

## A YfWUXc 6]hWc]b i bhYfghØhnh 6fUg]`]Ybg 7687!6Ya Ø\i b[Yb f6Yf]WX hŁ

A YfWUXc 16]hWc]b 'X]Y [fÒ» hY ?fmdhck À\fi b[gVÒfgY ]b
6fUg] ]Yb 'k ]fX 6Yf]Wk hYb ni Zc [Y Ua 'D] chd fc Y\_h XYg
@UbXYg ni f '9]b ZØ\fi b[Y]b Yg X][]hU Yb FYU 'hY] bY\a Yb "8]Y
NYbhfU YUb\_ 'VYUVg]Wk h][hž]a 'IJ\f &\$&(Y]b 'gc `Wk Yg
:]bUbndfcXi\_h\YfUi gni [YVYb" 8]Y @]ghY XYf A]hk ]f\_Yb XYb
K]Y Y]b 'c\_U Yg AYX]Ybi bhYfbY\a Yb VYf]Wk hYhYž \Uh X]Y
6Ub Wc 7YbhfU `Xc 6fUg] `A YfWUXc 6]hWc]b Ui hcf]g]Yfhž Ub XYf
768 7!9bhk ]W\_i b[hY] `ni bY\a Yb" Ni X]YgYa 'H\Ya U gdfUWk
: UVf]W]c 'HchUž 8]fY\_hcf ZØf BYi [YgWk ÀZh Ub XYf 6ÒfgY.
I bgYfY 'HY] `bU\a Y 'VYghÀh][h X]Y 5Vg]Wk h XYf NYbhfU `VUb\_ž

♣bcj Uh]cbYb ]b `XUg :]bUbngmghYa 'ni 'Vf]b[Ybži bX nk Uf 'VY]
XYbYbž X]Y 'VYfY]hg a ]h X]YgYf 'HYWk bc `c []Y [YUfVY]hYh
\UVYbži bX b]Wk h'bi f 'VY] XYb YhUV `]YfhYb '6YhfY]VYfbž X]Y 'g]Y
g]Wk '/ Ua d ∧ Y ``]d/



A YfWUXc '6]hWc]b' 'X]Y'[fÒ» hY'? fmd hck À\fi b[gVÒfgY']b'6fUg]`]Yb' k ]fX'6Yf]W\hYb'ni Zc`[Y'Ua 'D]`chdfc $\Upsilon$ \_h'XYg'@UbXYg'ni f 9]bZØ\fi b['Y]bYg'X][]hU`Yb'FYU`'hY]`bY\a Yb"

8]Y`NYbhfU`VUb\_`VYUVg]W\h][hž`]a `\\J\f`&\&( `Y]b`gc`\\Yg :]bUbndfcXi \_h`\YfUi gni [YVYb"

## 8]Y@]ghYXYfA]hk]f\_YbXYb

K ]Y Y]b ``c\_U`Yg`A YX]Ybi bhYfbY\a Yb`VYf]W\hYhYž`\Uh`X]Y '6UbWc 7YbhfU``Xc'6fUg]``A YfWUXc'6]hWc]b`Ui hcf]g]Yfhž'Ub`XYf'7687! 9bhk ]W\_`i b[ 'hY]`ni bY\a Yb"`Ni 'X]YgYa 'H\Ya U'gdfUW\': UVf]W]c HchUž'8]fY\_hcf'ZØf'BYi [ YgW\ÀZh'Ub`XYf'6ÒfgY.

I bgYfY 'HY]`bU\a Y 'VYghÀh][ h'X]Y '5Vg]W\h'XYf`NYbhfU`VUb\_ž

♣bcj Uh]cbYb ']b 'XUg': ]bUbngmghYa 'ni 'Vf]b[ Ybž'i bX 'nk Uf`VY]

XYbYbž'X]Y 'VYfY]hg'a ]h'X]YgYf'HYW\bc`c[ ]Y '[ YUfVY]hYh'\UVYbž'i bX

b]W\h'bi f'VY]'XYb 'YhUV`]YfhYb'6YhfY]VYfbž'X]Y 'g]Y 'g]W\'Ub[ YY][ bYh\UVYb"

Ni `XYb`k Y]hYfYb`Dfc^Y\_hhY]`bY\a Yfb`nÀ\`Yb`bUa \UZhY I bhYfbY\a Yb`k]Y`XYf`NU\`i b[gUVk]W\_`i b[gf]YgY`A UghYfWUfXž XUg`:]bUbngcZhk UfY!:]bhYW\`G]be]Už`XUg`A U\_`Yfi bhYfbY\a Yb ; Yb]U``i bX`UbXYfY"

 $8 ]Y VfUg]`]Ub]gWX Y NYbhfU`VUb\_`\ Uhrni j cf`XUf[ Y`Y[ hž`XUgg`bi f fY[ i `]YfhY`: ]bUbn]bgh]hi hY`a ]h`X]fY_hYa `Ni [ Ub[ `ni a `BYhnk Yf_ XYg`BUh]cbU`Yb`: ]bUbngmghYa g`fG: BŁ`X]Y '7687!6Ya Ø\ i b[ Yb i bhYfghØhnYb`_ÒbbYb"$ 

8 Ugʻ?cbgcfh]i a ʻVYUVg]W\h][ hžʻUbʻU``Ybʻ5gdY\_hYbʻXYgʻHYghghY]`ni bY\a YbžʻY]bgW\`]Y»`]W\ʻXYfʻJYf\UbX`i b[ YbʻØVYf K YfhdUd]YfYʻ]a ʻ; fc»\UbXY`žʻ]a ʻ9]bnY`\UbXY`i bX']a GhUUhga [b]ghYf]i a "

8]Y`NYbhfU`VUb\_`N]Y`Y``bÀW\ghYg`\*J\f`Y]b`7687'j YfÒZZYbh`]W\Yb"
8Ya 'i fgdfØb[`]W\Yb'D`Ub'ni Zc`[Y'k]fX'Yg'g]W\'VY]'XYa
; Y`XdfcXi\_h'i a 'Y]b'6`cW\_W\U]b!VUg]YfhYg'\*bghfi a Ybh'\UbXY`bž
XUg'9]bnY`\UbXY`ghfUbgU\_h]cbYb'i bhYfghØhnh'i bX'Xi fW\
6Ub\_Y]b`U[Yb'XYf'?i bXYb'UV[Yg]W\Yfh']gh''

 $8 \ ] Y g `\_ O b \ b \ h Y `X] Y `? f Y X] h\_ c g h Y b `g Y b\_ Y b \check{z} X] Y `? c g h Y b `Z \emptyset f `X] Y$ 

 $\label{eq:control_state} $JYfVYggYfib[XYf?Ud]hU`fYbX]hY"`9g`VYghY\h`Y]b`[fc»Yg`DchYbn]U`$ $ZØf`bYiY`8]Ybgh`Y]ghYf`ibX`:]bhYWXgž`X]Y`XYb`AUf_hni[Ub[XYac_fUh]g]YfYb`ibX`bYiY`8]Ybgh`Y]ghib[Yb`UbV]YhYb~ž`ZØ[hY:UV]c`5fUi~c`~XYf`?ccfX]bUhcf`XYg`7687!Dfc~Y_hg`~\]bni"$$ 

## Ni gÀhn`]WXY'?fmdhc!Ni ghÀbX][\_Y]h'ZØf'X]Y NYbhfU`VUb\_

8]Y'VfUg]`]Ub]gWXY'NYbhfU`VUb\_'k Uf'b]WXh'bi f'ZØf'X]Y'5i g[UVYX][]hU`Yf'K À\fi b[Yb'j YfUbhk cfh`]WXz'gcbXYfb'Ui WX'ZØf'X]Y
5i g[UVY'X][]hU`Yf'K À\fi b[Yb'ni [Yk]YgYb'U`g'?fmdhc!
FY[i`]Yfi b[gVY\ÒfXY'XYg'@UbXYg''8Ug'j cb'DfÀg]XYbh'@|]n'\D'ZW]c
@|`U`XU'G]`j U'i bhYfnY]WXbYhY'; YgYhn'k i fXY'Ua'\&\\$''\I b]'c\ZZ]n]Y``"

8 Y b F Y [ Y `b `ni Zc`[ Y `XØfZY b ``c\_U`Y `I bhYfbY\a Yb `\_Y]bY
? fmd hc X]Y b ghY `Ub V]Y hY b ž c\bY `X]Y `; YbY\a ][ i b [ `XYg
: ]b Ub n]b gh]hi hg `Y]b ni \c`Yb " 8 ]Y `6 Ub\_ `k ]f X `Ui W\ `ØVY fk UW\Yb ž c V
C f [ Ub ]g Uh]c b Y b `X]Y `J Yf Z U\fYb `ni f `6 Y\_A a d Z b [ `XYf `; Y`Xk A g W\Y
Y]b\U`hYb `i b X `c V `g]Y `a ]h \_ f ]a ]b Y``Yb `5 \_ h ]j ]h A hY b ž `Y]b g W\`]Y » `]W\
XYf : ]b Ub n]Y fi b [ 'j c b `HYffc f]ga i g ž ]b `J Yf V]b X i b [ `ghY \ Yb"

5i W. 'X]Y 'VfUg]`]Ub]gWXY 'G97 'k ]fX ']a 'FY[i `]Yfi b[gdfcnYgg'Y]bY Fc``Y 'gd]Y `Yb" '9g'k ]fX 'a ]h'XYf'6UbWc 'Xc '6fUg]` ni gUa a YbUfVY]hYbž'i a 'U`g'K YfhdUd]YfY 'Y]b[Yghi ZhY 'X][]hU`Y K À\fi b[Yb'ni 'ØVYfk UWXYb" '9g']gh'Yfk À\bYbgk Yfhž'XUgg'XUg [Y`hYbXY']bbYfghUUh`]WXY 'FYWX h'b]WX h'ZYgh`Y[hž'k Y`WXY JYfa Ò[Ybgk YfhY']b'X]YgY'? UhY[cf]Y'ZU``Yb'i bX'k Y`WXY'U`g'K UfYbUb[YgY\Yb'k YfXYb"

. . .

8 Y hU]`a