Uh''8]Y': YghghY``i b['X]YgYf'? Ài ZY']gh VYgcbXYfg'Ui ZgW\`i ggfY]W\ž']bgVYgcbXYfY'k Y]`'XYf'6]hWc]b!?i fg]a 'nk Y]hYb'Ei UfhU``i a 'Yhk U'%* 'DfcnYbh'[Ygi b_Yb']gh'''+b'X]YgYa?cbhYl h'j YfXYi h']W\h'XUg'9b[U[Ya Ybh'X]YgYf'[fc»Yb'5_hYi fYž XUgg'g]Y'`Ub[Zf]gh]['Ub'XYf'GhUV]`]hÀh'i bX'XYa 'ni _ØbZh][Yb K UW\ghi a 'XYg'6]hWc]b!?i fgYg'ZYgh\U`hYb''

⇒bj Ygha YbhVYfUhYf]a 5i Zk]bX

 $8]Y `NU `Yb `gdfY W. Yb `ZØf `g] W. `9g `[UV `Y] b Yb `5 b gh] Y[`j cb `(* DfcnYbh `VY] `XYb `< YX[YZcb Xg `i b X `Y] b `D`i g `j cb `%, `DfcnYbh `VY] `XYb F $= gž `X] Y `6] h W c] b ! 9 H: g `]a `nk Y] h Yb `E i Ufh U``Ui Z[Yghc W_h `\ UVYb " 8] Yg Yg `[Ygh Y][Yfh Y $= h Yf Ygg Y _Obbh Y `U`g `Y] b `$= X]_Uhc f `ZØf `Y] b Y Vf Y] h Yf Y 5_n Ydh Ubn `j cb `? fmd h ck \(\hat{A}\) fi b [Yb `] b `XYf `:] b Ubn Vf Ub W. Y] b h Yfd f Yh] Yfh `k Yf X Yb "$

8]Y`Ni ZØggY`]b`6]hWc]b!9H: g`g]bX`VYgcbXYfg`VYa Yf_Ybgk Yfhž`XUg]Y`]ba]hhYb`j cb`DfY]ggWk Ub_i b[Yb`i bX`Y]bYa `GY]hk ÀfhghfYbX XYg`6]hWc]b!A Uf_hYg`dfcZ]h]YfYb"`8YbbcWk`gWkY]bYb`\dip YghcfYb i bVYY]bXfi W_h'j cb`XYb`_i fnZf]gh][Yb`DfY]gVYk Y[i b[Yb`ni `gY]b i bX`nY][Yb`g]Wk`cdh]a]gh]gWk`\]bg]Wk`h`]Wk`XYf``Ub[Zf]gh][Yb 9bhk]W_`i b[`XYg`6]hWc]b!?i fgYg"

8]Y'[Y[Ybk Àfh][Y'5i g[Ub[g`U[Y']a '?fmdhck À\fi b[ga Uf_h'nY][hž XUgg']bgh]hi h]cbY``Y'=bj YghcfYb'ni bY\a YbX'VYfY]h'g]bXž']b'6]hWc]bni ']bj Ygh]YfYbž'cVk c\``X]Y'I bg]W\Yf\Y]h']b'XYb'A Àf_hYb'k Y]hYf\]bVYghY\h''8]Yg'_ÒbbhY'Ui Z'Y]bY'hUhgÀW\`]W\Y'J YfÀbXYfi b[']b'XYf

K U\fbY\a i b['j cb'6]hWc]b'U`g'k YfhVYghÀbX][Yf'5b`U[YZcfa\]bk Y]gYbž'X]Y'a Ò[`]W\Yfk Y]gY'Ui W\'Y]bY'[fÒ»YfY'5_nYdhUbn'VY]]bX]j]Xi Y``Yb'=bj YghcfYb'bUW\'g]W\'n]Y\Yb'_ÒbbhY"

9]b '6`]W_ ']b 'X]Y 'Ni _i b Zh

8]Y``Ui ZYbXYb`9bhk]W_`i b[Yb']a '6YfY]W\`6]hWc]b`i bX`XYggYb`9H:!

Bi hni b['gd]Y[Y`b'b]W\ hrbi f`XUg`k UW\\gYbXY`\DhYfYggY'j cb

:]bUbn]bgh]hi hYb`k]XYfz'gcbXYfb'_ObbhYb`Ui W\`XYb`K Y['ZØf

ni _ØbZh][Y`fY[i`Uhcf]gW\Y`JYf\AbXYfi b[Yb`YVbYb"\8]Y

9bhgW\Y]Xi b['ni f`Ni`Uggi b['j cb'6]hWc]b!Gdch!9H: g'_ObbhY

ni _ØbZh]['U`g`Y]b`k]W\h][Yf`GW\f]hhi]b`F]W\hi b['Y]bYf`VfY]hYfYb

\DhY[fUh]cb'j cb'?fmdhck \A\fi b[Yb']b`XUg'hfUX]h]cbY``Y

:]bUbngmghYa '[YgY\Yb`k YfXYb"\8]Y`ghY][YbXY`BUW\ZfU[Y'j cb
]bgh]hi h]cbY``Yb`5b`Y[Yfb'_ObbhY``Ub[Zf]gh]['XUg'JYfhfUi Yb']b

6]hWc]b`U`g'j Yf`Agg`]W\Y`5b`U[YZcfa 'ghAf_Yb'i bX'X]Y'; fi bX`U[Yb

ZØf`Y]bY'ghAf_YfY'A Uf_hghUV]`]h\Ah`Y[Yb"

5 i gk]f_i b[Yb'XYf'6]hWc]b!?i fgYbhk]W_`i b[Ui Z']bgh]hi h]cbY``Y'=bj Ygh]h]cbYb

8]Y'j cf\YffgW\YbXY'A Uf_hgh]a a i b['gd]Y`h'Y]bY'YbhgW\Y]XYbXYFc``Y"'9]bY'I a ZfU[Y'j cb':]XY`]hm' \(\phi\) Ygha Ybhg'Yf[UV\(\frac{z}{z}\)\Ugg') &'I XYf']bgh]hi h]cbY``Yb'5b`Y[Yf']b'XYb'I G5'Ub'Y]bYf': cfa 'j cb X][]hU`Yb'5ggYhg']bhYfYgg]Yfh'g]bX'fl]XY`]hm\(\frac{z}{z}\) Yg'j YfXYi h`]W\h\(\frac{z}{z}\) XUgg'j]Y`Y'5b`Y[Yf'X]Y'A Uf_hj Yf\(\frac{z}{z}\) b[Yb'U_h]j 'VYcVUW\hYb

K UWX ghi a 'XYg'6]hWc]b!A Uf_hYg

8]Y'Ni bU\a Y'XYg' \(\phi\) hYfYggYg'Ub'6]hWc]b!9H: g'_Ubb'Ui W\'U`g'HY]`Y]bYg'[fÒ» YfYb'HfYbXg']bbYf\U`V'XYf':]bUbna Àf_hY'VYhfUW\hYh k YfXYb"'K À\fYbX'j]Y`Y'5b`Y[Yf'k Y]hYf\]b']b'hfUX]h]cbY``Y 5b`U[YZcfa Yb']bj Ygh]YfYbž'Yf_YbbYb'g]Y'ni bY\a YbX'X]Y'JcfhY]`Y j cb'? fmdhck À\fi b[Yb"'8UhYb'j cb'7c]bA Uf_Yh7Ud'nY][Ybž'XUgg X]Y'A Uf_h_Ud]hU`]g]Yfi b['j cb'6]hWc]b']a '@Ui ZY'XYg'\\\fYg'\&\&'\VYXYi hYbX'[Yk UW\gYb']gh'i bX'Y]b'< ÒW\\ghghUbX'j cb'\ØVYf'*\\$\\$A]``]UfXYb'I G8'YffY]W\\h'\Uh"

7\Ub\W\b'i\bX'<\YfUi\g\ZcfX\Yfi\b[\Y\b']a\'6]\h\c\b'\b!\ 9H:\!G\Y_\hc\f

8 Yf'NY]hfUi a 'bUW\ XYf'; YbY\a][i b['XYf'6]hWc]b!Gdch!9H: g`\Uh [YnY][hž'XUgg'Y]bY'J]Y`nU\`'j cb'< YX[YZcbXg'i bX \dip j Ygha YbhVYfUhYfb'?fmdhck À\fi b[Yb'U`g'k]W\h][Yb'6YghUbXhY]`]\fYf'5b`U[YghfUhY[]Yb'VYhfUW\hYh"8]Yg'\Uh'YXcW\'Ui W\ < YfUi gZcfXYfi b[Yb'a]h'g]W\'[YVfUW\hž']bgVYgcbXYfY']b'6Yni [Ui Z'X]Y'FY[i `]Yfi b['i bX'X]Y'Jc`Uh]`]hÀh'XYg'A Uf_hYg"

9]bYf'XYf'<Ui dhUgdY_hYž'X]Y'Yg'ni 'VYUW\hYb'[]`hž'g]bX'X]Y
fY[i`Uhcf]gW\Yb'FU\a YbVYX]b[ib[Yb"'8]Y'G97'ibX'UbXYfY
5i Zg]W\hgVY\ÒfXYb'a ØggYb'g]W\YfghY``Ybž'XUgg'X]Y'+bhYfYggYb'XYf
5b`Y[Yf'[YgW\Øhnh'k YfXYb"'9]b'hfUbgdUfYbhYf'ibX'g]W\YfYf'A Uf_h
]gh'YbhgW\Y]XYbX'ZØf'XUg'`Ub[Zf]gh][Y'K UW\ghia 'XYf
?fmdhck À\fib[gVfUbW\Y"'

Ni XYa 'V`Y]Vh'X]Y'Jc`Uh]`]hÀh'Y]b'XfÀb[YbXYg'H\Ya U"'=bj YghcfYbg]bX'cZh'VYgcf[h'ØVYf'X]Y'Yf\YV`]WXYb'DfY]gVYkY[ib[Ybž'X]Y6]hWc]b'ibX'UbXYfY'X][]hU`Y'K À\fib[Yb'VYhfYZZYb'_ObbYb"'9]bYIbhYfgi WXib['jcb'XYf'6Ub_'cZ'5a Yf]WU'nY][hž'XUgg'X]YDfY]gj c`Uh]`]hÀh'jcb'6]hWc]b'\O\Yf']gh'U`g'X]Y'j]Y`Yf'hfUX]h]cbY``Yf5b`U[Y_`UggYbž'kUg'ZØf']bgh]hih]cbY``Y'=bj YghcfYb'gckc\``Y]bY7\UbWY'U`g'UiWX'Y]b'F]q]_c'XUfghY``Yb'_Ubb'f6Ub_'cZ'5a Yf]WU''

8 Y f '6 `] W_ '] b 'X] Y 'Ni _i b Zh

 $\pm 0.5 \, \text{bVYhfUW} \, \text{h'XYf'V} \, \text{gNYf} \, \text{[Yb'9bhk]} \, \text{W_i} \, \text{ib} \, \text{[Yb'gWNY]} \, \text{bh'XYf'6]} \, \text{hWc} \, \text{]b!} \, \text{A} \, \text{Uf_h'Ui} \, \text{Z'Y} \, \text{bYa} \, \text{K} \, \text{UW} \, \text{ghi} \, \text{a} \, \text{gd} \, \text{ZUX'ni'} \, \text{gY} \, \text{]b} \, \text{Z'XYf'Xi'} \, \text{fW} \, \text{]bgh]} \, \text{hi} \, \text{hjcbY''Y'I} \, \text{bhYfghØhni} \, \text{b} \, \text{['kY]hYf'[YghAf_h'k]} \, \text{fX'''5b'Y[Yf_2hAf_h'k]} \, \text{gy} \, \text{gy} \, \text{gy} \, \text{hi} \, \text{bY} \, \text{a} \, \text{YbX'Ub'X]Y' = XYY''[Yk ONbYbž'XUgg'6]} \, \text{hWc} \, \text{]b} \, \text{b} \, \text{gy} \, \text{hi} \, \text{bY} \, \text{gdY_i'} \, \text{uh} \, \text{gy} \, \text{Yyf} \, \text{gd} \, \text{gy} \,$

8]Y'_ca a YbXYb'A cbUhY'k YfXYb'YbhgW\Y]XYbX'gY]bž'i a 'ni VYcVUW\hYbž'k]Y'g]W\'XUg' \DhYfYggY'XYf' \Dgh]hi h]cbYb'Ybhk]W_Y`b k]fX'i bX'k Y`W\Y'F]W\h`]b]Yb'`YhnhYbX`]W\'XYb'FU\a Yb'ZØf'X]Y k Y]hYfY' \DhY[fUh]cb'j cb'6]hWc]b'i bX'UbXYfYb'?fmdhck À\fi b[Yb]a ':]bUbngmghYa 'V]YhYb"

8 Y hU]`g

6 Ygi WX Yb G]Y i bg Ui Z b!U["XY