

; GA!Gi ddcfh'i `"'8cVfY[c'DUghYfnU'%\$&#) ž'' %! ( %\* '? fU\_Œk a cV]`Y`Ž(, '\*\$, %\$+()) žB=D', %'''), \*\$- 'F9; CB.'%, %\$, %''( k k k "[ ga ! gi ddcfh"bYh

## 





7FI =G9F 'DFC&']g'h\Y'Z|fgh']bXYdYbXYbh'gcZhk UfY'Zcf'i b`cW\_]b[ž'`Ub[i U[Y'W\Ub[Yž'XYW ghca ]nY'UbX'fYdU]f'cZ'bYk 'Gcbm 9f]Wggcb`d\cbYg``]\_Y. `?+\$\$]ž`?+\$\$Wt`?)\$\$]ž`?)\$\$Wt`?)\$\*\Z`?)\$, \Z`?)\$, Wt`:)\$\$]ž`G+\$\$]ž`G+\$\$Wt`G+%\$Už`N%\$%\$]ž`N%\$%\$Wt`J,\$\$ž  $\label{eq:continuity} J_{,\,\$\&G9"UbX"ch\Yfg"'Hc[Yh\Yf'k]h\h,]g'dfcXiWh'mci'k]^*[Yh'U'gc'ZfYY'UWW'gg'Zcf'bYk'idXUhYg'']} Let $$ J^*[Yh'U'gc'ZfYY'UWW'gg'Zcf'bYk'idXUhYg'']$$ 

Bck mci XcbchbYYX]bhYfbYhWcbbYWh]cbcfVim`c[g#WfYX]hg"

Gi ddcfhYX a cXY`g.

B9K 'AC89@G. G\Ufd'J+\$' G<ž'G\Ufd'J, \$%G<ž'G\Ufd'J, \$&G<ž'G\Ufd'J-\$\G<Z'8+)\$]z':)\$\$]z'>&\\$\DZ':)\$\$]z'>&\\$\DZ':)\$\$ >'\$\$]z`?'\$\$\Vz`?'\$\$]z`?'\$\$\Vz`?)\$\$]z`?'\$\$\Vz`?)\$\$, [z`?)\$, \Vz`?\*\$\$]z`?\*\$\$\Vz`?\*\$, [z`?+\$\$]z`?+\$\$\Vz`?+)\$]z`?+)\$\Vz`?+), \Vz`?\*\$ 

C@8 'A C 8 9@G. 'H\*' \$z'H\* &, z'H\* %\$z'H\* %\* z'H\* % z'N\* \$\$z'N\* \$, z'D, \$\$z'D, \$\$z'D- \$\$z'D- \$, z'H\* \$\$'H\* \$&z'H&&\* z'H&&\* gz'H&' \$z'H&' \$z'H&', z'H H\*\*Ž'H\*\*WZ'H%\$\$Z'H%\$\$VZ'H%\$\$Z'H%\$)Z'H%\$\$Z'5'\*% gZ'5'\*% gWF\*\$\$gZ'F\*\$\$gWZ'H'%\$Z'H'%\$Z'H'\$\$Z'H'\$\$Z'H&\$\$Z'H&\$&Z'H&\$\$Z'H\*, ]Z  $H^*$ ,  $]Y\check{z}'H^*$ ,  $a\check{z}'H^*$ ,  $a\check{W}'H^*$ )  $g\check{z}'H^*$ )  $gWH'-a\check{z}'H'-a\check{W}'H^*$ , +

: YUhi fYg.

BC'@C; G'F 9E I =F 98

BC =BH9FB9H'7CBB97H=CB F9EI =F98

Gi ddcfhg`dUfU``Y``ZUg\]b[ `cZi d`hc`%\* `d\cbYg"`GdYYX`i d`hc`%( \$A 6mhYg`dYf`&`a ]bi hYg" `H\Y`Z]fgh`gcZhkUfY`Zcf`ib`cW<u>\</u>]b[`G\Ufd`J,\$%G<ž`G\Ufd`J,\$&G<`UbX`J-\$&G<`d\cbYg"

`H\Y`Z]fgh`gcZhkUfY`h\Uh`Wci`X`ib`cW\_`fYX`7=8'\*`d\cbYg"

:: i ```gi ddcfh'Zcf'fYX#Vfck b'7=8' \* 'd\cbYgž'bck 'k ]h\ci h'hYghdc]bh' '7Ub'Wbj Yfh'fYX'7=8' \* 'd\cbYg'hc'Vfck b'7=8' \* 'k ]h\ci h'i g]b[ 'U'hYghdc]bh'

`Dcgg]V]`]hm`hc`cdYfUhY`k]h\`id`hc`%\*`d\cbYg`]b`dUfU``Y``ig]b[`W\YUd`:][\hYf`IG6`WWV`Yg"

Dcgg]V]`]hmhc'cdYfUhY'j ]U'h\Y'cf][]bU`'8GG

&\$ 'UbX'8GG! &) 'gmbWXfcb]nUh]cb 'WfUX`Yg"

 $\label{eq:cw_g} \begin{tabular}{ll} $\text{I}$ b`cW_GG=A!`cW_gG''.7Ub`U`gc`fYUX`WcXYg`fgi ddcfhg`U`gc`%* \\ \end{tabular}$ 

X][]h``cb[ 'WcXYgŁ"

 $\label{eq:cw_def} \hbox{$^{\prime}$ b`c$$\underline{W}$ i gYf`c$$\underline{W}$ "$^{\prime}$Ub`U`gc`fYUX`i gYf`c$$\underline{W}$ `$W$^{\prime}$XY"}$ 

 $FY`cW\_G=A!`cW\_hc`U`gdYWJZ]WbYhfh\UbXm`Zcf`@_'d\cbYgŁ"`AB7`cZ'_'X][]hg`]g`gi ddcfhYX`hcc"$ 

`7\Ub[Y``Ub[iU[YdUW\_'UbX`gcZhkUfY`Wighca]nUh]cb`fU`gc`k]h\cih``cg]b[`igYf`XUhUŁ"

`7cbhJ]bg`Ub`YUgmlct!i gY`785`cc`"`H\]g`U``ck g`cc`i gY`h\Y`cf][]bU``Gcbm9f]Wggcb`I d[fUXY`GYfj]W**'**"

'I d[fUXY'd\cbY'Z]fa k UfY"

'I d`cUX'g][ bYX'Z]`Y'UfVX]j Yg'fG: 5Ł"

\*8ckb[fUXY\*@ 'Z]`YgmghYa 'hc'U``ck'i b`cW\_]b[

7cbj Yfh'8+) \$ hc ? +) \$"

`7cbjYfhJ, \$\$`hc`N, \$\$`!`hc`Zi``m[Yh`f]X`cZ`JcXUZcbY`W\ghca]nUh]cb"

'7cbj Yfh': ) \$\$ 'hc '?) \$\$"

`J,\$\$#N,\$\$#8+)\$#?+)\$#K,\$\$`9FCA`fYdU]f"`6fckb`UbX`fYX`d\cbYg`cZ`7=8&-#7=8' \*"

`7\Ub[]b['VUbX`c\<u>W</u>'gYhh]b['fhc'YbUV`Y'% \$\$A<n']b'gca Y'N%\$%\$'d\cbYgŁ"

7\Ub[]b['Wc`cf'cZ'FG5'WYfh]Z]WUhY

'hc`ZcfWY`XYjY`cdYf'i b]hg`fNfckbŁ'hc`UWWYdh`fYhU]``flfYXŁ`Z]fakUfY"

': i ```gi ddcfh'Zcf`Wfcgg! 7 =8 'ZUg\]b[ "'=h`]g`dcgg]V`Y`hc`ZUg\ '7 =8 %\* ž'7 =8 %+ 'UbX '7 =8 &- 'd\cbYg`Vm'Ubm 7 =8 'Z'Ug\ Yg"

'5i lca UhjWa Ya cfmWcbZj[i fUhjcb'UbU`rrgjg'lc'dfYj Ybh'UWJXYbhU`; 8:G'XUa U[Y'!'i b`]\_Y'ch\Yf'lcc`g"

K f]hY'U`a cgh'Ubm'Wca V]bUh]cb'cZ`Ub[i U[Yg"

`K f]hY`U`a cgh`Ubm`Wca V]bUh]cb`cZ`H- `X]Wh]cbUf]Yg"

`8ckb`cUX``Ub[iU[Yg`UbX`H-`X]Wh]cbUf]Yg`Zfca`h\Y`d\cbY"

 $\hbox{Id`cUX'igYf'Z]`Yg'hc'h\Y'd\cbY'fUiX]c\check{z}'j]XYc\check{z}'h\YaYg\check{z}'YhW'L}\\$ 

`I d`cUX`Ubm`Z]`Y`hc`Ubm'dcg]h]cb`]b`h\Y`X]fYWhcfmighfi Whi fY`!`Zcf`UXj UbWYX`i gYfg"

 $\label{eq:final_problem} \hbox{FYdU]} f`XYUXž`V`]b\_]b[``UbX`WcbhUWh$ 

cdYfUhcf'd\cbYg"

`FYdU]f]b[`d\cbYg`k]h\`Wca d`YhY`mXYghfcmYX`gYW\f]hm`ncbY`]b`WUgY`mci `\Uj Y`bc`VUW<u>\</u>i d"

`Hifb`WJaYfU`g\ihnYf`gcibX`cb#cZZ'

6UW\_i d gYW f]hmincbY"

FYghcfY'gYW'f]hmincbY"
FYWU'W'UhY'U``gYW'f]hmincbY'7F7g"

7\Ub[Y'd\cbY'hmdY'XYgWf]dhcf"

`FYgYh`U]f`h]a Yž`fYgYh`hchU``WU```h]a Yž`fYgYh``]ZY`h]a Y"

`FYgYh`^cmgh]W\_`WcibhYf"

`9bUV`Y#X]gUV`Y`W\UbbY``]bZcž`VUhhYfm]bZcž`G=A`hcc`\_]hgiddcfhž`GAG`WUdUV]`]hm''

7CAD@9H9`:=;<H9F`:IB7H=CB5@=HM=B7@I898°f[]"Y"'U```dfYj]cig`d\cbYg`UfY`giddcfhYXŁ

# PPO

69@CK 'MCI '75B': =B8'< =GHCFMC: '5@@'I D85H9G'I BH=@'%' H< 'A5M&\$\$\*  $BYk\ Yf'i\ dXUhYg'k\ ]```VY``]ghYX'U`gc"$ 

J Yfg]cb - "\* ' ff%' h\ A Um&\$\$\* Ł.

K Y `` Uj Y `XYV]XYX`hc `fY`YUgY `gYdUfUhY': ]fa k UfY `F YghcfU``]bghU``Yf''

5XXYX': ]fak UfY'fYghcfY'Vi hhcb'hc'h\Y'GYW/f]hmdU[Y"'=h'Ui hca Uh]WD`m`cc\_g'Zcf'dfcdYf'Z]fak UfY'fYghcfU`'Z]Y'UbX'Z'Ug\Yg']h hc h\Y d\cbY"

312 C

< Y `d Z] `Y `i dXUhYX"

J Yfg]cb '- "\* % fl%&h\ 'A Um&\$\$\* Ł.

5XXYX'gi ddcfh'Zcf'?) %\$'d\cbYg"

J Yfg]cb '- "\* \$ fl\%h\ 'A Um&\$\$\* Ł.

 $5XXYX \cdot gi \cdot ddcfh \cdot Zcf \cdot fYUX]b[ \cdot i \cdot b \cdot c\underline{W} \cdot \#fY \cdot c\underline{W} \cdot WcXYg \cdot Zfca \cdot N' \cdot \$\$"$ 

5XXYX gi ddcfh Zcf fYUX]b[ ZUg\ Zfca N' \$\$"

I dXUhYX 'H57 ``]gh Zcf 'N) ' \$]"

I dXUhYX Vi ] h ]b W ghca ]nUh]cbg"

J Yfg]cb '- ") ( 'fl, h\ 'A Um'&\$\$\* Ł.

 $: ] | YX`Udd`YhgY`YVM]cb`dfcV`Ya "`G\ci`X`Z] | h\Y`GYbX]b[`Udd`YhdfcV`Ya "`G\ci`X`Z] | h\X`GYbX]b[`Udd`YhdfcV`Ya "`G\ci`X`Z] | h\X`GYbX]b[`X`G`X "`G\ci`X`Z] | h\X`G`X`G`X "`G\ci`X`Z] | h\X`G`X`G`X "`G\ci`X`Z] | h\X`G`X`G`X "`G\ci`X`G`X "`G\ci`X`G$ 

J Yfg]cb - ") ' fl, h\ A Um&\$\$\* Ł.

 $I\ dXUhYX`H57``]gh`Zcf`H&'\ \$]\check{z}`H\&-\ \$]\check{z}`H\&'\ \$\check{z}`H^*'\ *\check{z}`H^*'\ +\check{z}`J\ ,\ \$\$\check{z}`K\ ,\ \$\$]\check{z}`K\ ,\ \$\$]\check{z}`K\ ,\ \$\$]\check{z}`N)\ \&\$]``UbX``@,\ `I\ ,\ \%'\ ,\ 7"$ 

: ]I YX bcb! 9b[ `]g\ ``Ub[ i U[ Y ghf]b[ g"

J Yfg]cb '- ") & fl, h\ 'A Um&\$\$\* Ł.

: i ```gi ddcfh'Zcf`Xck b`cUX]b[ 'Z]`Yg`Zfca 'K , %\$`UbX`N) ' \$`d\cbYg" < Y`d`Z]`Y`g`][\h`midXUhYX`!`acfY`hc`WcaY`gccb"

J Yfg]cb '- ") % fl, h\ 'A Um&\$\$\* Ł.

Gca Y cdYfUh]cbg a UXY ZUghYf" =bWfYUgYX^ZUg\Yf^jYfVcg]hm'

: ]I YX a ]bcf K - \$\$! fY `UhYX `Vi [ "



## J Yfg]cb '- ") \$ fl+h\ 'A Um'&\$\$\* Ł.

 $5XXYX^*Z bWM]cbU^*]hm^*Zcf^*bcb! HD^*ZUg^*]b[^*f^YX^*7 = 8(-^*d^cbYg^*f]bW^*X]b[^*K , \%^*UbX^*N)^* \\ \$E^*k ]h^*CcW_YX! Xck b^*9FCA^*UfYU'' + (-^*d^cbYg^*f]bW^*X]b[^*K , \%^*UbX^*N)^* \\ \$E^*k ]h^*CcW_YX! Xck b^*9FCA^*UfYU'' + (-^*d^cbYg^*f]bW^*X]b[^*K , \%^*UbX^*N)^* \\ \$E^*k ]h^*CcW_YX! Xck b^*9FCA^*UfYU'' + (-^*d^cbYg^*f]bW^*X]b[^*K , \%^*UbX^*N)^* \\ \$E^*k ]h^*CcW_YX! Xck b^*9FCA^*UfYU'' + (-^*d^cbYg^*f]bW^*X]b[^*K , \%^*UbX^*N)^* \\ \$E^*k ]h^*CcW_YX! Xck b^*9FCA^*UfYU'' + (-^*d^cbYg^*f]bW^*X]b[^*K , \%^*UbX^*N)^* \\ \$E^*k ]h^*CcW_YX! Xck b^*9FCA^*UfYU'' + (-^*d^cbYg^*f]bW^*X]b[^*K , \%^*UbX^*N)^* \\ \$E^*k ]h^*CcW_YX! Xck b^*9FCA^*UfYU'' + (-^*d^cbYg^*f]bW^*X]b[^*K , \%^*UbX^*N)^* \\ \$E^*k ]h^*CcW_YX! Xck b^*9FCA^*UfYU'' + (-^*d^cbYg^*f]bW^*X]b[^*K , \%^*UbX^*N)^* \\ \$E^*k ]h^*CcW_YX! Xck b^*9FCA^*UfYU'' + (-^*d^cbYg^*f]bW^*X]b[^*K , \%^*UbX^*N)^* \\ \$E^*k ]h^*CcW_YX! Xck b^*9FCA^*UfYU'' + (-^*d^cbYg^*f]bW^*X]b[^*K , \%^*UbX^*N)^* \\ \$E^*k ]h^*CcW_YX! Xck b^*9FCA^*UfYU'' + (-^*d^cAYg^*f)bW^*X]b[^*K , \%^*CW_YX! Xck b^*9FCA^*UfYU'' + (-^*d^cAYg^*f)bW^*X]b[^*K , \%^*CW_YX! Xck b^*9FCA^*W_YX! Xck b^*YY + (-^*d^cAYg^*f)bW^*X + (-^*d^cAYg^*f)bW^*X$ 5XXYX`ZIbWM]cbU`]hm`Zcf`bcb!HD`ib`cW\_]b[#fY`cW\_]b['fYX`7=8(-`d\cbYg`f]|bWiX]b[`K,%\$`UbX`N)'\$Ł'k]h\``cW\_YX!Xckb'9FCA UfYU"

 $5XXYX`bcb!\ HD`:\ G`Z\ bWh]cbU`]hm`Zcf`fYX`7=8(-`d\ cbYg`f]bWi\ X]b[`K\ ,\ \%$`UbX`N)`\ \$E`k\ ]h\ ``cW_YX!\ Xck\ b`9FCA`UfYU''5XXYX`gi\ ddcfh`Zcf`bcb!\ HD`=A\ 9=`W\Ub[`Y`]b`fYX`7=8(-`d\ cbYg`k\ ]h\ ``cW_YX!\ Xck\ b`9FCA`UfYU''$ 

 $5XXYX'gi\ ddefh'Zef'Webj\ Yfhlb[\ 'fYX'7=8(-\ '?+)\ \$\check{z}'K\ ,\ \$\$'UbX'N)\ \&\$'\ d\ cbYg'k\ ]h\ 'i\ b\ c\underline{W}\ YX'9FCA'\ UfYU'hc'Vfck\ b'7=8(-\ ''+)\ B'A' YbhYX'I \ b\ c\underline{W}\ 'FG5'\ Zb\ bWh]cb'Zef'fYX'7=8(-\ 'd\ b)'g''$ 

 $\text{HVY} \textbf{F} \textbf{YdU} \textbf{f} \textbf{'Wffi} \textbf{Z} \textbf{WWh} \textbf{'Z} \textbf{bWh} \textbf{(Z} \textbf{bWh}) \textbf{cb} \textbf{`]} \textbf{g'bck} \textbf{'X} \textbf{]} \textbf{gUV'YX'} \textbf{Zcf'} \textbf{fYX'} \textbf{7} = 8 (- \textbf{'d} \textbf{cb} \textbf{Yg'Vm'XYZU} \textbf{'h''} \textbf{H} \textbf{YfY'} \textbf{]} \textbf{g'U'k Um'hc'YbUV'Y'} \textbf{hz'h} \textbf{ch} \textbf{cl} \textbf{['\']} \textbf{hg'i} \textbf{gY} \textbf{g'Ym'XYZU} \textbf{h'''} \textbf{H} \textbf{YfY'} \textbf{g'U'k Um'hc'YbUV'Y'} \textbf{hz'h} \textbf{ch} \textbf{cl} \textbf{['\']} \textbf{hg'i} \textbf{gY} \textbf{g'Ym'XYZU} \textbf{h'''} \textbf{h} \textbf{y'Y} \textbf{g'Ym'XYZU} \textbf{h} \textbf{h} \textbf{h} \textbf{h} \textbf{g'Y} \textbf{g'Ym'XYZU} \textbf{h} \textbf{h} \textbf{g'Ym'XYZU} \textbf{h} \textbf{g'Ym'$ 

 $5XXYX`gi\ ddcfh`Zcf`Ui\ hca\ Uh]WZ]fa\ k\ UfY`]XYbh]Z]WUh]cb`]b`fYX`7=8(-`d\cbYg"$ 

 $\label{eq:continuity} Gca\ Y'dUhW.Yfg'k\ YfY'UbU'm]b[\ :: CH5'UfYU'Vm'U'a\ ]ghU_Y'f]"Y"'bch'][\ bcf]b[\ ']hL'UbX'h\ YfYZcfY'bch'Zl\ bVM]cb]b[\ 'dfcdYf'm'Zcf'gca\ Y'dUhW.Yfg'k\ YfY'UbU'm]b[\ 'chf'Zcf'y'bch'Zl\ bVM]cb]b[\ 'dfcdYf'm'Zcf'gca\ Y'dUhW.Yfg'k\ YfY'UbU'm]b[\ 'chf'Zcf'y'bch'Zl\ bVM]cb]b[\ 'chf'Zcf'y'bch'Zcf'y'bch'Zl\ bVM]cb]b[\ 'chf'Zcf'y'bch'Zcf'y'bch'Zcf'y'bch'Zl\ bVM]cb]b[\ 'chf'Zcf'y'bch'Zc$ d\cbY'a cXY'g"

GYj YfU`'Udd`Yhg'i dXUhYX"

Gca Y'Vi ]`h! ]b W ghca ]nUh]cbg k YfY i dXUhYX"

## J Yfg]cb '- "&' 'fl) h\ 'A UfVX '&\$\$\* Ł.

=bghU``Yf'i dXUhYX"

 $\label{eq:Gk-YX-W} Gk\ YX]g\ ``Ub[i\ U[\ Y`ghf]b[\ g`i\ dXUhYX`U[\ U]b"$ 

## J Yfg]cb '- "&& fl%gh'A UfVX '&\$\$\* Ł.

=bghU``Yf'i dXUhYX"

8 YVi [ @c[ Z] bWh]cbU`]hmii dXUhYX"

A ]bcf WX Ub[ Yg hc V cch Wc XY"

G`][\h`m`]b\\fYUgYX`Z\\g\Yf`j\YfVcg]\m'

 $Gk YX]g\ ``Ub[i U[Y`ghf]b[g`i dXUhYX"$ 

 $G`cjU_-``Ub[iU[Y`ghf]b[g`idXUhYX"]$ 

## J Yfg]cb '- "&%'fl&\* h\ ': YVfi Ufm'&\$\$\* Ł.

=bghU``Yf'idXUhYX"

9FCA 'UbX': CH5'Z]`Yg'a cj YX'ci h'Zfca 'h\Y'\Y`d'Z]`Y"

:fca ˈbck ˈcbžˈh\Yː cfa Uh; 8:GʻZ bWhjcb k]``VYi bUj U]`UV`Y" ≔hk UgʻUVi gYX hcc cZhYb"

 $< Y^d^Z^Y i dXUhYX$ 

I gYf'a Ubi U``]b'D8: 'Z]`Y'Zcfa Uh'fY`YUgYX"

## J Yfg]cb - "&\$ fl&) h\ : YVfi Ufm&\$\$\* Ł.

A ]bcf WW.Ub[ Yg hc  $^\circ$ 9F C A  $^\circ$ UfYU  $^\circ$ ZUg\ ]b[  $^\circ$ WcXY"

I dXUhYX'?+) \$#K )) \$#K , \$\$#K - \$\$#N) &\$ 'Vi ]'h! ]b 'W ghca ]nUh]cbg"

## J Yfg]cb - "% fl&( h\ : YVfi Ufm&\$\$\* Ł.

: ]| YX 'U'Vi [ 'fY[ UfX]b[ '7fYUhY 'Z]`Y'dUW\_U[ Y'cdh]cb"

A ]bcf WX Ub[ Yg hc Vcch]b[ 'WcXY"

CdYb#gUj Y`X]U`c[ 'W¢XY'i dXUhYX"

## J Yfg]cb - "%, 'fl&( h\ : YVfi Ufm&\$\$\* Ł.

Zcf'h\YgY'd\cbYg'fYWYbh`m'

=bWfYUgYX\_j YfVcg]hmZcf\_cdYfUhcffga ]ghU\_Yg"

 $7 \ \mathsf{Ub} [\ \mathsf{Y} \mathsf{g}^{\cdot}] \mathsf{b}^{\cdot} \mathsf{HD} ! \ \mathsf{Ub} \mathsf{X}^{\cdot}] \mathsf{b} [^{\cdot} \mathsf{W} \mathsf{c} \mathsf{X} \mathsf{Y}''$ 

## J Yfg]cb '- "%+ 'fl&' fX': YVfi Ufm'&\$\$\* Ł.

I dXUhYX``Ub[dUW\_'XYgWf]dh]cb'Zcf'K - \$\$"

:]| YX`Vi [ `]b`; 8:G`UWWYgg`WcXY`Zcf`d\cbYg`k]h\`VUgYVUbX`=8g`\$|, \$\$\$`UbX`\$|, \$(\$"

FYXi WYX']a dcfhUbWY'cZ'I b`cW\_'FG5'Z bWh]cb"'=h'g\ci `X'bch'VY'bYYXYX'Zcf'Vfck b'UbX'V'i Y'd\cbYg'Ubma cfY"

## J Yfg]cb - "%\* fl&&bX : YVfi Ufm&\$\$\* Ł.

A ]bcf WX Ub[ Yg ]b F G5 d\cbY Vcch]b[ 'UbX g\i hXck b WtXY" I dXUhYX H57 ``]gh Zcf '>&%\$]"

 $FYXi\ bXUbWmXYWfYUgYX~U[\ U]b"$ 

Ch\Yfa]bcfVi[Z]lYg"

BchY. =h]gfYWta a YbXYX'hc'Z]``U```G9'Ya dhmVcUfXgfY[UfX`YggcZh\Y]fd\cbY'hmdY'Vm'Vfck b'7=8(-'Wffh]Z]WUhY'j]U'7=8(-fYWtjYfm'Vcch'UbX'Wffh]Z]WUhY'fYdU]f"'JYfg]cb'- "%) 'fl&bX': YVfi Ufm'&\$\$\*L.

5XXYX gi ddcfh Zcf i b`cW\_]b[ 'gYj YfU 'bYk 'I , % \$ 'Zjfa k UfYg" | dXUhYX '5FA '&\$\$(#&\$\$) : 5E '\Y`d! Z]Y 'gYWf]cb" | 5XXYX : 5E '\Y`d! Z]Y 'gYWf]cb 'Zcf G\Ufd ' ; 'd\cbYg"

 $: ]I YX^{\cdot}Vi \ [ \ ^{\cdot}]b^{\cdot\cdot}Ub[\ dUW\underline{\ \ }^{\cdot}XYgWf]dh]cb^{\cdot}Zcf^{\cdot?} + \$\$"$ 

## SUPPORT J Yfg]cb - "%( ff% h\ : YVfi Ufm&\$\$\* Ł. $5XXYX "gi ddcfh" \hbox{\it Zcf"} i b "cW\_]b["gYj YfU" bYk" I", '' $ Z]fa k UfYg"$ I dXUhYX H57 ``]gh'Zcf G]Ya Ybg 7 \* &" : ]I YX`a ]bcf`H\*%\$`Vi [ `a Ub]ZYgh]b[ `]hgY`Z`cb`gca Y`K ]bXck g`j Yfg]cbg" $\label{eq:local_conditions} $$I\ dXUhYX^@,\ I\ ,\ )\ ) $$'V`cW_{-}^{-}]gh'Wta\ Vc!\ Vcl\ 'Zcf'ZUg\ fYUX]b[$ J Yfg]cb '- "%' 'ff%- h\ ': YVfi Ufm&\$\$\* Ł. : ]| YX 5J F 'ZUg\ ]b[ 'Vi [ 'Zfca 'j Yfg]cb '- "%\$" I dXUhYX 'H57 '`]gh 'Zcf' >' \$\$] 'UbX '?' \$\$]" BYk 'Z[fa k UfY 'dUhW\Yf'Yb[]bY ']a d'Ya YbhYX" 'ff5dd`]YX 'hc'@ 'Zcf'bck ž'G\Ufd'UbX'G9``UhYf"Ł 5XXYX gi ddcfh Zcf dUhW ]b[ bYk Yf @ ''; Z]fa k UfYg" J Yfg]cb '- "%& fl%\* h\ ': YVfi Ufm&\$\$\* Ł. : ]I YX a ]bcf FG5 i b cW\_ Vi [ " 5UPPORT J Yfg]cb - "%% fl%\* h\ : YVfi Ufm&\$\$\* Ł. : `Ug\Yf'a cXi `Yg'i dXUhYX'U[ U]b" J Yfg]cb - "%\$ ff%\* h\ : YVfi Ufm&\$\$\* Ł. =h']g'dcgg]V'Y'hc'cdYb'a cfY'Z'Ug\'Z]'Yg'Uh'cb\\"BchY.' >i gh'\c'X'h\Y'7hf'\_Ymk\]'Y'gY'Y\\"b]b['Z]'Yg'' =h']g'dcgg]V`Y hc'W'ghca]nY'Z[`YgmghYa'Ui hcaUh]VW``mf][\h'UZhYf'Z'Ug\]b['fUk': G" 5```ZUg\Yf`a cXi `Yg`k YfY`i dXUhYX" A ] bcf'WXUb[Yg']b'7=8) ('WcbZ][ifUh]cb'UbU'mg]g'WcXY'' $A \ c \ X \ Z \ Y \ X \ Y \ Z \ J \ h' \ g \ h \ h \ h' \ c \ Z' \ 9 \ h' \ b \ X \ Y \ X' \ W \ b \ Z \ [\ \ ' \ c \ d \ h] \ c \ b \ g''$ $D\cbY': ]fa\ k\ UfY'6U\underline{W}i\ d'ff'dZVŁ'Z]'Yg'WfYUffY']b'fh']g'j\ Yfg]cb'UfY'bch'VU\W_k\ UfXg'Wca\ dUfl]V'Y'f]]''Y'''g\ci'`X'bch'VY'i\ gYX'k\]fh\$ dfYj ]ci g'j Yfg]cbgŁ" : ]I YX'a ]bcf': G'W ghca ]nUh]cb']ggi Y" : ]I YX a ]bcf'; 8: G#. G'Vi [ 'Zfca 'j Yfg]cb'- "\$\$" K))\$fbYk < K L'hYghdc]bh'd]Whi fY'i dXUhYX" 5UPPORT I dXUMYX H57 ``]gh Zcf H&- \$Už?' \$\$] UbX ?+\$\$]" 7ca a i b]WWn]cb WcXY i dXUMYX" GhUfhi d'WcXY'a cX]Z]YX" 5 ZYk a Ya cfm`YU\_g'fYa cj YX" J Yfg]cb - "\$' fl- h\ : YVfi Ufm&\$\$\* Ł. : ]I YX FG5 5JF Vcch]b[ 'Vi [ 'Zfca 'j Yfg]cb '- "\$\$" : ]I YX a ]bcf gYW f]hm ncbY WfYUh]cb Vi [ " I dXUhYX J #? \* \$1 hYghdc]bh'd]Wi fYg" J Yfg]cb - "\$& fl, h\ : YVfi Ufm&\$\$\* Ł. : ]I YX'; 8: G'UbX': G'UVWYgg'Vi [ 'Zfca 'j Yfg]cb'- "\$\$" : ]I YX'Vfck b#V'i Y'7=8' + 'Vcch]b[ 'Vi [ 'Zfca 'j Yfg]cb'- "\$\$"

## J Yfg]cb '- "\$%'fl, h\ ': YVfi Ufm'&\$\$\* Ł.

: ]I YX G\ Ufd '' ; 'Z Ug\ ]b[ 'Vi [ 'Zfca 'j Yfg]cb'- "\$\$"

## J Yfg]cb '- "\$\$ fl+h\ ': YVfi Ufm&\$\$\* է.

 $= a \ d^Ya \ YbhYX^@, \ I_{,\, })) \ fYX^7 = 8) \ (\ i \ b^c \underline{W}]b[\ k\ ]h\ ci\ h^i \ g]b[\ hYghdc]bh''K \ cf^Xfig^Z]fgh^U[\ U]b^*$ 

: ]I YX `U `Vi [ `]b `Z Ug\ ]b[ `fUk `: G `Z]`Yg `j ]U `9D=`I G6"

 $: ] | YX`g`ck!ZUg \ ] b[ `Vi [ `Zcf`GH`A ] WfcY`YVWfcb] Wg`VX ] dg'' \\$ 

7\Ub[Yg]bG\Ufd'; ZibWh]cbU`]hm'

7\Ub[Yg]b@"; ZbWh]cbU`]hm"

9bUV`YX`ZUg\`fYUX]b[ 'Zfca 'bYk '5FA 'd\cbYg'Zcf'U```i gYfg"

5XXYX`Z|````gi ddcfh`Zcf`6`i Y`7=8(- 'd\cbYg`k ]h\`VUgYVUbX`VX]d`=8`\$I +%\$\$"

 $\label{thm:condition} Gca\ Y`cdYfUh]cbg`cb`6`i\ Y`UbX`6fck\ b`d\cbYg`k\ YfY`a\ UXY`ZUghYf"$ 

5XXYX gi ddcfh Zcf HA G WUV Y Ui hcXYhYWh]cb "

: ]| YX`Vi [ ']b'8]gUV`Y#9bUV`Y`CHD'=A 9='VXYW\_'Z bVY)cb'Zcf'bYk '5FA 'd\cbYg"

 $H\Y'dfYj$  ]ci g'WcXY'k Ug'Yl WYgg]j Y`m'cdh]a ]nYX

: ]I YX`a ]bcf`>' \$\$`Z]Y`gY`YVM]cb`]ggi Y" I dXUMYX`H57``]gh`Zcf`N' \$\$]ž`N' \$\$U`UbX`?+) \$]"

FYXi bXUbWmXYWfYUgYX'U[U]b"

## JYfg]cb', "%%ff \$h\ >Ubi Ufm&\$\$\* Ł.

 $FYYUgYXZUgYZZUgYZCf'ib`cW_]b[`@,`I,,)) $"`=b`hYg'jYfg]cb`]hYUg'hc`VYZUgYXJj]U'HD"$  $\label{thm:condition} \mbox{Hc fYdU]f'd\cbYg'XUa\ U[\ YX'Vmch\Yf'hcc'g'h]$$ $W'Cj\ Yfk\ f]$ hY'Z'Ug\ 'W'fh]$Z]$$ WhY'cdh]cb'' $$ \mbox{Hc fYdU]f'd\cbYg'XUa\ U[\ YX'Vmch\Yf'hcc'g'h]$$ $W'Cj\ Yfk\ f]$$ hY'Z'Ug\ 'W'fh]$$ $Z'Ug\ 'W'fh]$$$ $Z'Ug\ 'Y'Ug\ 'Y'Ug\$ -#rg\ci`X`VY`bc`a cfY`bYWfggUfm`hc`i b`c\W\_FG5`VYZcfY`i b`c\W\_]b[`bYk`G\\Ufd`d\cbYg'j ]U'dUh\W]b[" =bghU``Yf'i dXUhYX"

SUPPOR : ]I YX 'U'Vi [ 'fY[ UfX]b[ 'D- %\$U'd\cbYg"

I dXUhYX 'H57 '`]gh'Zcf 'H\*' \$] 'UbX 'G\Ufd 'J +\$' G<" GYj YfU``dfchchmdY!fY`UhYX`i dXUhYg" 6i ]`h! ]b 'W' ghca ]nUh]cbg i dXUhYX"

## J Yfg]cb', "%\$'fl&&bX'>Ubi Ufm'&\$\$\* Ł.

 $Cb[c]b[\ gcZhk\ UfY\ UfVX]hYWhi\ fU\ WX\ Ub[\ Yg"]$ 

FYXi bXUbWmXYWfYUgYX"

5XXYX gi ddcfh Zcf dfc[fUa a ]b[ K , %#7 Yc#A i `Ub Ya dhm VcUfXg"

8ck b`cUX]b[ 'Z]`Yg'Zfca '?+) \$#K , \$\$#N) &\$ 'YbUV`YX 'Zcf'U```i gYfg" 8ck b`cUX]b[ 'Z]`Yg'Zfca 'K ) ) \$#K \*\$\$ 'YbUV`YX 'Zcf'U```i gYfg"

8ck b`cUX]b[ 'Z]`Yg`Zfca 'K - \$\$ 'YbUV`YX 'Zcf'U```i gYfg"

I dXUhYX`H57``]gh`Zcf`H&' \$]`UbX`>&\$\$]"

5XXYX gi ddcfh Zcf HA G WUV Y"

 $H\$  fck b Uk Umh\Y c`Xž gdcfUX]\W\`mk cf\_]b[  $\check{z}$  \Y`d Yb[ ]bY"

I dXUhYX`a Ubm`hYI hg`]b`7fi ]gYf`\Y`d`Z]`Y"`H\Ub\_g`hc`Ai ddYh"

< Y`d`Z]`Y`Wcad`YhY`mfYcf[Ub]nYX"'Bck`]h`gYYag`hc`VY`acfY`hcdc`c[]\W\``m\VcffY\W'

 $<\verb!Y`d`Z]`Y`gWfYYbg\chg`i dXUhYX<math>\check{z}`XYgWf]dh]cbg`i dXUhYX`hcc"$ 

< Y`d`Z]`Y '9F C A ! Z]`Yg'i dXUhYX"

 $\label{eq:K-spin} K - \$\$] `hYghdc] bh'd] Whi fY`] bWi XYX`hc`h\Y`\Y`d`Z]`Y"$ 

H\Y'@Ub[DUW\_']bZc'Vi hhcb'g\ci `X'VY'fY`]UV`Y'bck"

5XXYX gi ddcfh Zcf 7=8% 9FCA fYWcj Yfm'

**8YVi** [ '@c[ 'Z bWh]cbU']hm'a cX]Z]YX'gc'h\Uh']h'WUb'VY'i gYX'k]h\'K]bXckg'BchYdUX"

 $\textbf{GYWV f]} \textbf{hm} = \textbf{fYbUa} \ \ \textbf{YX hc} \ \ \textbf{GYWV f]} \textbf{hm} \textbf{5J F} \ \textbf{"}$ 

6i ]`h! ]b 'W' ghca ]nUh]cbg i dXUhYX"

## J Yfg]cb', "\$\$'fl%( h\'>Ubi UfmŁ

= a dYa YbhYX fYX 7 = 8(-ib)cW]b[UbX ZUg]b[ik]hAcihig]b[UhYghdc]bh''

H\Y'fYU`'ghUbXU`cbY'k Umž'bc'9A A 5 'ga UfhWUfX'i gU[Yž'k cf`Xfg'Z]fgh°

Gi ddcfhYX'd\cbYg'UfY'K))\$]#Wt'K\*\$\$]ž?\*\$\$]#Wt'?\*\$,]'UbX'J\*\$\$]"'A cfY'a cXY'g'W&a ]b['g\cfh'm' @cUXYfg'i dXUhYX"

## J Yfg]cb + "% fl% h\ >Ubi UfmŁ

=bghU``Yf`i dXUhYX"'BYk 'WVV`Y'Xf]j Yf`j Yfg]cb`fk\%+\* Ł`]bWi XYX" 6i ]`H]b'W ghca ]nUh]cbg`i dXUhYX"'9l dYf]a YbhU``: CH5`gi ddcfh'UXXYX"

Gca Y'; 8: G! fY`UhYX'W\Ub[ Yg"

7\Ub[Yg']b'i b`c\\\\_'\Z| b\\\\\]cb\U`]\m'

 $\label{eq:G'} $$G'[\hm'VXUb[YX'Z]bVM]cbU']hm'cZ'h\Y'd\cbY'hmdY'Z]'hYf''$$ 

5XXYX gi ddcfh Zcf hk c bYk ZUg\ =8 g"

 $FG5 \cdot WcbZ][ifUh]cb \cdot UbU \cdot mg]g \cdot WcXY \cdot idXUhYX \cdot U[U]b''$ 

@cUXYfg'k YfY'i dXUhYX"

A ]bcf'UfVX ]hYWhi fU`'VX Ub[Yg"

5``ck YX`hc`WXUb[Y``Ub[i U[Y`hc`7\]bYgY#A U`Um'Zcf`bcb! 7\]bYgY`UbX`bcb! A U`Um'WJfX`i gYfg"

## J Yfg]cb + "%) fl%gh > Ubi Ufm & \$ \* Ł.

GYj YfU``Wca a i b]WWh]cb gWf]dhg i dXUhYX"

@ 'I , ' , \$ 'hYghdc]bh']bWl XYX'hc 'h\Y'\Y`d'Z]`Y"

5XXYX "Ub cdh]cb hc k f]hY fYd UW a Ybhi b]h W ghca ]nUh]cb"

6hk ž`\UddmibYk 'mYUf°

J Yfg]cb '+"%( 'ff' %gh'8YWYa VYf'&\$\$) Ł. 5bch\Yf'?\* \$, ]'hYghdc]bh'd]Wfi fY ]bWl XYX'hc'h\Y'\Y`d'Z]'Y"

>&% K cf'X'; YbYf]WXYW ghca ]nUh]cb'\Ug'VYYb'fY'YUgYX"

>&%\$`fYdU]f`Z]`Y`\Ug`VYYb`fY`YUgYX"`FYaYaVYf`hc`fYWU`W``UhY`7F7g`fh\Y`d\cbY`g\ci`X`VY`UhHUW\YX`Ug`>&\$\$Ł"

6fck b'7=8(-': CH5'fl`Ug\!CjYf!H\Y!5]fL'fYdU]f'Z]Yg'Zcf'K))\$ž'K\*\$\$ž'G\*\$\$'UbX'K-\$\$`\UjY'VYYb'UXXYX'hc'h\Y'\Y`d'Z]Y" Gca Y``cUXYfg'k YfY'i dXUhYX"

BchY. =Z'mci f'd\cbY'ZfYYnYg'f][\h'UZhYf'dck Yf]b['cbž'hfmX]fYVhii b`cW\_]b[']h"

## J Yfg]cb + "% 'fl&- h\ '8 YWYa VYf '&\$\$) Ł.

7fi ]gYf']g'bck 'Uj U]`UV`Y`]b'9b[ `]g\ž7\]bYgYž'7nYW\ž'; fYY\_ž'=bXcbYg]Ubž'A U`Umž'Dc`]g\žFi gg]Ubž'G`cj U\_'UbX'Gk YX]g\ `Ub[i U[Yg"

A Ubmh\ Ub\_g'm: - J c'm: Zcf'dfYdUf]b[ '; fYY\_'hfUbg`Uh]cb" 5XXYX'@Ub[ i U[ Y`dU[ Y`m: h\ Y`GYh]b[ g'k ]bXck "'H\ ]g'dU[ Y`]g'bch'g\ck b' Zcf'7\ ]bYgYž'A U'Um'UbX`=bXcbYg]Ub'WUfXg" I dXUhYX'H57 ``]gh'Zcf'H&- \$]ž'? +) \$]ž'N) &\$Už'K \*\$\$]ž'@ 'I ,' '\*\$ž'G]Ya Ybg'7\*&"

=a d`Ya YbhYX`gYj YfU``: G!fY`UhYX`Z bWh]cbg`Zcf`Vfck b`7=8(-`K))\$#K \*\$\$`d\cbYg"

I dXUhYX K \*\$\$] Vi ] H ]b W ghca ]nUh]cbg"

I dXUhYX K - \$\$] Vi ] h! ]b W ghca ]nUh]cbg"

Gca Y'dfchchmdY!fY`UhYX'i dXUhYg"

#### J Yfg]cb + "%& fl&&bX 8YW a VYf &\$\$) Ł.

: ]I YX 9F CA 'fYdU]f']ggi Y'Zcf'Vfck b'7 =8 ( - '? \* \$, '

I dXUhYX'K - \$\$]'`Ub[ dUW\_']bZc"

Gca Y'VXUb[Yg'hc'Udd`Yh'i d`cUX'ghfUhY[]Yg"

## J Yfg]cb '+ "%%'fl' fX '8 YWYa VYf '&\$\$) Ł.

 $5XXYX gi \ ddcfh \ \ Zcf \ \ ZUg\ ]b[\ \ 7=8) \ (\ \ 'd\ \ cbYg \ fl@\ \ I\ ,\ )) \ \$k'k \ ]h\ ci \ h'i \ g]b[\ \ 'hYghdc]bh''$ 

FG5 WcbZ[[i fUh]cb UbU`mg]g WcXY 'g`][ \ h`mi dXUhYX 'hc 'fYZYWh'7 =8) (!fY`UhYX 'WX Ub[ Yg"

=bWfYUgYX fcVi ghbYgg cZFG5 'WcbZ[[ i fUh]cb 'UbU'mg]g 'WcXY 'hc 'dfYj Ybh'dchYbh]U' 'WfUg\Yg 'cb ']bj U']X 'ZUg\ 'WcbhYbh'  $5XXYX`U`hYfbUhY`a~Yh\cX`cZ`fYd`UV]\!b[~FG5`WYfh]Z]WUhYg"$ 

: ]I YX cbY Vi [ ']b ``ck ! `Yj Y ``Wta a i b]\WJh]cb `WtXY

: ]| YX`ga U```Vi [ `]b`**FYdU]f`WYfh]Z]VWhY**`Zi bWh]cb"

: ]| YX`cbY`dfYj ]ci g`m`]bhfcXi WYX`Vi [ `]b`; 8: G`UWWYgg`Zcf`D- %\$"

I dXUhYX'?+) \$]'Vi ]'h ]b W ghca ]nUh]cbg" I dXUhYX'K , \$\$]'Vi ]'h ]b W ghca ]nUh]cbg"

I dXUhYX`H57``]gh`Zcf`?' \$\$]ž`?+\$\$]ž`H&-\$]ž`@, `I , ' ' \$`UbX`G\Ufd`J-\$' G<"

## JYfg]cb + "% fl&bX Bcj Ya VYf &\$\$) Ł.

: fca 'bck 'cb']h']g'dcgg]V'Y'hc'Xck b`cUX'Z]'Yg'Zfca ': G'hc'gdYW]U''UfW.]j Y'Z]'Yg']b'''WZd'ff7fi ]gYf': ]'Y'DUW\_U[YŁ'Zcfa Uh'' : fca 'bck 'cb']h']g'dcgg]V'Y'hc'i d`cUX'''WZd'dUW\_U[Y'WcbhYbh'hc'd\cbY': G''

5b'@ 'I , ) ) \$ 'hYghdc]bh'd]Whi fY'UXXYX'hc'h\Y'\Y`d'Z]`Y"

I  $dXUhYX^K * $$ ]  $Vi ]^h ]b W ghca ]nUh]cbg"$ 

I dXUhYX '? \* \$, ] 'Vi ] 'h! ]b 'W ghca ]nUh]cbg"

I dXUhYX ? +\$\$] Vi ] h! ]b W ghca ]nUh]cbg"

: ]| YX´f) 9\$K fiW ghca ]nUh]cb`Vi [ 'Zfca 'j Yfg]cb'+"\$\$"

: ]I YX gca Y Vi [ g ]b Dc ]g\ hfUbg Uh]cb"

H\Y'7i ghca ]nY': G'Vi hhcb'k Ug'a cj YX'hc': `Ug\ '5F A 'dU[Y" : ]I YX'c\WUgg]cbU''?\*\$\$#?\*\$, #K - \$\$'Vcch]b['Vi ["

I dXUhYX K ) ) \$]#K ) ) \$W#K \* \$\$] `Ub[ dUW\_ ]bZc"

I dXUhYX 'H57 '`]gh Zcf'? +\$\$]"

## J Yfg]cb '+"\$\$ 'f1%+h\ 'Bcj Ya VYf '&\$\$) Ł.

5XXYX gi ddcfh Zcf ZUgh X]fYVMi b C V\_ CZ G Ufd J +\$' G<#J - \$' G<#GL' %' #GL, '' d\cbYg"

 $5bmk\ Um\check{z}\ h\backslash ]g\cdot ]g\cdot h\backslash Y\cdot Z UghYgh\cdot k\ UmcZi\ b`cW\_]b[\cdot h\backslash YgY\cdot d\backslash cbYg\cdot Uj\ U]\cdot UV\cdot Y\cdot cb\cdot h\backslash Y\cdot a\ Uf\_Yh''$ 

H\Y`X]fYWh`C`HD#, 8: G`W\YW\_'YbUV`Y#X]gUV`Y`Z bWh]cb`g\ci``X`VY`a i W\`a cfY`[YbYf]W!`bck`]h`\UbX`Yg`G\Ufd

 $\label{eq:continuous} J + \$' \ G < \#J - \$' \ G < \#GL' \ \% \ \#GL \ , \ ' \ ' \ Z] fa \ k \ Uf Yg \ hcc''$ 

Gi ddcfh'Zcf'i b`cW\_]b[ 'Ubm' 7=8 '5FA 'd\cbYg'k ]h\ 'VUgYVUbX'W\]d'=8g'\$I +\$\$\$z'\$I +\$\$\$z'\$I , \$\$\$'UbX'\$I , \$(\$"'9j Yb'K - \$\$ d\cbYg"

Gi ddcfh'Zcf'ZUg\]b[ 'Ubm'7=8'5FA'd\cbYg'k]h\ 'VUgYVUbX'W.]d'=8g'\$I+\$\$\$z'\$I+\$\$\$z'\$I, \$\$\$'UbX'\$I, \$(\$`k]h\ci h'W.Ub[]b[ df]a Ufm'Wfh]Z]WUhY"

BYk '? \* \$\$#? \* \$, 'hYghdc]bh'd]Whi fY'UXXYX'hc'h\Y'\Y`d'Z]`Y"

 $5\,{\rm K}$  ))  $\$  'hYghdc]bh'd]Whi fY`UXXYX`hc`h\Y`\Y`d`Z]`Y"

 $5 K * $$ hYghdc]bh'd]Whi fY'UXXYX'hc'h\Y'\Y`d'Z]Y"$ 

H\Y`ZUgh`@`'; `i b`c\W\_]b[`Z b\M]cbU`]hmj ]U`Z]fa k UfY`dUh\X\]b[`k Ug`YI hYbXYX`hc`gi ddcfh`gca Y`@, `I , ))\$`Z]fa k UfYg" 5XXYX`gi ddcfh`Zcf``c\W\_]b[`CHD`UfYU`]b`@`'; `UbX`G\Ufd''; `Ya dhm\VcUfXg"

 $5XXYX`Ub`cdh]cb`m`kf]hY`bYk`6`iYmch\`A 57`UXXfYgg`m`FG5!dfchYWhYX`5FA!VUgYX`G9`d\cbYg"`=h`]g`Uj`UJ`UV`Y`Uacb[`AcX]Zm$ ; 8: G cdh]cbg"

FG5 Vcchcdh]cbg \Uj Y VYYb a cX]Z]YX"

7Yfh]Z]WUhY fYWcj Yfm'Zi bWh]cb i dXUhYX"

FYdU]f'9FCA Z bVM]cbU']hmi dXUhYX'hc'fYZYVM'K))\$ UbX'K \*\$\*d\cbYg"'6ch\'Vfck b'7=8(-'UbX'fYX'7=8(-'d\cbYg'UfY gi ddcfhYX bck '

: ]I YX`a ]bcf`Vi [ `]b`FG5`WcbZ][i fUh]cb`UbU`mg]g`WcXY"

I dXUhYX 7i ghca ]nY : G Z bWh]cb"

I dXUhYX'H57'`]gh'Zcf'K \*\$\$]ž'>'\$\$U'UbX'?+)\$]"

Gca Y'W\Ub[Yg']b'7\]bYgY'hfUbg`Uh]cb"

J Yfg]cb \* "%\$ f) h\ Bcj Ya VYf &\$\$) Ł.

5XXYX'gi ddcfh'Zcf'i b`cW\_]b['>&%\$'d\cbYg"

H\Y'**FYWU**`W87F7g'Vi hhcb'k Ug'YbUV`YX'Zcf'>&%\$`Vm'U'a ]ghU\_Y"

Bch]VVY.  $DYUgY'dfYZYf'ig]b['fYUX]b['WcXYg'hc'X]fYVWiib'cW_]b['k\Yb'dcgg]V'Y$ 

J Yfg]cb '\* "\$) 'f&, h\ 'C Whc VYf'&\$\$) Ł.

K)) \$ Vi ]`h!]b W ghca ]nUh]cbg``]gh'i dXUhYX"

: ]I YX 'Ub ']ggi Y 'k ]h\ 'i b`c\\\\_]b[ 'gca Y 'G]Ya Ybg '7 \* & 'd\ cbYg"

: ]I YX`U`VI [ `]b`X]fYVM`C`HD#; 8: G`VX\Y<u>W</u>`X]gUV`Y#YbUV`Y`ZI bVM]cb`fY[UfX]b[ `@, `'; `d\cbYg`k ]h\`c`X`Z]fa k UfYg"

JYfg]cb'\*"\$('f&\*h\'CWhcVYf'&\$\$) Ł.



JPPOR

 $5XXYX^*gi\ ddcfh^*Zcf^*;\ 8:\ G^*]XYbh]hm^{VX}.Ub[\ ]b[\ ^{Z}cf^*7=8\%+^{\circ}@,\ ^{\circ};\ ^{\circ}d\ cbYg^{"'}fBch^{\circ}Uj\ U]^{`UV^*Y^*}]b^{\circ}@Y[\ U^{``9X}]h]cbL\\ 5XXYX^*gi\ ddcfh^*Zcf^*;\ 8:\ G^*]XYbh]hm^{VX}.Ub[\ ]b[\ ^{Z}cf^*7=8(\%^{\circ}UbX^{\circ}7=8(\&^{\circ}@,\ ^{\circ};\ ^{\circ}d\ cbYg^{\circ}]\ ]U^{h}Yghdc]bh^{"}fBch^{\circ}Uj\ U]^{`UV^*Y^{\circ}}]b^{\circ}@Y[\ U^{``9X}]h]cbL$ 

5XXYX'gi ddcfh'Zcf'; 8: G']XYbh]hm'W\Ub[]b['Zcf'7=8&('G\Ufd''; 'd\cbYg"'fBch'Uj U]'UV'Y']b'@Y[U''9X]h]cbŁ

5XXYX`ZUgh`X]fYVM`CHD#, 8:G`VX\Y<u>W\_</u>X]gUV`Y#YbUV`Y`ZIbVM]cb`Zcf`7=8%+ž`7=8(%`UbX`7=8(&`@, ''; 'd\cbYg`UbX`Zcf`7=8&(`G\Ufd '; 'd\cbYg" 'fBch'Uj 'U]'UV'Y']b @Y[ U''9X]h]cbŁ

BchY. ': cf'@ 'I , ' \*\$ 'UbX'@ 'I , ' , \$ ']h]g'bYWyggUfm'rc'i b'cW\_'d\cbY'j ]U'dUhW\]b["

 $5XXYX "gi \ ddcfh" \hbox{\it Zcf"} YI \ d`] \hbox{\it W} \hbox{\it Inf} fYghcf] b [\ "cZ"; \ 8: G"] XYbh] \hbox{\it Im}"$ 

 $: ]I YX`U`Z`Ug` ]b[`Vi [`h`Uh`WUi gYX`I , ' , \$`j \%\$5`Z]fa k UfYg`hc`VY`i b`c W\underline{YX`]b WcffYWh`m' \\$ 

5bch\Yf'VXUb[Y'hc'FG5'dfchYWh]cb'ib`cW\_]b['WcXY"

 $\label{eq:continuity} $$G'[\hm']bWfYUgYX'jYfVcg]hm'cZ'; 8: G'UWWfgg']b]h]U']nUh]cb'Yffcf'\UbX`]b['WcXY''] $$$ 

 $\label{eq:continuity} $$JYfg]cb^*"$''fl\&^*h\CWhcVYf^\&$$)$ Ł.$ 

? \* \$\$#? \* \$, 'hYghdc]bh'd]Whi fYg'i dXUhYX"

 $A \ | bcf'W \ | b[Y'fY'UhYX'hc'i b`cW]b['FG5'dfchYWh]cb'cZ'C \ | hD'7=8.4-'d\ | cbYg'k \ | h\ 'VUgYVUbX'W \ | d'=8g'$I \ , $$$'UbX'$I \ , $($'a') \ | h' \$ 

I dXUhYX X]fYWn C HD#; 8: G WX YW\_ fYa cj U`WcXY hc gi ddcfh c XYf Z|fa k UfY j Yfg]cbg"

 $\label{eq:Gamma-def} $$G'[\hm]bWfYUgYX'jYfVcg]hmcZ'Udd'YhYffcf'\UbX`]b[\WcXY'']$$ 

5XXYX Z bWh]cb Zcf ZUgh fYghcf]b[ Z]fa k UfY C HD#, 8: G Wk YW\_"

a cX]Z]WUh]cb^fK]fYWh@\_ib[^cf^CHD#, 8:G^WXYW\_X]gUV^]b[#YbUV^]b[E"

: ]| YX^U^Vi [ ^]b^Dc^]g\ hfUbg`Uh]cb'

J Yfg]cb '\* "\$& fl&( h\ 'C Whc VYf '&\$\$) Ł.

 $: ]I YX`Ub`]ggi Y`k]h\`G\Ufd`J + \$' G<`d\cbY`hmdY`Ui hcXYhYVh]cb"\\ : ]I YX`U`Vi [ `fY[ UfX]b[ `ZUg\]b[ `G\Ufd`J - \$' G<`d\cbYg`Vm`WffhU]b`ZUg\ `Z]`Yg"$ 

5bch\Yfa]bcfidXUhYg"

=bghU``Yf'i dXUhYX"

J Yfg]cb '\* "\$% fl&( h\ 'C Whc VYf '&\$\$) Ł.

: ]I YX Ub ]ggi Y k ]h\ G]Ya Ybg 7 \* &'

J Yfg]cb '\* "\$\$ 'fk( h\ 'C Whc VYf '&\$\$) Ł.

5XXYX Vcchigi ddcfh Zcf G]Ya Ybg 7 \* & ff7 = 8 & + L"

 $5XXYX`gi\ ddcfh`Zcf`ZUg\]b[\ `cf][\ ]bU``GGK\ `Z]`Yg`]bhc`5JF!VUgYX`d\ cbYg`ffY''[\ ''`G]Ya\ Ybg`7*\&L''$ 

5XXYX gi ddcfh Zcf X]fYVWi b`cW\_]b[ 'G]Ya Ybg 7 \* & j &) ž'j &\* ž'j &+ 'UbX'j &,

5XXYX gi ddcfh'Zcf fY`cW\_]b[ 'G]Ya Ybg 7 \* & j &) ž'j & \* ž'j & + 'UbX'j &, "

N) & '' N) ''' N) W ghca ]nUh]cbg^^]gh^i dXUhYX"

Ch\Yf W\Ub[Yg]b Vi]h]b W ghca ]nUh]cbg"

5XXYX`; 8: G`]XYbh]hm'VXUb[]b[ 'Zcf'5FA'd\cbYg'k]h\ 'VUgYVUbX'WX]d'=8g'\$I +\$\$\$z\*\$I +\$\$\$z\*\$I , \$\$\$`UbX'\$I , \$(\$"'fBch'Uj U]`UV'Y ]b @Y[U`.9X]h]cbŁ

5XXYX`ZUgh`X]fYWh`CHD#, 8:G`W\YW\_fYacjU``ZIbWh]cb'Zcf`bYk`5FA`G9`d\cbYg"`fBch`UjU]`UV`Y`]b`@Y[U``9X]h]cbŁ

A ]bcf'WkUb[Y']b'Z]Y'Xck b`cUX'Z bWh]cbU']hm''=hg\ci `X'WcdmYa dhmX]fYWhcf]Yg'hcc" I dXUhYX'H57 ``]gh'Zcf'K) ) \$]ž'N) &\$]ž'K, \$\$]ž'?' \$\$]ž'? +\$\$]ž'G\Ufd'J +\$' G< 'UbX'J - \$' G<"

FYa cj YX`dcgg]V]`]hmhc`WXUb[Y`7=8(%`UbX`7=8(&`d\cbYg`hc`Vfckb`Wt`cf`XiY`hc`U`gUZYhmfYUgcb'

5XXYX Vcchigi ddcfh Zcf '>&%\$"

5XXYX gi ddcfh Zcf ZUg\]b[ '>&\\$"

H- X]Wh]cbUf]Yg fYa cj U``\Ug`VYYb gYdUfUhYX Zfca ``Ub[i U[Y Z]`Yg fYa cj U``Z bWh]cb"

=bhYfbU`: K 'XUhUVUgY'YI hYbXYX"

H\Y'K f]hY'hc'CHD'Z bWh]cb'bck 'U'`ck g'cfX]bUfmi gYfg'hc'W\ccgY'Zfca 'a cfY'7=8g"

 $FYYUgYX`G\Ufd`J-\$\&G<`hc`GL, \%``Wcbj`Yfg]cb`ZUg\`Z]Y"FYYUgYX`G\Ufd`J-\$'`G<`hc`GL, '``Wcbj`Yfg]cb`ZUg\`Z]Y"$ 

FY`YUgYX`G\Ufd'J-\$' G< hYgha cXY`ZUg\`Z]`Yg"

5XXYX`Vcch'gi ddcfh'Zcf'7=8(-'d\cbYg'k]h\`VUgYVUbX`W\]d'=8g`\$I+\$\$\$`UbX`\$I+%\$\$`ff?\*\$, ž`YhWt"

5XXYX 8] fYWhi b`cW Zcf 6fck b 7 =8 ( - 'd\cbYg"

5XXYX @cW\_ hc bYhk cf\_ Zcf 6fck b 7 =8 ( - 'd\cbYg"

 $5XXYX^TFYUX]b[WcXYg^Tfca 6fck b^7=8(-d\cbYg^Tfca)$ 

5XXYX 'GUj Y 'gYW' f]hm'Zcf '6fck b '7 =8 ( - 'd\cbYg"

5XXYX F YghcfY gYW f]hmZcf 6fck b 7=8(- 'd\cbYg"

 $5XXYX "gi \ ddcfh" \hbox{\it Zcf"} Vcch]b[\ "7=8(-\ "d\ cbYg" ffYX" UbX"V"i \ Y"j \ ]U" HD" \hbox{\it Zcf"} bck \ L"$ 

5XXYX'gi ddcfh'Zcf'ZUg\]b['6fck b'7=8(-'d\cbYg"

5XXYX'gi ddcfh'Zcf'ZUg\]b['FYX#6`i Y' $7 = 8(-id\cdot cbYg'j)U'HD''$ 

 $5XXYX`gi\ ddcfh`Zcf`W.Ub[]b[.`FG5`Wffh]Z]VUhY`Wc`cf`cZ`7=8(-`d\cbYg`flVmi\ g]b[.`HD`Zcf`bck\ L"\\5`Vfck\ b`7=8(-`hc`fYX`7=8(-`Wcbj\Yfg]cb`Z]`Y`Zcf`?*$, `\Ug`VYYb`]bWi\XYX`hc`\Y`d"`=h`]g`bch`bYWfggUfmhc`fYZ`Ug\`d\cbY`Z]fa\ k\UfY$ 

UZhYf`i g]b[ 'h\]g`Z]Y"

5XXYX`ZJgh`@ ''; 'i b`c\\]b[ 'Z b\\]cbU`]hmj ]U`Z]fa k UfY`dUh\\]b[ "'5i hca Uh]\\U``mgUj Yg`U`Z]fa k UfY`VU\\i d`Z]Y`hc`h\Y`**8UhJ#5FA Z'Ug\ `VUW\_i dg** 'Zc`XYf" 'Gi ddcfhYX 'UfY 'h\ YgY 'a cXY`g. 'I , % \$ž'I , % , ž'I , % , \$ž'I , ' \* \$`UbX`I , ' , \$"

SUPPORT  $\label{eq:decomposition} Dcgg]V]`]hm`hc`i d[fUXY`@, `l , %' , `hc`l , %, $"$ Dcgg]V]`]hm'hc'i d[fUXY'@, 'I, %' \$'hc'I, 7 nYVX ``Ub[i U[Y`ghf]b[g`i dXUhYX" $Dc^{g}\$  "Ub[i U[Y'ghf]b[g'i dXUhYX" <Y`d`Z]`Y`i dXUhYX`!`UXXYX`G]Ya Ybg`7\*&`d]bci hž`gca Y`@, `'; `gYWfYh`WcXYgž`YhW J Yfg]cb') "\$&'fl%gh'GYdhYa VYf'&\$\$) Ł. =a dcfhUbhbchJVV. 8c bchUhhYa dhinc Wcbj YfhCHD7=8' + d\cbYginc Ubmch\Yf7=8'  $Ch Yfk \ ]gY'mci \ k \ ]```bch' VY' UV'Y \ hc' Vcch'h Y' \ d \ cbY' \ Ubma \ cfY''' \ 7fi \ ]gYf' Xc Yg' bch' U``ck' \ mci \ 'hc' Xc'h \ Uhž' Vi \ h'ch \ Yf' gc Zhk \ UfY' a \ Um'' \ h'ch \ Yf' gc Zhk \ Um'' \ h'ch \ Yf' gc Zhk \ UfY' a \ Um'' \ h'ch \ Yf' gc Zhk \ Um''$ 7fi ]gYf']g'bck 'Uj U]`UV`Y']b'9b[`]g\ž'7\]bYgYž'7nYW\ž'=bXcbYg]Ubž'A U`Umž'Dc`]g\ž'Fi gg]Ubž'G`cj U\_ 'UbX'Gk YX]g\``Ub[i U[ Yg"  $: ] | YX `cbY `VX ] \underline{W} Yb! \ UbX! \ Y[ \ [ \ `g]h \ Uh] cb `k \ ] h \ `I \ b `c \underline{W} \ `F \ G5"$ : ]I YX`cbY`: G! UWWYgg`Vi [ `fY[ UfX]b[ `?+) \$#K , \$\$`d\cbYg`h\Uh`k Ug`]bhfcXi WYX`k ]h\`j Yfg]cb`) "\$\$" : fca 'bck 'cb'h\Y': cfa Uh'; 8: G'cdh]cb']g'dfchYVMYX'Vm'U'dUggk cfX'"? =@'H<9'D<CB9" J Yfg]cb') "\$% fl %gh 5i [ i gh &\$\$) Ł. I dXUhYX`H57``]gh`Zcf`K , \$\$]`UbX`>&%\$]" : ]| YX Ub C HD = A 9=fbcb! k]bgYfh]cb Vi [ ']b h\ Y GYW f]hm = dU[ Y" FG5 i b`cW]b[ Z bWh]cbU)hmg`][ \h`ma cX]Z]YX" J Yfg]cb") "\$\$"f1 \$h\"5i [igh"&\$\$) Ł. 5XXYX`ZI bWh]cb`Zcf`YUg]Yf`fYd`UW]b[ `cz`ZUg\`WYfh]Z]WbHYg"`5``]gh`cZ`W&a dUh]V`Y`WYfh]Z]WbHYg`]g'X]gd`UmYX`]b`h\Y`W&a Vc`VcI ``cWbHYX VY`ck 'h\Y'**FYd`UWY'WYfh]Z]WUhY** 'Vi hhcb" BchY. @UhYgh 9F CA g fYei ]fY mi 'hc fYghcfY h\Y ZUg\ WYfh]ZJWUhY VUW\_ hc ]hg cf][]bU `ghUhY hc 'U`ck 'h\Y d\cbY hc VY hi fbYX cb" K, \$\$'Vi ]`h!]b'W ghca ]nUh]cbg'`]gh'i dXUhYX" A ]bcf $^{-}7 = 8 \% + ! fY`UhYX`WXUb[Yg"$ K f]hY VUbX`c $\underline{W}$  Z bWh]cbU`]hmg`][ \h`ma cX]Z]YX"  $5 XXYX `h YcfYh] WU ``gi ddcfh' Zcf' c `X `G-,, `dfchchmd Yg'' 5 XXYX `gi ddcfh' Zcf' Z Ug \ ]b[ `@ `I , ' * $''$ PPOR 5XXYX'gi ddcfh'Zcf'ZUg']b[ 'G\Ufd'J - \$' G<" H\Y`i gYf`]bhYfZUWY`\Ug`VYYb`a cX]Z]YX" : `Ug\  $^{\circ}$ 6H  $^{\circ}$ 2 b\Wh]cb \ Ug \ VYYb \ gYdUfUhYX \ Zfca \ : `Ug\  $^{\circ}$ 5FA "  $5XXYX^{T}fYUX]b[WcXYg^{T}cf^{T}=8'+d^{b}yg''$  $\textbf{FYWcj Yf'7Yfh]Z]WWhY'Z} \text{ bWh]cb'bck'gi ddcfhg'7=8'+'d\cbYg''} \\$ BchY. 5b UhhYa dh'hc ghUfh'U 7=8' + d\cbY WebhU]b]b[ k cf\_]b[ 'Z]fa k UfY ]b 'U fYWej Yfm'a cXY k ]``ZU]\*\* =a d`Ya YbhYX'**I b`c\<u>W</u> FG5**'Zi b\\n]cb'Zcf'7=8' + 'd\cbYg"  $H\Y'I\ b`cW\_FG5`Vi\ hhcb'g\ci`X'bch'VY'YbUV`YX']b'fYWcj\ Yfma\ cXY''$ :`Ug\Yf`ZibWh]cbU`]hm`acX]Z]YX`Zcf`7=8'\*`UbX`7=8'+"  $5XXYX^{T}$ 7 i ghca ]nY : G Z bWh]cb Zcf 7 =8 + + 5XXYX Hi fb WUa YfU gci bX cb#cZZ Z bWh]cb Zcf 7=8' +"  $5XXYX \ \textbf{A} \ \textbf{c} \textbf{X}] \textbf{Zm}; \ \textbf{8} : \textbf{G} \ \textbf{Z} \ b \textbf{Wh}] \textbf{c} \textbf{b} \textbf{U} \cdot ] \textbf{hm} \ \textbf{Zc} \textbf{f} \cdot \textbf{7} = \textbf{8}' \ +"$ 5XXYX K f]hY hc; 8: G Z bWh]cbU ]hm Zcf 7=8' +" 5XXYX **GUj Y gYW f]hm**Zcf 7=8' +" 5XXYX F YghcfY gYW f]hmZcf 7 =8' +" 5XXYX 8]fYWhib cW\_ 7cf 7=8' +" 5XXYX @cW\_hcbYhkcf\_ Zcf7=8'+" LIPPOR 5XXYX FYUX; 8: GincbYg Zcf 7=8' +" 5XXYX'I d`cUX'Z]`Yg'hc': G'Zcf'7=8' +" 5XXYX'@Ub[iU[Y'cdYfUh]cbg'Zcf'7=8'+"  $5XXYX^{\circ}K f]hY^{\circ}hc^{\circ}gYW^{\circ}f]hm^{\circ}nc^{\circ}bY^{\circ}Z^{\circ}c^{\circ}7=8^{\circ}+"$  $@cW_{\underline{\underline{}}} CHD_{\underline{}}UfYU_{\underline{}}bck_{\underline{}}gi_{\underline{}}ddcfhg_{\underline{}}7=8'+"$  $5XXYX^TFYdU]f^T9FCA^TZ_0bVM]cb^TZcf^T7=8'+d^cbYg''$ BchY. FYZUg\ 'h\ Y'a U]b Z]fa k UfY'k \ Yb'i g]b[ 'h\ ]g'Z bVh]cb Zcf Vfck b 7=8' + " 5XXYX: cfa Uh; 8: G Z bWhcb" 5XXYX FYa cj Y FG5 i b cW hfuWg Z bWhjcb = h ]g cwhyX Ua cb[ A cX]Zm; 8: G cdh]cbg I bi gYX WcXY fYa cj YX" < Y`d`Z]`Y`g`][ \h`mi dXUhYX" J Yfg]cb '(" \$ fl%( h\ '>i `m'&\$\$) Ł. ? \* \$\$#J \* \$\$ `Vi ]`h! ]b `W ghca ]nUh]cbg``]gh'i dXUhYX" ?\*\$\$#J\*\$\$`ZUg\`Z]Y`\UbX`]b[`]a dfcj YX" <Y`d`Z]Y`i dXUhYX`!`?\*\$\$#J\*\$\$``Ub[i U[Y`dUW\_`]bZc`UXXYX" 5XXYX'gi ddcfh'Zcf'X]fYWh'\UbX`]b['cZ'V'i Y'7=8' \*'d\cbYg'ffYWcj Yfma cXY'bch'fYei ]fYX'Ubma cfYŁ" A ]bcf'W.Ub[ Yg:]b 'WcXY'UWWrgg]b[ 'h\Y': G'cZ'Vfck b'7=8' \*'d\cbYg" =bWfYUgYX'j YfVcg]lmcZ; 8: G'Yffcf'\UbX`]b['WcXY'" 7cbj Yfg]cb 'hc 'Vfck b '7 =8' \* 'Zcf' VUgYVUbX' W\]d '=8 g \\$I , \$\$\$ 'UbX' \\$I , \$(\$'\ Ug' VYYb 'cdh]a ]nYX'' \\$ | 10 \quad \qq \quad \quad \quad \quad \q  $7 cbj \ Yfg]cb \ hc \ Vfck \ b \ 7 = 8' \ * \ Zcf \ VUgYVUbX \ W \ d'= 8 \ g' \ s \ + $$ \ UbX' \ s \ + \% \ Vug' \ VYYb' \ cdh]a \ ]nYX'' \ d'= 8 \ g' \ s \ + $$$ 

=bhfcXi WYX`XYhYWh]cb`cZ`XUhU`Vi g`]bhYfZYfYbWYg`Zcf`@ `d\cbYg"

5Vci H Vcl ']bZcfa Uh]cb 'g'][\h`mi dXUhYX"'Bck '%+\$'d\cbY'hmdYg'UfY'gi ddcfhYX' < Y`d`Z]`Y`7 =8 `]bZcfa Uh]cb`i dXUhYX"  $5XXYX^*\textbf{GdYW}\textbf{JU}^*: \textbf{J}^*\textbf{Yg}^*\textbf{mcd}]W\textbf{m}^*\textbf{h}^*\textbf{Y}^*\textbf{5}XX]\textbf{h}]\textbf{c}\textbf{b}\textbf{U}^*=\textbf{b}\textbf{Z}\textbf{c}^*\textbf{g}YW\textbf{h}]\textbf{c}\textbf{b}^*\textbf{c}\textbf{Z}^*\textbf{h}^*\textbf{Y}^*\textbf{V}^*\textbf{d}^*\textbf{Z}]^*\textbf{Y}^*$ CdYb!ZUg\!ZjY:X]U'c[ 'Vcl Yg'UWWdh'"Yfca %'UbX'"Yfca &'ZjY'hmdYg'k \YfY'Uddfcdf]UhY" H\Y: cfWYFG5 fYWcj YfmWca Vc!Vcl bck X]gd`Umg`a Ubi ZUWfi fYfbUa Ygbcc" A ]bcf WX Ub[ Yg ]b I = J Yfg]cb '( "&( 'f\%\h\ '>i \m'&\\$\) Ł.  $5``ck\ YX`X]fYWh`ZUg\ ]b[\ `cZ'bcfa\ U``ZUg\ Yg`]b`fYWcj\ Yfma\ cXY`Zcf`7=8(\%`UbX`7=8(\&'')b``ck\ YX`X]fYWh`ZUg\ ]b[\ `cZ'bcfa\ U``ZUg\ Yg`]b`fYWcj\ Yfma\ cXY`Zcf`7=8(\%`UbX`7=8(\&'')b``ck\ YX`X]fYWh`ZUg\ ]b[\ `cZ'bcfa\ U``ZUg\ Yg`]b``fYWcj\ Yfma\ cXY`Zcf`7=8(\%`UbX`7=8(\&'')b``ck\ YX`X]fYWh`ZUg\ ]b[\ `cZ'bcfa\ U``ZUg\ Yg`]b``fYWcj\ Yfma\ cXY`Zcf`7=8(\%`UbX`7=8(\&'')b``ck\ YX`X]fYWh`ZUg\ ]b[\ `cZ'bcfa\ U``ZUg\ Yg`]b``fYWcj\ Yfma\ cXY`Zcf`7=8(\%`UbX`7=8(\&'')b``ck\ YX`X]fYWh`ZUg\ Yfma\ CXY`Zcf`7=8(\&'')b``ck\ YX`X]fYWh`ZUg\ Yfma\ CXY`Zcf`7=8(\&'')b``ck\ YX`X]fYWh`ZUg\ Yfma\ Yfma\$ 7cbj Yfg]cb 'm' Vfck b '7=8' \* 'fYei ]fYg'd\cbY'UbU`mg]g'dYfZcfa YX"'Ch\Yfk ]gY']h'X]gd`Umg'Ub'Yffcf'a YggU[ Y" A ]bcf'W\Ub[Yg']b'?\*\$\$#J\*\$\$'\overline{Z} bWh]cbU\]hm' 5XXYX gi ddcfh Zcf G\*\$\$]#G\*\$\$W#K \*\$\$U" Gca Y'Udd`Yhg'i dXUhYX" 6cch]b[ 'WcXY'a cX]Z]YX" `Ug\]b[ 'WcXY'a cX]Z]YX"  $\Ug\\Z]\Upsilon\cdYb\X]U\c[\WcXY\idXUhYX"$ : ]`Y! gmghYa 'Z bWh]cbU`]hm`Zcf`Vfck b`7=8' \* 'd\cbYg`fYYbUV`YX" : ]I YX`gca Y`]ggi Yg`k ]h\`dfchchmdY`7 =8' \* d\cbYg" : ]I YX`U`Vi [ `]b`f**YgYh``]ZY! h]a Yf**`Z bWh]cbU`]hm' I dXUhYX 'H57 '`]gh Zcf '@, 'I , ' , \$"  $H\Y'Hi fb'cZZ'd\cbY'Vi hhcb'g\ci 'X'VY'YbUV'YX'Zcf'i b]XYbh]Z]YX'bYk '5FA'd\cbYg''$  $H\ Y'FYdU]f'WYfh]Z]VWhY'Vihhcb'k Ug'X]gUV'YX']b'gca Y'WUgYg''$  $7 \ Ua \ YfU'ZcW'g'gci \ bX']g'bck \ `UZZYWWYX'Vmh\Y'$ **7 Ua \ YfU'gci \ bX'cb#cZ'** $Z \ bWM]cb'hcc''$ 5XXYX gi ddcfh Zcf ZUg\]b[ Vfck b 7 = 8% d\cbYg fl9A DL"  $5XXYX'd\cbY'hmdY'Z]`hYf"$ J Yfg]cb '( "&\$ 'f&- h\ '> i bY '&\$\$) Ł.  $5XXYX "gi ddcfh" \c f" \c hc bj Yfh]b["?+) $"d\c hc \c K , $$"$ 5XXYX gi ddcfh Zcf N) &\$]#N) &\$W =bWfYUgYX`gUZYhm`k\Yb`WcbjYfh]b[`fYX`7=8' \*`d\cbYg`hc`Vfckb`7=8' \*" G\Ufd''; 'ZUg\]b[ 'gdYYX'j ]U':][\hYf#7fi ]gYf'\WV`Y'g`][\hm]a dfcj YX"  $H\Y'a\ U]b\YI\ YW\ hUV\Y'\UbX\\Y'd\ Z]\Y'\UfY\ bck\ ghcfYX\ ci\ hg]XY\ h\Y'\]bghU\Yf''\J\ Yfg]cb\ (\ ''\%)\ fl\&(\ h\ '>i\ bY\ \&\$\$)\ h\Y'\A$  $: ]I \ YX \ cbY \ Vi \ [ \ `]b \ fcXi \ WYX \ ]b \ h \ Y \ dfYj \ ]ci \ g \ j \ Yfg]cb"$ J Yfg]cb '( "%( 'f&' fX' >i bY '&\$\$) Ł. ⇒bghU``Yf'i dXUhYX" =h']g'dcgg]V'Y'hc'i gY'N, \$\$'Z]'Yg'Zcf'J, \$\$#J, \$&G9'd\cbYg'X]fYWh'm'  $FYUX]b[\ 'd\ cbY'Wfh]Z]WUhY'WUi\ gYX'dfcV'Ya\ g'k\ \]Y'ZUg\ ]b[\ 'Wca\ dcg]hY'ZUg\ 'Z]Yg'j\ ]U'9D=IG6''$ J Yfg]cb ( "%' fl&%gh > i bY &\$\$) Ł.  $5XXYX \circ giddcfh \circ Zcf \circ Wf cgg! ? = 8 \circ Z \cup g \setminus [b[ \circ Z \circ 7 = 8 (\% \cup b X \circ 7 = 8 (\& \circ d \setminus cb Y g \circ k)]h \setminus cih'h Y ghdc]bh''$ 

5xxxxx\*gi ddcfh7cf\*Wcgg! 7=8\*2Ug\]b[ \*c27=8(%Ubx\*7=8(&`d\cbYg`k]h\ci h`hYghdc]bh\* A]bcf\*WkUb[ Y`]b\*I ="

J Yfg]cb '( "%% fl&\$h\ '>i bY '&\$\$) Ł.

A ]bcf'W.Ub[Y']b'I d`cUX'Z]`Yg'hc': G'Z bWh]cb"
?+)\$]#8+)\$]``Ub[i U[Y'dUW\_']bZc'i dXUhYX'U[U]b"
BYk 'Vfck b'7=8' \* 'hc'fYX'7=8' \* 'Wbj Yfg]cb'Z]`Y'Zcf'?+)\$#8+)\$#K,\$\$`\Ug'VYYb']bWi XYX'hc'\Y`d"'=h']g'bch'bYWfggUfm'hc'fYZUg\d\cbY'Z]fa k UfY'UZhYf'i g]b['h\]g'Z]`Y''
: 'Ug\'Z]`Y'Zcfa Uh'a cX]Z]YX"

J Yfg]cb '( "\"f\" h\ '>i bY '&\$\$) Ł.

?+) \$]#8+) \$] Vi ] h! ]b W ghca ]nUh]cbg ]gh i dXUhYX"

?+) \$]#8+) \$]``Ub[i U[Y`dUW\_`]bZc`i dXUhYX"

6i ]'hl]b'9FCA 'fYWtj YfmZ bWh]cb'Zcf'?+) \$#8+) \$#K , \$\$'d\cbYg']a dfcj YX"'=h'g\ci `X'VY'dcgg]V'Y'hc'ZUg\`a cfY'd\cbYg'Uh'cbW' j ]U'9D='I G6'hcc"

7\]bYgY``Ub[i U[Y`ghf]b[g'i dXUhYX"

<Y`d`Z]`Y`YI hYbXYX`Vm`U`XYgWf]dh]cb`cZ`7=8' \* 'd\cbY`cdYfUh]cbg"

JYfg]cb'("%\$'f%' h\'> bY'&\$\$) ž'VYhU'j Yfg]cbŁ.

SUPPOR 5XXYX'I d`cUX'G: 5'Z bWh]cb'Zcf'fYX'7=8' \*'d\cbYg" 5XXYX'K f]hY'fUk :: G'Z bWh]cb'Zcf'fYX'7=8' \* 'd\cbYg" 5XXYX 7i ghca ]nY : G Z bWh]cb Zcf fYX 7=8' \* d\cbYg" 5XXYX @Ub[i U[Y'cdYfUh]cbg'Z bWh]cb'Zcf'fYX'7=8' \* 'd\cbYg" 5XXYX`I d`cUX`Z]`Yg`hc`: G`Z bVM]cb`Zcf`fYX`7=8' \* 'd\cbYg" 5XXYX.7Ua YfU.gci bX.cb#cZZZJ bWh]cb.Zcf.fYX.7=8' \* 'd\cbYg" 5XXYX`GUj Y`gYWVf]mmZ bWh]cb`Zcf`fYX`7=8' \* 'd\cbYg" 5XXYX:FYghcfY:gYW/f]hmZ/bWh]cb:Zcf:fYX:7=8' \* d\cbYg" 5XXYX FYUX; 8: G'ncbYg'Z bWh]cb Zcf'fYX 7=8' \* d\cbYg"  $5XXYX^{-}AcX^{-}Zm^{-}$  8:  $G^{-}Z^{-}bWM^{-}cb^{-}Zcf^{-}fYX^{-}7=8'^{+}d^{-}cb^{-}Yg''$ 5XXYX'K f]hY'hc'; 8: G'Zfca 'Z]'Y'Z bWh]cb'Zcf'fYX'7=8' \* 'd\cbYg"  $5XXYX`gi\ ddcfh`Zcf`VUW\underline{i}\ d`cZ`VUhhYfm`WU`]VfUh]cb`ncbY`cZ`bYk\ `5FA`d\cbYg"$  $5XXYX "gi ddcfh" Zcf" VUW\_i d"cZ" X]gd" Um'WU"] VfUh] cb" ncbY" cZ"bYk "5FA" d \cbYg" and cbYg" and cbYg$  $5XXYX "gi \ ddcfh" \hbox{\it Zcf"} VUW\_i \ d"cZ" Ui \ X]c" WU"]VfUh]cb" ncbY"cZ" bYk "5FA" d\cbYg"$  $5XXYX "gi \ ddcfh" Zcf" VUW\underline{i} \ d"cZ" fUX]c" VW"] VfUh]cb" ncbY" cZ'bYk "5FA" d\cbYg"$ 6i]`H]b`Wghca]nUh]cbg``]gh'i dXUhYX`UbX`YI hYbXYX`Vm`>'\$\$]`XUhU" =bghJ``Yf`i dXUhYX""9D='l G6'Xf]j Yf']bWi XYX'hc'U``ck 'ZJghYf`ZUg\]b['cZ'@, ''; ž'G\Ufd''; 'UbX'J, \$\$#N, \$\$#N%\$%\$`d\cbYg" 5XXYX'Ub'cdh]cb'hc'ZUg\'ZJghYf'j ]U'9D='l G6"  $5 XXYX "gi ddcfh" Zcf" 9FCA "fYVVcj Yfm"] b "fYX#Vfck b "7 = 8" * "? +) $\#8 +) $\#K \ , $$"$ J Yfg]cb ( "\$& fl, h\ '>i bY '&\$\$) Ł. 5 'G\Ufd'J, \$%G<'; 8: G'fY`UhYX']ggi Y'Z]I YX" I dXUhYX`H57``]gh'Zcf'@, 'I,''\$" J Yfg]cb'("\$%'fl, h'>i bY'&\$\$) ž'VYhU'j Yfg]cbŁ $5XXYX^YI dYf]a YbhU^gi ddcfh^Zcf^G\Ufd^J, $G<$ I dXUhYX'Udd`Yh'Zcf'G\Ufd''; 'd\cbYg" 5XXYX'gi ddcfh'Zcf'ZUg\'=8'\$I, -\$:' 5XXYX'gi ddcfh'Zcf'ZUg\'=8'\$1, - %\$" :]IYX`U`Vi[`WUig]b[`gcaY`Vihhcbg`hc`VY`X]gUV`YX`Zcf`@``d\cbYg`ibXYf`WYfhU]b`W}fWlaghUbWYg" G\Ufd'WcbbYWhcf'd]WhifY'idXUhYX" J Yfg]cb ( "\$\$ fl+h\ '> bY &\$\$) Ł.  $F \ Y`Y U g Y X`d] b c i \ h`Z c f`G \setminus U f d`J \ , \ \$\&G < `U b X`J - \$\&G < `d \setminus c b Y g"`=h`] g`] b`h \setminus Y` \setminus Y`d`Z]`Y"$  $5 XXYX^*8] fYWhi b`cW_igi ddcfh'Zcf'G\Ufd''; '7=8\&('d\cbYg''5 XXYX'@cW_ihc'bYhigi ddcfh'Zcf'G\Ufd''; '7=8&('d\cbYg''$  $5XXYX`GUj\ Y`gYW\ f] \\ \\ fm`UbX`F\ YghcfY`gYW\ f] \\ \\ fm`gi\ ddcfh`Zcf`G\Ufd`'\ ;\ `7=8\ \&(\ `d\ cbYg'') \\ \\ \\ fm'gi\ ddcfh`Zcf`G\Ufd`'\ ;\ `7=8\ \&(\ `d\ cbYg'') \\ \\ fm'gi\ ddcfh`Zcf`G\ Ufd`'\ ;\ `7=8\ \&(\ `d\ cbYg'') \\ \\ fm'gi\ ddcfh`Zcf`G\ Ufd`'\ ;\ `7=8\ \&(\ `d\ cbYg'') \\ \\ fm'gi\ ddcfh`Zcf`G\ Ufd`'\ ;\ `7=8\ \&(\ `d\ cbYg'') \\ \\ fm'gi\ ddcfh`Zcf`G\ Ufd`'\ ;\ `7=8\ \&(\ `d\ cbYg'') \\ \\ fm'gi\ ddcfh`Zcf`G\ Ufd`'\ ;\ `7=8\ \&(\ `d\ cbYg'') \\ fm'gi\ ddcfh`Zcf`G\ Ufd`'\ Ufd`$ : cfW/FG5 fYWtj Yfmcdh]cbg bck ]bWi XY7=8&( ž7=8( %UbX7=8( &" 5XXYX`X]gd`Um]b[ 'cZZZUg\ 'a Ubi ZUVWi fYf'k \Yb`Vcch]b[ 'bYk '5FA 'd\cbYg J Yfg]cb''"- ('f) h\' $\Rightarrow$  bY'&\$\$) ž'VYhJ'j Yfg]cbŁ.5XXYX fYUX]b[ 'WcXYg Zfca '7=8(%fl@ 'I , % \$L'UbX '7=8(&'d\cbYg'j ]U'hYghdc]bh' 7fcgg! 7 =8 'ZUg\]b[ 'YI hYbXYX'hc '7 =8 %+#7 =8 ( %#7 =8 ( &" 7fi ]gYf'Ui hca Uh]VW`mdUhVXYg'ZUg\`Z|Yg'VmfYd`UV]b[ 'h\Y]f'FG5'WYfh]Z|VWHY"'I gU[Y. ']h']g'dcgg]V'Y'hc'ZUg\`I,%\$'VmI,%' Z]fa k UfY" ]| YX`Ub`]ggi Y`k ]h\`ZUg\]b[`F\*\$\$" 5XXYX gi ddcfh Zcf 9FCA fYWcj Yfm]b j YfmfUfY Vfck b 7 =8 % J, \$\$#N, \$\$"  $\label{eq:localization} I \ dXUhYX`H57``]gh`Zcf`H^* \%$\check{z}`:) $$]\check{z}`?) $^*W\check{z}`? + $$]\check{z}`N, $$]\check{z}`? +) $]\check{z}`? +) $WUbX`8 +) $]"$  $< Y^d^Z^Y i dXUhYX''$ 

J Yfg]cb" "-' 'fi fX'>i bY'&\$\$) Ł.

J, \$\$#N, \$\$ $^{\cdot}7$ =8  $^{\cdot}hYghdc]bh^{\cdot}fY^{\cdot}YUgYX''$ 9A A 5 'ga UfhWUfX'a i hYl ']g'bck 'fY`YUgYX`WcffYWh`m' : `Ug\ `Z]`Y `cdYb `X]U`c[ `W $^c$ XY `i dXU $^c$ X"  $8i\ \bar{Y}'hc'a\ UbmfYei\ Yghg\check{z}'8]fYWhi\ b`cW\_'UbX'FYUX'WcXYg'k\ cf\_'bck''a\ i\ W.'ZUghYf'cb'bYk''5FA''d\ CbYg'''$ 7fi ]gYf'Wcg]b[ ']ggi Y'Z]l YX" I dXUhYX 'H57 ``]gh 'Zcf 'N&\$\$ž 'N\* \$\$ž 'N\* \$, 'UbX '@, 'I, %\$\$ž

PPOR

JYfg]cb'' "- & fl/gh' >i bYž'[ Ua a U'j Yfg]cbŁ.

?' \$\$`7 =8 'hYghdc]bh'fY`YUgYX"

6i ]`h! ]b W ghca ]nUh]cbg ``]gh Yl dUbXYX"

: ]| YX^Ub^]ggi Y^k ]h\^\UbX^]b[ ^N,  $$^TYX^7=8' ^*$ 

: ]| YX U'Vi [ ']b '9FCA 'fYdU]f 'Zcf'fYX '7 =8 &- 'J , \$\$#N, \$\$"

 $: ]I YX`U`Vi [ `WWi g]b[ `h\Y`8]fYV\fii b`c\W_ `hc`VY`X]gUV`YX`Zcf`>&$$#N&$$#H\%$$#5' *\% `d\cbYg" + hc`VY`X]gUV`YX`Zcf`\fine \final \$ 

 $\label{eq:final_state} F\ Yd\ U]f\ '9F\ C\ A\ 'g\ U\ 'b\ ch'\ VY\ 'Yb\ U\ 'YX\ ']b\ 'W\ fh\ U]b\ 'g]h\ Uh]c\ bg''$ 

@ `i b`cW\_]b[ `Z bWh]cbU`]hmk Ug`X]gUV`YX`Vm'U`a ]ghU\_Y" 5`VUi XfUhY! fY`UhYX`a cX]Z]WUh]cb`fY[ UfX]b[ `@ `d\cbYg"`J Yfg]cb`' "-%`fl%gh`>i bY`&\$\$) Ł.

`FYk cf\_YX`i b`c\\\\_]b[ #fY`c\\\\_]b[ 'cZ`fYX`7 =8' \* 'd\cbYg'j ]U'hYghdc]bh"

`5XXYX`U`Vi hhcb`Zcf`WcbjYfg]cb`Zfca `fYX`7=8' \*`hc`Vfckb`7=8' \*`fj]U`hYghdc]bhĿ"

J Yfg]cb" "- \$ fl %gh A Um &\$\$) Ł

 $\begin{tabular}{ll} $ \begin{tabular}{ll} $ \begin{tabular}{ll}$ 

`H\Y`FYX]fYWhG7F7`W\YW\_hc`ncbY`=`W\YW\_Vcl`\Ug`VYYb`fYacjYX"

`H\Y`GYW`f]lm`=`dU[Y`k Ug`fYa cj YX`Ug`]h`\Ug`VYYb`a UXY`gi dYfZi ci g`VmYl hYbX]b[`h\Y`GYW`f]lm`=`dU[Y`Zi bWh]cbU`]lm`hc F) &\$#H' - #H\*) `d\cbYg"

`I dXUhYX`H57``]gh`Zcf`@, `I , %, \$ž`?) \$\$]ž`?' \$\$]ž`J , \$&G<`UbX`J - \$&G<"

`=bghU``Yf`i dXUhYX"`=h`YbUV`Yg`X]gd`Um]b[ `\]XXYb#bcbdfYgYbh`XYj ]Wfg`]b`8Yj ]Wf`A UbU[ Yf`i bXYf`K ]bXck g`&\$\$\$#LD"

`CbWY`U[U]bž`gcaY`VUiXfUhY!fY`UhYX`acX]Z]WUh]cbg"

`A U`Um`UbX`G`cj U\_``Ub[i U[Y`ghf]b[g'i dXUhYX"

′8]fYWhi b`cW\_'Vi hhcb`k UgʻYbUV`YX`Zcf`U```@, ''; 'd\cbYgʻVmU'a]ghU\_Y"'I gY`fYUX`WcXYgʻ]bghYUX"

18 YVi [1@c[1ZYUhi fY1fY`YUgYX1hc1diV`]W7

'<Y`d`Z]`Y`i dXUhYX`!`UXXYX`]bZc`cb`\ck 'hc`Vcch'i bVcchUV`Y`D-\$\$`ga Ufhd\cbYg"</pre>

`5b`Yffcf`a YggU[Y`]g`bck`g\ckb`k\Yb`hfm]b[`hc`Vcch`Ub`]bWcffYWhmid[fUXYX`D-\$\$`hc`U`D-%\$"`GiW\`d\cbY`\Ug`hc`VY`VcchYX ig]b[`U`hYghdc]bh`WcbbYWhYX`hc`;B8"

6cch WcXY a cX]Z]YX"

<sup>.</sup>5 <sup>.</sup>ZYk <sup>.</sup>WX Ub[ Yg <sup>.</sup>]b <sup>.</sup>WcbZ][ i fUh]cb <sup>.</sup>UbU`mg]g <sup>.</sup>WcXY"

'A ]bcf'a cX]ZJWUh]cbg'hc'h\Y'GYhh]b[g'k]bXck ž'a cgh'm'9A A 5'ga UfhWUfX'fY`UhYX"'6Y'gi fY'hc'YbhYf'WtffYWh'D=B'Zcf'mci f'9A A 5'ga UfhWUfX"

"5XXYX"U"dcgg]V]"]hmhc"Vcch"5J F"VUgYX"d\cbYg"ghJfh]b["Zfca"F) &\$a"Vma YUbg"cZ"Ub"9A A 5"ga UfhWUfX"

 $\begin{tabular}{ll} $`5XXYX$'gi ddcfh'Zcf'WVUb[]b['d\cbY'`Ub[i U[Yg']b'fYX'7=8' * 'd\cbYg'fb' $$\#?' $$\#N, $$\#? +) $\#K , $$#? *$$\#bYk '? +$$#bYk J , $$£'Vma YUbg'cZ'Ub'9A A 5'==ga UfhWUfX" $$$$$$$ 

`5XXYX`Z````gi ddcfh`Zcf`Vfck b`7=8' \* `d\cbYg`fb' \$\$#?' \$\$#N, \$\$#?+)\$#K , \$\$#?\*\$\$#DYk `?+\$\$#bYk `J , \$\$L"

5XXYX ZI bWf]cb hc fYdU]f P'bc bYhk cf\_P' dfcV'Ya cb bYk 'H\*' \$ d\cbYg h\Uh\Uj Y VYYb XUa U[ YX VmXck b[ fUX]b[ 'Z]fa k UfY"

'5'ZYk 'a Ya cfm`YU\_g'fYa cj YX"

'9a dhm\/cUfX`dfc[fUa a]b[ˈcZˈbYk ˈ5FAˈd\cbYgˈf]|bWi X]b[ˈ>ˈ\$\$#?' \$\$#N, \$\$#?+) \$#K , \$\$#?\*\$\$#J \*\$\$ĿfY`YUgYX`Zcf'U``i gYfg"

`5XXYX`ZibWh]cb`FYdU]f`WYfh]Z]WWhY`hc`g]ad`]Zm`d\cbY`fYj]jU``cb`ZUg\`ZU]`ifY"

`5XXYX`ZIbVMjcb`FYdUjf`9FCA`hc`g]ad`jZm`9FCA`UfYU`fYdUjf`jb`fYX`UbX`Vfckb`d\cbYg`cZ`7*=*8&-`UbX`7*=*8'\*"

<sup>.</sup>5XXYX<sup>.</sup>XYhYWh]cb<sup>.</sup>cZ<sup>.</sup>7=8(&<sup>.</sup>@, <sup>.,</sup>; <sup>.</sup>d\cbYg"

^5XXYX^gi ddcfh^Zcf^ZUg\]b[ ^fYX^@ ^I , | | | 1 ^k ]h\ ^7 =8 ( &"

: ]I YX Ub ]ggi Y Wli g]b[ F', \$ D85!dUfh Vcch dfcV Ya

"5XXYX"YI dYf]a YbhU``gi ddcfh'Zcf'Vcch]b[ž'ZUg\]b["UbX"Wcb]b["<YXj]["dfchchmdYg"

`H\Y`Vi hhcb!YbUV`]b[ `gmghYa `\Ug`VYYb`a cX]Z]YX`hc`fYZYVM`ga UfhWUfX`dfYgYbWY`UbX`j Uf]ci g`7=8`cdh]cbg"



SUPPORT

'Gca Y`cVgc`YhY`ZUg\]b[ 'cdh]cbg`fYa cj YX"

J Yfg]cb" ", &fM(h\5df]\&\$\$) Ł.

'6cch]b[ 'VUi XfUhY']a ]hYX'hc'&' \$(\$\$6X'Zcf'c`XYf'd\cbYg"'DfYj ]ci g`m'h\Y``]a ]h'k Ug'gYh'hc'‰) &\$\$6Xž'Vi h'h\Y'j Yfg]cb'' ", \$fYa cj YX'h\Y'Vcch'VUi XfUhY'WcbghfU]bhž'WUi g]b[ 'cWWgg]cbU`'Vcch'dfcV'Ya g"

`FYa cj YX`:]`Y`GmghYa `hUV`Vi [ 'Zfca 'j Yfg]cb'' ", %"

J Yfg]cb" ", %f%(h\5df]~&\$\$) Ł.

:: ]I YX'hk c']ggi Yg'fY`UhYX'hc'Vi ]`h!]b'W ghca ]nUh]cbg"

J Yfg]cb'' ", \$'f%' h\'5df]`'&\$\$) Ł

`7fi ]gYf`]g`bck `Uj U]`UV`Y`]b`9b[`]g\z`7\]bYgYz`=bXcbYg]Ubz`A U`Unz`Dc`]g\z`Fi gg]Ubz`G`cj U\_ 'UbX`Gk YX]g\``Ub[ i U[ Yg"

 $Bck ']h']g'dcgg]V'Y'hc'di h'fYX'Z'Ug\Yg']bhc'Vfck b'UbX'V'i Y'd\cbYg'cZ'7=8\%' \sharp'7=8\%+ 'UbX'7=8\&- 'k ]h\ci h'Wcbj Yfh]b['h\Ya'hc'fYX'' H\Y'd\cbY'Wfh]Z]WUhY']g'bch'UZZYWhYX''$ 

`5XXYX`gi ddcfh`Zcf`ZUg\]b[`fYX`UbX`V`i Y`@, `I , %II `cZ7=8%+`j ]U`g]a d`Y`gYf]U``WWV`Y`hcc"

<sup>.</sup>5XXYX<sup>.</sup>gi ddcfh<sup>.</sup>Zcf<sup>.</sup>ZUg\]b[ <sup>.</sup>fYX<sup>.</sup>@, <sup>.</sup>I , %| I <sup>.</sup>cZ<sup>.</sup>7=8(%"

6Ui XfUhY gi VgmghYa Wca d`YhY`mfYZUWhcfYX"

`6Ui XfUhY`dU[Y`Zfca 'h\Y`GYhh]b[g'k]bXck 'kUg'fYd`UWYX`Vm'h\Y`@]a]h`VUi XfUhY`Wca VcVcl `]b`h\Y`Df]aUfm'dU[Y`cZ7cbhfc` k]bXck "

 $\label{thm:condition} $$ '6Ui XfUhYg'i gYX'Zcf'ZUg\]b['D85'dUfh'cZD, $I \#D-\%$'UfY'`]a ]hYX'hc'(*$, $$6X'k \Yb'i g]b['I G6'WUV'Yg'h\Uh'UfY'bch'Yb\UbW'X'VmUXX]b['hk c'fYg]ghcfg'''H\]g']g'bch'fY'UhYX'hc'8GG! &$'bcf'8GG! &$'$bcf'8GG! &$'$bcf$ 

·=bghU``Yf`i dXUhYX`! a ]bcf`K ]bXck g`-, `]ggi Y`ZJI YX"`5b`Yffcf`a YggU[Y`a][\h`\Uj Y`VYYb`X]gd`UmYX`k\Yb`bc`Yffcf`c\WW ffYX"

`7i ghca ]nY`: G`Zi bWh]cbU`]hm`g`][ \h`m`a cX]Z]YX"

'7G'Udd`Yh'Wca a i b]WUh]cb'a UXY'a cfY'j YfVcgY"

`5j U]`UV`Y`ZfYY`gdUWY`]g`bck `X]gd`UmYX`VYZcfY`kf]h]b[ 'i gYf`Z[`Yg`hc`h\Y`d\cbY"

 $< Y^d^ZY'i dXUhYX''$ 

DUW\_U[Y'WcbhU]bg

'\UfXk UfY'Xcb[ `Y

'UWWygg'hc'gi ddcfh'UfYU

k UffUbhm



Mci 'k ]``[Yh'cbY'cZ'h\YgY'I G6'\UfXk UfY'Xcb['Yg'!'U``'cZ'h\Ya 'UfY'CF =; =B5@

¥ &\$&& k k k "[ ga !gi ddcfh"bYh

