

6]hWc]b 'VY`UghYh'6]`UbnYb'j cb'HYg`Už 6`cW_ž'A]WfcGhfUhY[m'i bX'a Y\f

BUW\ XYa ?Ui Zj cb 6]hWc]b Ui ZXYa K Y[ni *\$"\$\$\$ I G! 8c``Uf`g]bX a Y\fYfY' [fc» Y I bhYfbY\a Yb a]h]\fYb V]g\Yf][Yb → j Ygh]h]cbYb h]YZ]b XYb fchYb NU\`Yb → JW_ 8cfgYmg 6`cW i bX A]W\UY``GUm`cfg A]WfcGhfUhY [m`\UVYb g]W\]b X]YgYa → J\f' [Y [YbØVYf'6]hWc]b i bhYfXi fW\gW\b]hh`]W\Ybhk]W_Y`h 8YdfYgg]j Y 6]hWc]b!A Af_hY VY`UghYb X]Y 6]`UbnYb Y]b][Yf XYf`k Y`hk Y]h [fò» hYb 5_h]Yb [YgY``gW\UZhYb `gW\k Yf" 8Yf'9`Y_hfcUi hc[][Ubh HYg`UžUb [YZØ\fhj ca '8c[YWc]b! 6i ``Yb '9`cb A i g_ž]gh XYfnY]h VY] gY]bYb 6]hWc]b!? Ai ZYb i a ZUgh () i 'fØW_`Ai Z]['fk Ybb 'Yf bUW\ gY]bYf C ZZYb`Y[i b[']a YfghYb E i UfhU`_Y]bY j Yf_Ui Zh`\Uh\"@Ui h`HYg`U`\Uh\HYg`U |bg[YgUa h (' "&\$\$ 6H7 ZØf'%) A]``]UfXYb I G!8c``Uf Yfk cfVYb 6]hWc]b!GW\AhnY 8 UhYb "A i g_g`:]fa Ybj Yfa Ò[Yb]gh 'Yhhh'k Yb][Yf'U`g' Ua d \Y`]d/

- BUWX 'XYa '? Ui Z'j cb'6]hWc]b'Ui Z'XYa 'K Y['ni '* \$"\$\$\$'I G! 8c``Uf'g]bX'a Y\fYfY'[fc»Y'I bhYfbY\a Yb'a]h']\fYb V]g\Yf][Yb'=bj Ygh]h]cbYb'h]YZ']b'XYb'fchYb'NU\`Yb
- \(\frac{1}{2}\w_1\) \(\frac{1}{2}\w_1\w_1\) \(\frac{1}{2}\w_1\) \(

 $8 \ Y \ df \ Y \ gg] \ Y \ '6] \ hWc \]b! A \ Af_hY \ 'VY \ UghY \ b \ 'X] \ Y \ '6] \ `UbnY \ b \ 'Y] \ b] [\ Yf' \ XYf \ k \ Y \ hk \ Y] \ h'[\ fO) \ hY \ b \ '5_h] \ Y \ b[\ YgY \ `gW \ UZhY \ b \ 'gW \ k \ Yf''$

8 Y f'9'Y_hfc Ui hc[][Ub h'HYg`Už'Ub[Y ZØ\fh'j ca '8 c[Y Wc]b!6i ``Yb 9`cb'Aig_ž']gh'XYfnY]h'VY]'gY]bYb'6]hWc]b!? Ài ZYb'ia 'ZUgh'() 'I fØW_`Ài Z]['fk Ybb'Yf'bUWX 'gY]bYf'C ZZYb`Y[ib[']a 'YfghYb'Ei UfhU` _Y]bY'j Yf_Ui Zh'\UhŁ"

@Ui h'HYg`U`\Uh'HYg`U`]bg[YgUa h'('"&\$\$'6H7'ZØf'%ž)'A]``]UfXYb'I G!8c``Uf'YfkcfVYb'6]hWc]b!GW\AhnY'8UhYb"Aig_g
:]fa Ybj Yfa Ò[Yb']gh'Yhnh'k Yb][Yf'U`g', (('A]``]UfXYb'I G!8c``Uf
k Yfh' 'k Ug'ZUgh'*))'A]``]cbYb'I G!8c``Uf'Ub'DUd]Yfj Yf`i ghYb
Ybhgdf]W\h''8]Y'6]`Ubn'j cb'HYg`U'k]Yg'ni a'' %"'A Àfn'%+ž))
A]``]UfXYb'I G!8c``Uf'Ub'NU\`i b[ga]hhY`b'i bX'Ÿei]j U`YbhYb'Ui Z''

8 Ugʻl bhYfbY\a Ybʻ_Ui ZhYʻgY]bYʻ6H7ʻk À\fYbXʻXYgʻ[YgUa hYb YfghYbʻE i UfhU`gʻ&\$&%žʻU`gʻXYfʻVYghYʻX][]hU`YʻJ Yfa Ò[Ybgk Yfh'ni a YfghYbʻA U``Ui ZʻXYa ʻK Y['ni '*\$"\$\$\$'``k Uf"'HYg`UʻgWkbUddhYʻg]Wk gY]bYʻ6H7ʻZØfʻXi fWkgWkb]hh`]Wkʻ' ("+&&'`"'8Yfʻ5_h]Yb_i fgʻ]ghʻ]a V]g\Yf][Ybʻ\$J\fYgj Yf`Ui Zʻi a '') i '[YZU``Yb"

 $K Ug'X]Y'; fO`* YbcfXbib[`VYhf]ZZhž'gc']gh'XYf'hYW.bc`c[]Y`Ugh][Y B5G85E '%$$ž']b'XYa 'HYg`U'dfca]bYbh'j YfhfYhYb']ghž']b'X]YgYa $U\f'ia '&-'i '[Ygib_Yb'''8Yf'VfY]hYfY'G/ D') $$`\Uh']a '[`Y]WXYb NY]hfUia '&$'i 'j Yf`cfYb'''6]hWc]b'\Uh'ZUgh'*$'i 'Vca VUfX]Yfh''' $ ``$

6`cW_ž'XYf']a '8 i fWkgWkb]hh'&+"(\$+'``nU\`hYž'VY[Ubb']a 'C_hcVYf &\$&\$ 'a]h'XYa '? Ui Z'j cb'6]hWc]bž'U`g'Yg'j YfÒZZYbh`]Wk h'gY]b ghc]gWkYg'6]hWc]b'=bj Ygha Ybh'K \]hYdUdYf"'8 Ug': `U[[gWk]ZZ'XYg I bhYfbY\a Ybgž'X]Y'7 Ug\ '5ddž'i bhYfghØhnh'6]hWc]bž'cVk c\`'6`cW_Ui g'X]YgYb'HfUbgU_h]cbYb'k Yb]['; Yk]bb'[YbYf]Yfh"'

 $5b[Yg]WXhg:XYf:fUgUbhYb:9bhk]W_i:b[:XYf:?fmdhckA\fi:b[:i:bXXYf:VY]gd]Y:cgYb:I:bg]WXYf\Y]h:Ui:g:a:U_fcO_cbca]gWXYf:i:bXkA\fi:b[:gdc:]h]gWXYf:G]WXh:[:Ui:VYb:k]fz:XUgg:Yhnh:XYf:f]WXh][YNY]hd:b_h:ZØf:i:bg']ghz:i:bgYfY:[fO)*hYbhY]:g:Ui:Z:I:G8::Ui:hYbXY6]:Ubn:ni:YfkY]hYfb:i:bX:Y]bY:g]bbj:c:`Y:\deltajYgh]h]cb:]b:6]hWc]b:ni:hAh][Yb:z'gWXf]YV:6:cW_:XUa:U`g:"8Yf:5_h]Yb_i:fg:j:cb:6`cW_:]gh:]bX]YgYa:\deltaJ\fi:a:*$::[YZU:`Yb"$

A]WfcGhfUhY [mž'X]Y 'Xf]hh[fÒ» hY 'V ÒfgY b b c h]Y fhY '5_h]Y 'a]h'Y]bYf 6]hWc]b!6]`Ub nž']gh'[Y[Yb ØVYf'6H7'i a '' * 'i '[Ygi b_Yb"'8 Ug 8 UhY b Ui Z_`Àfi b [gi b hY fbY\a Yb'j c b 'A]W\UY``GUm`cfž'XUg'j c b 5 b U`mghY b 'k Y [Yb'gY]bYf'J YfXcddY`i b [']b 'XYf'j Yf[Ub [YbYb K c W\Y'_f]h]g]Yfh'k i fXYž'j YfZØ[h'ØVYf'X]Y 'VY]'k Y]hYa '[fÒ» hY '6H7! GW\Uhn_Ua a Yf'U``Yf'V ÒfgY b b c h]YfhYb'l b hYfbY\a Yb'' 'XfY]a U``gc j]Y``k]Y 'HYg`U"

GUm`cf'[UV'ZUgh'('A]``]UfXYb'I G!8c``Uf'ZØf'%&-"*-,'6H7'ZØf

A]WfcGhfUhY[m'Ui gž'bUWXXYa 'Yf'Y]bYb'[fc»Yb'HY]`'X]YgYf'A]hhY`

Xi fWX'XYb'JYf_Ui Z'j cb'I bhYfbY\a YbgUb`Y]\Yb'Ui Z[YVfUWXh
\UhhY"'=a'8i fWXgWXb]hh'[UV'XUg'I bhYfbY\a Yb''\$"*))'`'dfc'6H7

Ui g"'8]Y'A]WfcGhfUhY[m'5_h]Y']gh']b'X]YgYa '*J\\f'V]g\Yf'i a '+\$''

Y]b[YVfcWXYb"'9bXY'AÀfn'aY'XYhY'XUg'I bhYfbY\a Yb'k Yb][Yf'U`g-''A]``]cbYb'I G!8c``Uf'Ub'`]ei]XYb'A]hhY`b"

A]WfcGhfUhY [m'bU\a 'Ui W. '&\$) 'A]``]cbYb'8c``Uf'a]h'6]hWc]b!

I bhYfghØhni b ['Ui Z'8 Uf`Y\Yb'j cb'XYf'_fmdhcZc_i gg]YfhYb'6Ub_
G]`j Yf[UhY']a 'A Àfnž'U`g'6H7'Yhk U'(\$"\$\$\$'8c``Uf'k Yfh'k Uf"'9]b

FØW_[Ub ['i bhYf'&%"\$\$\$'` 'Vf]b [h'Yg'hYW\b]gW\' [YgY\Yb']b'X]Y

BÀ\Y'Y]bYg'A Uf[]b'7U``gž'[Yk Ufbh'D\cb['@Yž'7\]YZ:]bUbW]U`

C ZZ]WYf'j cb'A]WfcGhfUhY [mž'VY]'Y]bYf'HY`YZcb_cbZYfYbn']a 'A U]"

 $\pm g[YgUa h'\setminus UVYb'HYg`Už'6`cW_ibX'A]WfcGhfUhY[m'VY]']\setminus fYbV]g\setminus Yf][Yb'6]hWc]b! \pm jYgh]h]cbYb'& 2%*'A]``]UfXYb'IG!8c``UfjYf`cfYb''$

GhUf_Y'9]bbU\a Yb'Ui » Yf\U`V'j cb'? fmdhc VYXYi hYb'; Yk]bbY'ZØf'XYb''UdUb]gW\Yb Gd]Y`Y\YfghY``Yf

9]bY'k Y]hYfY'dfca]bYbhY'6]hWc]b!GW\Uhn_Ua a Yf'[Y\Òfh'XYa W\]bYg]gW\Yb': chc!5dd!<YfUi g[YVYf'A Y]hi ž'XYf'Ui Z'XYb?U]a Ub]bgY`b'Y]b[YhfU[Yb']gh''

8 Ugʻ]bʻ< cb[_cb['bch]YfhY`I bhYfbY\a Ybʻ[UVʻnk]gW\YbʻA Àfnʻi bX 5df]``&\$&%'i bYfk UfhYhʻ(-ž) 'A]``]cbYbʻI G!8c``UfʻZØfʻ6]hWc]bʻUi gž [YfUXYʻfYW\mY]h]['ZØfʻDY_]b[gʻk Y]hfY]W\YbXYʻ9bhgW\Y]Xi b[Ybʻni?fmdhck À\fi b[Ybž'Y]bgW\`]Y»`]W\`6YgW\fÀb_i b[YbʻZØfʻXUgʻDfccZlcZlcZlkcf_!A]b]b[ž'Ui ZʻXUgʻg]W\`6H7ʻghØhnh"

A Y]hi g'6H7']gh'Yhnh'bi f'bcW.'%, ž('A]``]cbYb'l G!8c``Uf'k Yfhž'k Ug Y]bYa 'FØW_[Ub['jcb'*' 'l 'Ybhgdf]W.hž'bUW.XYa '- (%'6H7'ni Y]bYa '8i fW.gW.b]hhgdfY]g'jcb') &"*\$('l G!8c``Uf'Yfk cfVYb k i fXYb"'

8 Ugʻl bhYfbY\a Ybʻ_Ui ZhYʻUi W\`' %"\$\$\$`9H<`ZØf`]bg[YgUa h`)\$ž) A]``]cbYbʻ8c``Ufž'k UgʻXi fW\gW\b]hh`]W\`%"*'\$'8c``Ufʻdfc`Hc_Yb Ybhgdf]W\h"`GY]bʻ9h\Yfj cffUh`k]fX`XYfnY]h`Ui Z''(ž(`A]``]cbYbʻl G! 8 c``Uf`[YgW\Ahnhž'k UgʻY]bYfʻ5Vk Yfhi b[jcb''&i Ybhgdf]W\h"`

A Y]hi ž'XUg'Y]bYb'A Uf_hk Yfh'j cb') &&'A]``]cbYb'I G!8c``Uf'\À`hž'\Uh `Ui h'gY]bYb''Øb[ghYb'I bhYf`U[Yb'_Y]bY'gY]bYf'?fmdhck À\fi b[Yb

j Yf_Ui Zh" '9g'; YgYbXYh'V]g'ni ') & A]``]cbYb'8c``Uf'Ub'JYf`i ghYb U`g': c`[Y"'8Yf'5_h]Yb_i fg'j cb'AY]hi ']gh']b'X]YgYa '\\\fi a'' ' ' [YZU``Yb"

8 Yf 'UdUb]gWX Y '< YfghY``Yf'j cb' < Ub Xmgd]Y`Yb'B 9L CB'i bX'X]Y bcfk Y[]gWX Y '? fmd hc!9]b\Y]h'GYYhYY'fY]bY'Hc WX hYf[YgY``gWX UZh'XYf \(\psi \) ghf]Y]bj Ygha YbhZ]fa U'5_Yfk'g]bX'YVYbZU``g'XYi h`]WX']a 'A]bi g VY]'6]hWc]bž'bUWX XYa 'g]Y'**'i 'Vnk "'*' i 'ZØf'DUd]Yfj Yf`i ghY']a K Yfh'j cb'%\$&'A]``]cbYb'I G!8c``Uf'j Yf`cfYb'\UVYbž'k]Y'Ui g'8UhYb j cb'6]hWc]b'HfYUgi f]Yg'\Yfj cf[Y\h"

8]Y`AihhYf[YgY``gW\UZh'jcb`GYYhYYž5_Yfž']gh`]a`\\J\f`&\$&&`iakYb][Yf`U`g`%)`i`[Ygib_Ybž'cVkc\``?fmdhc`Y]bYb`_`Y]bYb`HY]`gY]bYf'; YgUah]bjYgh]h]cbYb`UigaUW\h"

 $B 9 L C B "ghY ``h"g]WX "_ca d `Yhh"[Y [Yb "XYb "HfYbX""8]Y "]b "Hc_]c bch]YfhY "5_h]Y "]gh"]b "X]YgYa "$J\f"V]g\Yf"hUhgÀWX`]WX "i a "&%"i [Ygh]Y [Ybž"Ub [Yhf]YVYb "j cb "XYf"ghUf_Yb "9bhk]<math>W$ `i b [" J YfX]YbghY"]a "YfghYb"E i UfhU`"

8 Ug @YYfj Yf_Ui ZYb j cb 6]hWc]b!5_h]Yb _ObbhY]b Ni _i bZh f]g_UbhYf gY]b

HUhgÀWX`]WX`k Uf`Yg`]b`X]YgYa `\J\f`gW\k]Yf][\ž`XUg`?fmdhc!
9b[U[YaYbh']b`XYb`6]`UbnYb`UiZfYWXhniYf\U`hYb"`@YYfjYf_ÀiZYf\UVYb`A]WfcGhfUhY[mibX`7c]bVUgY`gck]Y`Y]bY`FY]\Y`jcb`6]hWc]b!
A]b]b[!5_h]Yb`k]Y`AUfUh\cb`ibX`F]ch`6`cW_WXU]b`ia_fY]gh"

8]Y'bYi YghYb'G\cfh! \$\text{hYfYgh! 8 UhYb'fX]Y'j YfZc`[Ybž'k]Y'j]Y`Y
Ui gghY\YbXY'I bhYfbY\a YbgU_h]Yb'`YYfj Yf_Ui Zh'k i fXYbŁ'k i fXYb
Ua '%) "'\$\text{b}'j YfOZZYbh`]W\hž'c\bY'5_hi U`]g]Yfi b[Yb'V]g'bÀW\ghYb
8]YbghU["'8YbbcW\nY][hYb'X]Y'\Øb[ghYb'8UhYbž'XUgg'XUg'G\cfh!
\$\text{b}\text{hYfYggY'j cb'7c]bVUgY'gY]h'XYa'' \%"'A U]'i a '%) 'DfcnYbhdi b_hY
[Yqh]Y[Yb']qh/'A UfUh\cbq'k Uf'Ui Z'\&\footnybhdi Z'\&\footnybhdi b_hY

A]WfcGhfUhY[m' 'XUg'l bhYfbY\a Yb'a]h'XYf'[fÒ» hYb'6]hWc]b!

GWXUhn_Ua a Yf' 'j YfnY]WXbYhY']a '[`Y]WXYb'NY]hfUi a 'Y]bYb

5bgh]Y['XYf'G\cfh!N]bgYb'i a 'ZUgh'+'DfcnYbhdi b_hYž'k cVY]'a Y\f

U`g'(' 'I 'XYg': `cUhg'`YYfj Yf_Ui Zh'k i fXYbž'gc'X]Y'NU\`Yb'XYg 8 UhYb!GhUfhi dg'ei UbhL"'

@YYfj Yf_Ui Z'j cb'A]WfcGhfUhY[m'k]fX']f[YbXk Ubb'f]g_Ubh ž'gU[hYei UbhL!; fØbXYf'C]g]b'A U\Yfž'XYf'ZYghghY``hYž'XUgg'@YYfj Yf_Ui Z j cb'?fmdhc!5_h]Yb'VYfY]hg'[YZÀ\f`]W\']ghž'XU'X]Y'NY]h'V]g'ni f 8 YW_i b['fK]Y'5bnU\`'XYf'HU[Yž'X]Y'YfZcfXYf`]W\'g]bXž'i a @YYfj Yf_Ài ZY'a]h'; Yk]bb'UVni gW\`]Y»YbŁ'Ub[Ygh]Y[Yb'ni 'gY]bgW\Y]bh'VYXYi hYbX"'

5bXYfYfgY]hg'Z]Y`Yb'6`cW_!G\cfh!N]bgYb'hUhgÀW\`]W\'i a'(ž)
DfcnYbhdib_hY'UiZ', 'i'XYg'GhfYiVYg]hnYg"'HYg`Ug'G\cfh! +bhYfYggY
gW\]Yb'YVYbZU``g'i bVYY]bZi ggh'i bX'VYkY[hY'g]W\'i a'X]Y''' i'"

п • п

8]Y'Dcghl6]hWc]bl6Y`Ughi b[gV]`UbnYb'j cb'HYg`Už'6`cW_ž A]WfcGhfUhY[m'i bX'a Y\f'YfgW\]YbYb'ni Yfgh'Ui Z'6`cW_k cf_g"

8 Y hU]`q

6 Ygi WX Yb 'G]Y 'i bg 'Ui Z. '_fmd hc!b Yk g"Uh