

GU`U[Xccb['6YUW\'G]ei]^cf''9d]gW\Yg ?`]ddYbgdf]b[Yb'ibX'5VYbhYiYf

GU`U[Xccb['6YUW.']gh'Y]bYg'XYf'VYghYb'<][\`][\hg'UiZG]ei]'cf'=g`UbXž'D\]`]dd]bYb"'9bhXYW_Yb'G]Y'ZUbhUgh]gWXY?`]ddYbgdfØb[Y'Ub'Y]bYa 'XYf'VYghYb'GhfÀbXY'jcb'G]ei]'cf']gh'Yg'gWXkYfžY]bYb':Ujcf]hYb'UignikÀ\`Yb"5VYf'kYbb']WX'a ØgghYžkØfXY']WX'XYb'Yd]gWXYb'GhfUbX'jcb'GU`U[Xccb['kÀ\`Yb'<\]Yf']gh'Y]b'jc``ghÀbX][Yf'@Y]hZUXYb'ZØf'XYb'6YgiWXžY]bgWX`]Y*`]WX'XYf'5bZU\fhž'kUg'G]Y'YfkUfhYhž'ibX':chcg'jcbX]YgYa 'Yd]gWXYb'?`]ddYbgdfib['Ua'GhfUbX'jcbGU`U[Xccb['Jcf[YghY``h']b.'H\Y'7cad`YhY'G]ei]'cf'=g`UbX;i]XY'U`h1/Uad/,&&\$/GU`U[Xccb['6YUWX'G=ei]'cf'?`]ddYbgdfib[/Uad/,&&\$/GU`U[Xccb['6YUWX'G=ei]'cf'?`]ddYbgdfib[/Uad/,&&\$/GU`U[Xccb['6YUWX'G=ei]'cf'?`]ddYbgdfib[/Uad/,&&\$/GU`U[Xccb['9]bhf]hhg[YVØ\f.''\$'D<D'DUf_[YVØ\f.'&\$'D<D'Uf_[YVØ\f.'']d/

 $GU`U[Xccb[`6YUW\`]gh`Y]bYg`XYf`VYghYb`<][\``][\hg`UiZ`G]ei]^cf \\ = @`UbXž`D\]`]dd]bYb"`9bhXYW_Yb`G]Y`ZUbhUgh]gW\Y`?`]ddYbgdfØb[YUb`Y]bYa`XYf`VYghYb`GhfÀbXY`jcb`G]ei]^cf"$

6Y] 'gc 'j]Y`Yb 'gW\ ÒbYb 'GhfÀbXYb 'Ui Z'G]ei] 'cf ']gh 'Yg 'gW\ k Yfž 'Y]bYb : Uj cf]hYb 'Ui gni k À\`Yb" '5VYf 'k Ybb ']W\ 'a ØgghYž 'k ØfXY ']W\ 'XYb Yd]gW\ Yb 'GhfUbX'j cb 'GU`U[Xccb['k À\`Yb '

<]Yf']gh'Y]b'j c``ghÀbX][Yf'@Y]hZUXYb'ZØf'XYb'6Ygi W\ž'Y]bgW\`]Y»`]W\
XYf'5bZU\fhž'k Ug'G]Y'Yfk UfhYhž'i bX': chcg'j cb'X]YgYa 'Yd]gW\Yb
?`]ddYbgdfi b['Ua 'GhfUbX'j cb'GU`U[Xccb[°</pre>

Jcf[YghY``h']b. 'H\Y'7ca d`YhY'G]ei]'cf'=g`UbX'; i]XY U`h1 GU'U[Xccb['6YUW\'G-ei]'cf'?`]ddYbgdfib[2

VYf'XYb'GhfUbX'jcb'GU`U[Xccb['

 $9]bhf]hhg[YV\emptyset\f."$D<D$

 $DUf_[YV\emptyset \ f. \ \&$ D < D$

8 UgʻYfghYž'k UgʻG]Yʻk]ggYbʻk cʻ`Ybžʻ]ghž'XUggʻGUʻU[Xccb['6YUW\ 'Y]b GhfUbXʻ]bʻDf]j UhVYg]hnʻ]gh"·8]YgYfʻ6YfY]W\ 'j cbʻG]ei]ʻcfʻk]fXʻj ca GUʻU[Xccb['6YUW\ 'F Ygcfhʻfk chY` '5[f]d]bcŁ'j Yfk UʻhYh"·8 U\Yf a ØggYbʻG]YʻY]bYʻ; YVØ\f'nU\`Ybžʻi a 'X]YgYbʻGhfUbXʻj cbʻG]ei]ʻcf ni '[Yb]Y» Yb"

 $8] Yg``c\bh`g] W``YXcWX ž`gcVU`X`G] Y`YbhXYW_Ybž`k] Y`[fc»Ufh] [X] YgYf`Cfh`Ub`XYf`Cghgd]hnY`jcb`G]ei]^cf`]gh`$

 $Ni \ XYb <][\ \][\ \ g'] \ cb \ GU \ U[\ Xccb[\ '6YUW \ '[\ Y\ OfYb.$

- & I 'hc``Y'?`]ddYbgdfØb[Y
- 9]bYK UggYffi hgWXY
- 9bhgdUbbYbXYf'GhfUbX
- Hc``Yg'GW\bcfW\Y`b

GU`U[Xccb['6YUW'@U[Y

K]Y'VYfY]hg'Yfk À\bhž``]Y[h'GU`U[Xccb['6YUW\'Ub'XYf'Cghgd]hnY XYf'\dgY``G]ei]'cf'UiZ'XYb'D\]`]dd]bYb"'G]Y'Z]bXYb'Yg']b'XYf'BÀ\Y XYf'GhUXh'AUf]U"'9g'[]Vh'Y]b'_ifnYg'GhØW_':cfghghfU»Y'bUaYbg GU`U[Xccb[':cfYqhž'XUq'nia'GhfUbX'ZØ\fh"

8 Y f 'K U`XUVgW\b]hh`]gh`ØVYf`X]Y`G]ei]^cf`7]fW a ZYfYbh]U``FcUX YffY]W\VUfž`X]Y`X]Y`\DgY``ØVYfgdUbbh"

I bhYb ']gh'X]Y '[YbUi Y '@U[Y 'XYg 'GhfUbXYg 'j cb 'GU`U[Xccb[ž'i a ⇒bYb 'VY] 'XYf'Gi WXY 'ni '\Y`ZYb"

6Yj cf'k]f'i bg'a]h'U``'XYb'Yd]gWXYb'?`]ddYbgdfØb[Yb'Ua

 $G]Y \land UVYb \land k Y] < Ui dhcdh]cbYb. \Upsilon]bY `[YZØ\fhY `Hci f`cXYf`X]Y 5bfY]gY `Ui Z`Y][YbY `: Ui gh"$

Cdh]cb'%.'6YghY'G]ei]^cf!=bgY`hcif'fY]bgW\`]Y»`]W\ GU`U[Xccb['6YUW\Ł

K Ybb'G]Y'k Yb]['NY]h'\UVYb'cXYf'Y]bZUW\'bif'X]Y'VYghYb

<][\`][\hg'j cb'G]ei]^cf'gY\Yb'a OW\hYbž'Y]bgW\`]Y»`]W\'Y]bYg

6Ygi W\g'XYf'7Ua Vi [U\Um': U``g'i bX'XYg'i b[`Ui V`]W\Yb

GU`U[Xccb['6YUW\ž'XUbb']gh'Yg'j]Y``Y]W\h'Y]bY'[i hY'=XYYž'Y]bY

Hcif'ni Vi W\Yb"

 $6YUWXhYbG]YZXUggG]YAf; YgW_jYfgiWXYb_ObbYbZY]bYb \\ : \emptyset Yff]bGUbAUbniZ]bXYb"CXYfZKYbbG]YbcWAJbB8iaU[iYhYg]bXZXUbbJghXUgTibhYbghYYbXYaJhG]WYfYJhXUgT6YghYZKUgG]YZ]bXYbKYfXYb"9gYUhAibXYfhYjcbGiWXib[YbTibXY]bY6YkYfhib[jcb(Z-#)GhYfbYbUiZG]ei]^cf"$

 $8]YgYFY]gYVY]b\U^hYh$

- $5V\cite{M} [UVY] ca #nia < chYi]b'8ia U[iYhY]$
- Df]j UhY Hcifia X]Y ⊕gY`G]ei]^cf
- <]b! i bX F \emptyset W_ZU\fha]h XYf : λ fY]b_i g]j Y
- ; YgWX]WX hghci f`a]h'6Ygi WX ' U f\i bXYfhYU`hYf'?]fWXYb
- HUi WXYb'G]Y'Y]b']b'XUg'hØf_]gZUfVYbY'K UggYf'XYf
 7Ua Vi [U\Um': U``g'i bX'gY\Yb'G]Y'XYb'VYfØ\a hYbž'ØVYf
 (\$\$'\\\J\\fY'U\hYb'6U\YhY!6Ui a
- 6YYbXYb'G]Y'XYb'HU[']a 'VYfØ\a hYb'Hf]UX'7UZY'a]h'6`]W_Ui Z'BY[fcg

'U`h1 6`Ui Y'@U[i bY'D\]`]dd]bYb 2

Cdh]cb & I bUV\Ab[][Y Cdh]cb

: Øf`X]Y Yb][Yb i bhYf' → bYbž'X]Y 'VYfY]hg`Ui Z'G]ei]^cf`g]bX i bX d`UbYbž'Y]b`dUUf`HU[Y`ni 'V`Y]VYbži a 'X]Y ⊕gY``ni 'Yf_i bXYb`i bX XUbb`XYb`GhfUbX'j cb`GU`U[Xccb['ni 'Yf_i bXYbž']gh'Yg'VY]'k Y]hYa Ua 'VYghYbž'Y]b`Y][YbYg'A chcffUX'ni 'a]YhYb"

5i Z'X]YgY'K Y]gY'_ÒbbYb'G]Y'Ui W\'Y]b][Y'XYf'UbXYfYb'<][\`][\hg k]Y'X]Y'@U[UUb': U``g'i bX'X]Y'7Ua Vi [U\Um': U``g'gY\Yb'

G]Y'_ObbYb'Y]bY']a '< Ui dhhci f]ghYbnYbhfi a 'j cb'GUb'¾ Ub'ZØf &) \$!') \$'DYgcg'dfc'HU['VY_ca a Yb"'8]Y': U\fh'j cb'GUb'¾ Ub'ni a GhfUbX'XUi Yfh'bcfa U'Yfk Y]gY'() 'A]bi hYb'Ui Z'XYf'7]fW a ZYfYbh]U` FcUX"'8Ug'`YhnhY'GhØW_ZØ\fh'Xi fWX'XYb'K U`Xž'XYf'`UbXgWXUZh`]WX gY\f'fY]nj c```]ghž'i bX'XUg'JcfXUWX']gh'Y]bY'gWX ObY'DUi gY'j cb'XYf GcbbY°

U`h1 G]ei]'cf!AchcffUX 2

K Ybb'G]Y'_Y]b': U\ffUX'a]YhYb'a ÒW\hYbž'_ObbYb'G]Y'YXYfnY]h'Y]b

Hf]WmWY!HUI]'ni a 'GhfUbX'j cb'GU`U[Xccb['bY\aYb"5W\hYb'G]Y

YXcW\'XUfUi Zž'ni 'Y]bYa 'ZU]fYb'DfY]g'ni 'hUi gW\Yb"

JYfk UbXhY.~&~VYghYb~G]ei]~cf!K UggYfZA`~Y

K Ug'G]Y'Ua 'GU`U[Xccb['6YUW\'G]ei]^cf Yfk UfhYh

GcVU`X'G]Y'Ub_ca a Ybž'Z]bXYb'G]Y'Y]bY'[fc»Y'@]W\hi b['a]h'j]Y` D`Uhnž'i a '\(\Rightarrow\) fYb'DUf_'ni 'j Yf`UggYb"'G]Y'gY\Yb'Y]bY'_`Y]bY'<\(\Omega\)hhYž']b XYf'G]Y'\(\Rightarrow\) fYb'BUa Yb'i bX'\(\Rightarrow\) f'@UbX'i bhYfgW\\ fY]VYb'gck]Y'X]Y\(\Rightarrow\) fYb'Z\(\Omega\)f': U\ffUX'i bX'X]Y'9]bhf]hhg_UfhY'VYnU\`Yb'_\ObbYb"

; $Y\Yb^G]Y^j cb^{]Yf^Ui g^{]bi bhYf^ni `XYb^k Y]_> Yb^GUbXghfÀbXYb j cb^GU^U[Xccb[`6YUW\ž'k c^XUg^5VYbhYi Yf^k]f_`]W\`VY[]bbh°$

8YfYd]gWXY?`]ddYbgdfib[

8 Ug' <][\`][\h'ZØf'a]W\'VY]'a Y]bYa '6Ygi W\'Ua 'GU`U[Xccb[6YUW\'G]ei]^cf'g]bX'X]Y'VY]XYb'hc``Yb'Gdfi b[VfYhhYf'Ui g'6Yhcb"

G]Y 'Z]bXYb 'X]YgY 'Ui Z'XYf'_`Y]bYb '@UbXni b[Yž'X]Y 'Ui g'XYf'6i W\h \YfUi gfU[h"

 $9g`[\]Vh`nk\ Y]`6fYhhYfž`Y]bYg`VY]`Yhk\ U`)``A\ YhYfb`cXYf``%*`:i\ "`i\ bXXUg`[\ f\`O")`YfY`VY]`Yhk\ U``%$``A\ YhYfb`cXYf`'\ &`:i\ "$

8 UgʻK UggYfʻXUfi bhYfʻ]ghʻUi gfY]WXYbXʻh]YZʻʻ5VYfʻk Ybbʻ]WXʻXUg gU[Yžʻk ØfXYʻ]WXʻk U\fgWXY]b`]WXʻ]a a YfʻbcWXʻa Y]bʻ6YghYgʻhi bžʻi a X]Yʻ: `i hʻZØfʻU``Yʻ: À``Yʻni ʻh]a Yb°ʻ9gʻ]ghʻUi WXʻY]bYʻ[i hYʻ¸ Vi b[ž ØVYfU```Xcfhžʻk cʻG]Yʻ?`]ddYbgdf]b[Ybʻa UWXYbžʻH]YZYbhYghg Xi fWXni ZØ\fYb°

8 UgʻK UggYfʻXUfi bhYfʻ\UhʻY]bYbʻk i bXYfgWkÒbYbʻHØf_]ghcb"ʻG]Y gY\Ybʻ[fc» Yʻ:]gWkgWk Àfa Yʻ\Yfi a gWkk]a a Ybʻi bXʻ[Ygi bXY ?cfU``Ybf]ZZYžX]YʻXYbʻA YYfYgVcXYbʻVYXYW_Yb" Uʻh1 GUʻU[Xccb['6YUWkʻG \oplus i]'cf'?`]ddYbgdfi b[2 Uʻh1 GUʻU[Xccb['6YUWkʻG \oplus i]'cf'?`]ddYbgdfi b[2

FihgWX][YFihgWXYUa GhfUbXjcbGU`U[Xccb[

 $8 \ Ug`UbXYfY`<][\ \ \][\ \ \ \] M`YghbUhØf`]WX`X]YgY`hc``Y`V`Ui Y`Fi hgWXY" @Y]XYf``]YZ`X]Yg`b]WX hž`U`g`]WX`Yg`VYgi WX hYž`UVYf`UbgcbghYb`\AhhY]WX`Yg`[YfbY`Ui gdfcV]Yfh° U`h1 GhfUbX`]b`G]ei]^cf 2$

$8]Y k Y] * Yb GUb X_ØghYb$

BUWX 'U```XYa '?`]ddYbgdf]b[Yb']gh'XUg'6YghYž'k Ug'a Ub'Ua 'GhfUbX j cb'GU`U[Xccb['hi b'_Ubbž'Y]bZUWX 'Ub'gY]bYb'I ZYfb'ni YbhgdUbbYb"'G]Y'_ObbYb'Ui WX'X]fY_h']a 'FYgcfh GWXbcfWXY`Ui gfØghi b[ž'GWXk]a a Yf'i bX'GI Dg'a]YhYb" U`h1 GU`U[Xccb[!GhfUbX'G]ei]^cf 2

K c]b G]ei]^cf ØVYfbUW hYb

8 Ugʻk]W\h][ghYʻHci f]ghYbnYbhfi a ʻUi ZʻG]ei]^cfʻ]ghʻU`gʻGUbʻ¾ Ub VY_Ubbh"ʻ9gʻ[]Vhʻ^YXcW\ʻUi W\ʻa Y\fYfYʻ; AghY\Ai gYfžʻ<cghY`gʻi bX FYgcfhqžʻX]YʻØVYfʻX]Yʻ‡bqY``j YfghfYi hʻq]bX"ʻ=a ʻ:c`[YbXYbʻ[YVY']W\ $= bYbX]YXfY]YYghYbCdh]cbYbZ0fY]bYTbhYf_ibZhT]bTG]ei]^cfžia = fYTFY]gYTniTdYUbYb"$

- 9d]W6Ua Vcc HfYY\ci gY. A UbXU`U'Hf]VY'HfYY\ci gYg' A ÒW\hYb'G]Y'=\fY'd\]`]dd]b]gW\Yb'=\bgY`UVYbhYi Yf'Ui Z'X]Y bAW\ghY'Ghi ZY'Vf]b[Yb3'8Ug'A UbXU`U'Hf]VY'V]YhYhYd]gW\Y 6Ui a \Ui gi bhYf_ØbZhY']b'dYfZY_hYf'@U[Y'Ui Z'G]ei]^cf"'8Ug : fØ\qhØW_]qh'qi dYf'i bX'XYf'DfY]q']qh'k]f_`]W\ZU]f°
- 6i X[Yh!; ÀghY\Ui g. @][\h<Ui g'8 Ygh]bUh]cb'D`UW' '8]Yg']gh XUg'Ua 'VYghYb'VYk YfhYhY'; ÀghY\Ui g'Ui Z'XYf' \$\pigY`' 8]YgYf'C fh'_cghYh'k Yb][Yf'U`g'%\$'8c``Uf'dfc'BUWkhž']gh]XYU`'[Y`Y[Yb'i bX'\Uh'Y]bY'j YffØW_hY'6Yk Yfhi b['j cb ž+#%\$'Ui Z'6cc_]b["Wca
- @ I i g. '8 YgWUbgc '9b 'DUfU]gc 'F Ygcfh' '8 YgWUbgc '9b DUfU]gc ']gh'Y]b '@ I i gfYgcfh'Ui Z'G]ei]'cf'c\bY'XYb fY[i `ÀfYb 'DfY]g° '8]YgYg'F Ygcfh'`]Y[h'bi f'Y]bYb'_i fnYb GdUn]Yf[Ub['j ca 'VY`]YVhYb'DcbhcX'6YUW\'YbhZYfbh'i bX j YfZØ[h'ØVYf'Y]b'Y][YbYg'F YghUi fUbhž'Y]bYb'Dcc`ž'Y]bYb; UfhYb'i bX'Y]bY'6Uf"

'U'h1 6Ui a \Ui g\chY``Ui ZG]ei]^cf 2

 $B]WWh'j YfdUggYb. ~^5dc~^{-}g`UbX~^fBia~U[iYhYž'DV]`]dd]bYbŁ$

$A Y \setminus f D \setminus]^{d} d b Y b F Y g Y Z \emptyset \setminus f Y f Y 6 c [g$

I bX`XUa]h`]gh`X]YgYf`?i fnZØ\fYf`ZØf`Y]bYb`6Ygi W\`Ua `GhfUbX`j cb GU`U[Xccb`Ui Z`XYf`±bgY``G]ei]^cf`Ui Z`XYb`D\]`]dd]bYb UV[YgW\`cggYb"

KÀ\fYbX'G]Y'\]Yf'g]bXž'gW\Ui Yb'G]Y'g]W\'i bVYX]b[h'Y]b][Y'a Y]bYf UbXYfYb'FY]gYZØ\fYf'ZØf'X]Y'FY[]cb'Ubž'i a 'a Y\f'FY]gY!'i bX 5VYbhYi Yf]bgd]fUh]cb'ni 'Yf\U`hYb'

п

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