

9!GWcchYf!: U\fYf']b'A Ubb\Y]a . 'Dc`]nY] ghcddh'VYhfi b_YbYb': U\fYf

Dc`]nY]'ghcddh'9!GWcchYf!: U\fYf']b'A Ubb\Y]a .'5`_c\c`!'i bX 8fc[Ybj YfXUW\h'ZØ\fh'ni 'GhfUZUbnY][Y'i bX'G]W\YfghY``i b[XYg'Fc``Yfg"

± Y]bYf'Vf]gUbhYb'5_h]cb'\Uh'X]Y'Dc`]nY]'Ua 'gdÀhYb
8]YbghU[UVYbXž'[Y[Yb'&' 'I \fž'Y]bYb'9!GWcchYf!: U\fYf']a
GhUXh[YV]Yh'Ui g'XYa 'J Yf_Y\f'[Ync[Yb"'8]YgYf'J cfZU``'k]fZh'Y]b
@]W\h'Ui Z'XUg'ni bY\a YbXY'DfcV`Ya 'XYf'J Yf_Y\fgg]W\Yf\Y]h']a
Ni gUa a Yb\Ub['a]h'9!GWcchYfbž']bgVYgcbXYfY'k Ybb'Yg'i a 'X]Y
; YZU\fYb'XYg': U\fYbg'i bhYf'9]bZi gg'j cb'5`_c\c`i bX'8fc[Yb
[Y\h"

8]Y 'Dc`]nY]'k Uf']b'XYf'A Ubb\Y]a Yf'GhfU» Y'i bhYfk Y[gž'U`g'g]Y'Ui ZXYb'&'!'À\f][Yb': U\fYf'Ui Za Yf_gUa 'k i fXY"'GY]bY': U\fk Y]gY'k UfU``Yg'UbXYfY'U`g'j cfV]`X`]W\. '9f'Zi \f'fYW\hgk]Xf]['Ui Z'XYa 6Øf[YfghY]['i bX'\UhhY'ni XYa 'Y]bY'A]hZU\fYf]b'XUVY]"'GY]b: U\fgh]```]Y» '_Y]bY'Nk Y]ZY`'Ub'gY]bYf'I bZ\]['Y]h'Ui Z_ca a Ybž'XU Yf'XYi h`]W\Y'GW\`Ub[Yb`]b]Yb'Zi \f'i bX']a a Yf'k]YXYf'c\bYYf_YbbVUfYb'5b`Ugg'UVfi dh'VfYa ghY'cXYf'VYgW\`Yi b][hY"'Gc`W\Y A UbÒj Yf'g]bX'b]W\h'bi f'[YZ\h'f]W\ZØf'XYb': U\fYf'gY`Vghz'gcbXYfb

5`_c\c`!'i bX'8fc[Yba]ggVfUi W\']a GhfU»YbjYf_Y\f

5`g`X]Y`6YUa hYb`XYb`^i b[Yb`A Ubb`gW\`]Y»`]W\`ghcddhYb`i bX`]\a Y]bY`?cbhfc``Y`Ui ZYf`Y[hYbž`gW\`i [`]\bYb`gcZcfh`XYf'; Yfi W\`j cb 5`_c\c``Ybh[Y[Yb"`9f`nY][hY`ni XYa '_`UfY`Gma dhca Yž`X]Y`Ui Z 8fc[Yb_cbgi a `\]bXYi hYb"`8]Y`Xi fW\[YZØ\fhYb`GW\bY``hYghg VYghÀh][hYb`X]Y`JYfa i hi b[Yb`XYf`Dc`]n]ghYb.`8Yf
5hYa U`_c\c`hYgh'Yf[UV`Y]bYb`K Yfh'j cb`\$\(\frac{z}{z}\) + 'Dfca]``Y"'8]Yg``]Y[h
nk Uf'i bhYf`XYa `[YgYhn`]W\Yb'; fYbnk Yfh'Z\(\textit{Q}\)f'5i hcZU\fYf\(\frac{z}{z}\)YxcW\
]gh'ni `VYUW\hYb\(\frac{z}{z}\)Yg'9!G\(\textit{C}\)chYf!: U\fYf`YVYb\(\frac{z}{z}\)Y\\
J cfq\(\frac{z}{z}\)f'5`_c\c``Ua `GhYi Yf'i bhYf`]Y[Yb"

6YgcbXYfg'U`Ufa]YfYbX'k Uf'YXcW.'XUg'9f[YVb]g'XYg
UbgWX`]Y» YbXYb'I f]bhYghgz'XYf'Ui Z'[`Y]WX'XfY]'j YfgWX]YXYbY
; fi ddYb'j cb'6YhÀi Vi b[ga]hhY`b'dcg]h]j 'fYU[]YfhY"'8]YgY
: YghghY``i b[Yb'i bhYfghfY]WXYb'X]Y'Bchk YbX][_Y]h'ghfYb[Yf
?cbhfc``Yb'i bX'5i Z_`Àfi b[']a 'I a [Ub['a]h'9!GWcchYfb"'8Yf'9!
GWcchYf'XYg''A b[Yb'A UbbYg'k i fXY'g]WXYf[YghY``hz'i bX'Yf'a i gghY
ni f'8]YbghghY``Y'a]h_ca a Ybz'i a 'Y]bY'6`i hdfcVY'UV[YVYb'ni
`UggYb"'8]Y'9fa]hh`i b[Yb'VYnØ[`]WX'XYg'J YfXUWX hg'Ui Z
Hfi b_Yb\Y]h']a 'JYf_Y\f'XUi Yfb'Ub'i bX'_ObbhYb'gWXk Yfk]Y[YbXY
?cbgYei YbnYb'Z0f'XYb': U\fYf'bUWX'g]WX'n]Y\Yb"

9gʻ]ghʻk]WXh]['ni 'VYhcbYbž'XUggʻ9!GWcchYfʻ]bʻj]Y`YbʻGhÀXhYbʻY]b VY`]YVhYgʻ: cfhVYk Y[i b[ga]hhY``g]bXž'XUgʻXYbʻi fVUbYbʻJ Yf_Y\f Ybh`UghYbʻgc``"'5``YfX]b[gʻVf]b[hʻX]YgYʻ: cfa 'XYfʻA cV]`]hÀhʻUi WX Yf\YV`]WXYʻF]g]_Ybʻa]hʻg]WXž']bgVYgcbXYfYʻk Ybbʻ: U\fYbXYʻi bhYf XYa '9]bZi ggʻj cbʻ5`_c\c``cXYfʻ8fc[YbʻghY\Yb"'8]YʻfYWXh`]WXYb FU\a YbVYX]b[i b[Ybʻa ØggYbʻXf]b[YbX'_`UfYfʻ_ca a i b]n]Yfh k YfXYbži a 'gWXk Yfk]Y[YbXYʻI bZÀ``Yʻi bXʻa Ò[`]WXYʻJ Yf`Yhni b[Yb]a 'GhfU» Ybj Yf_Y\f'ni 'j Yfa Y]XYb"

$8]Y'JYfUbhk cfhi b['XYf'9!GWcchYf!: U\fYf$

8]Y J cfZÀ``Y k]Y X]YgYf ghY``Yb Y]bY Yfbgh\ UZhY < YfUi gZcfXYfi b[
ZØf X]Y J Yf_Y\fgg]W\ Yf\ Y]h XUf" '9!GWcchYf k YfXYb '\ Ài Z]['U`g
i b_ca d`]n]YfhY i bX gW\ bY``Y A Ò[`]W\ _Y]h k U\f[Ybca a Ybžg]W\ ']b
XYf 'GhUXh 'Zcfhni VYk Y[Yb" J]Y `Y 'Bi hnYf 'gW\ Y]bYb 'g]W\ 'YXcW\ 'XYf
J YfUbhk cfhi b[ž'X]Y a]h XYa :: U\fYb 'Y]bYg :: U\fnYi [g'Y]b\Yf[Y\hž
b]W\ h'j c``gh\ bX]['VYk i ggh'ni 'gY]b" '8]Y 'ghY][YbXY '5 bnU\``j cb
I bZ\ ``Yb 'hf\ [h'ni 'Y]bYf k UW\gYbXYb '6 Ygcf[b]g 'VY]ž i bX 'Yg k]fX
ni bY\a YbX']b :: fU[Y'[YghY``hžk]Y 'gc`W\Y :: U\fnYi [Y 'g]W\Yf']b 'XUg
VYghY\YbXY'J Yf_Y\fggmghYa ']bhY[f]Yfh k YfXYb '_ObbYb"

9g'V'Y]Vh'UVni k UfhYbž'k Y'W\Y'k Y]hYfYb'A U» bU\a Yb'gY]hYbg'XYf 6Y\ÒfXYb'Yf[f]ZZYb'k YfXYbž'i a 'gc'W\Y'JcfZÀ``Y']b'Ni _i bZh'ni j Yf\]bXYfb"'GYbg]V]`]g]Yfi b[gU_h]cbYb'gck]Y'ghfYb[YfY'?cbhfc``Yb _ÒbbhYb'bchk YbX]['gY]bž'i a 'XUg'6Yk i gghgY]b'ZØf'X]Y'; YZU\fYb]a 'GhfU» Ybj Yf_Y\f'ni 'gW\ÀfZYb'i bX'X]Y'9!GWcchYf!Bi hnYf'ni j YfUbhk cfhi b[gVYk i gghYfYa 'JYf\U`hYb'ni 'VYk Y[Yb"

I a 'X]Y'JYf_Y\fgg]hi Uh]cb'bUW\\U`h]['ni 'j YfVYggYfbž']gh'Yg'j cb nYbhfU`Yf'6YXYi hi b[ž'XUgg'U``Y'JYf_Y\fghY]`bY\a Yf' 'gY]'Yg']a 5i hcž'Ui Z'XYa ': U\ffUX'cXYf'Ui Z'Y]bYa '9!GWcchYf' 'g]W\'XYf F]g]_Yb'VYk i ggh'g]bX'i bX'j YfUbhk cfhi b[gj c```\UbXY`b"

8]Y'ni bY\a YbXY'JYfVfY]hi b['j cb'9!GWcchYfb']b'ghAXh]gWXYb; YV]YhYb'\Uh'gck c\`'JcfnØ[Y'U`g'Ui WX'<YfUi gZcfXYfi b[Yb'a]h g]WX'[YVfUWXh"8]Y'Bi hni b['j cb'9!GWcchYfb']gh']b'XYb'`YhnhYb \\J\fYb'Yl d`cX]Yfhž'k Ug'Xi fWX'XUg'5b[YVch'j cb'G\Uf]b[! D`UhhZcfa Yb'VY[Øbgh][h'ki fXY"8]YgY'5bV]YhYf'Yfa Ò[`]WXYb'Yg Bi hnYfbž'9!GWcchYf'_i fnZf]gh]['ni 'a]YhYbž'k cXi fWX'XYf'Ni [Ub[ni f'A]_fca cV]`]hÀh'j YfY]bZUWXh'k]fX"'@Ui h'Y]bYf'Ghi X]Y'j cb GhUh]ghU'bi hnHYb']a '\J\f'&\$&&'ØVYf'%*'A]``]cbYb'A YbgWXYb']b 8Yi hgWX`UbX'9!GWcchYf"5``YfX]b[g'ZØ\fhX]Y'ghY][YbXY'5bnU\`Ui WX'ni 'Y]bYa 'VYgcf[b]gYffY[YbXYb'5bgh]Y['j cb'I bZÀ``Ybž'VY] XYbYb'X]Y'Bi hnYf'\Ài Z]['b]WXh'ØVYf'X]Y'[Y`hYbXYb'JYf_Y\fgfY[Y`b]bZcfa]Yfh'g]bX"

#b j]Y Y b 'GhÀ X h Y b 'Z Y \ Y b 'ni X Y a '_ `UfY 'F Y [Y `i b [Y b 'Z Ø f `X] Y B i hni b ['j c b '9! G W c h Y f b ž 'k Ug 'X] Y 'G]hi Uh]c b 'ni g À hn`] W \
 _ca d `]n] Y fh'' 8] Y '; Y g Y hn [Y V i b ['g] Y \ h j c f ž X Ugg '9! G W c c h Y f 'b i f 'U i Z F U X k Y [Y b 'c X Y f ž 'k Y b b 'X] Y g Y 'b] W h 'j c f \ Ub X Y b 'g] b X ž 'U i Z 'X Y f G h f U » Y '[Y b i hnh 'k Y f X Y b 'X Ø f Z Y b " H f c hn X Y a '_ca a h 'Y g '] a a Y f k] Y X Y f 'j c f ž X Ugg 'X] Y : U \ f Y f 'X Y b '6 Ø f [Y f g h Y] ['V Y b i hn Y b ž 'k Ug 'n i ; Y Z U \ f Y b 'Z Ø \ f Y b '_Ub b " '# \ X Y f '_cb_f Y h Y b 'G] hi Uh] c b ž X] Y 'ni f '? c b h f c `` Y 'X Y g '4 b [Y b 'A Ub b Y g 'Z Ø \ f h Y ž 'k i f X Y '_ ` U f ž 'X Ugg 'X] Y a] g g V f À i W \`] W X Y J Y f k Y b X i b ['X Y g '9! G W c h Y f g '] b '? ca V] b Uh] c b 'a] h 5 `_c \ c `! 'i b X '8 f c [Y b _cbg i a '_ `Uf Y 'F] g] _ Y b 'Z Ø f 'U `` Y J Y f _ Y \ f g h Y] `b Y \ a Y f 'X Uf g h Y ``h'"

 $5i Z_{\hat{y}} = [V_{\hat{y}} + V_{\hat{y}}] \times [V_{\hat{y}} + V_$

8]Y J Yf_Y\fgg]W\Yf\Y]h]a Ni gUa a Yb\Ub[a]h 9!GWcchYfb]gh Y]b [fc > Yg H\Ya Už XUg a Y\f 5 i Za Yf_gUa _Y]h VYb Oh][h" 8]Y Dc `]nY] i bX UbXYfY & gh]hi h]cbYb j Yfgi W\Yb Ž Xi fW\
5 i Z_`Afi b[g_Ua dU[bYb X]Y Bi hnYf ØVYf X]Y ; YZU\fYb i bX X]Y J cfgW\f]ZhYb ni]b Zcfa]YfYb " 9]b 6 Y]gd]Y `]gh X]Y ? Ua dU[bY G]W\Yf A]h 8 Ya 9!GWcchYf Ž X]Y]a *J\f & \$& j cb j YfgW\]YXYbYb J Yf_Y\fga]b]ghYf]Yb]bg @YVYb [Yfi ZYb k i fXYŽ i a XUg 6 Yk i gghgY]b ZØf g]W\YfY : U\fdfU_h]_Yb ni gW\AfZYb " 9g]gh k]W\h][Ž XUgg gck c\`X]Y Bi hnYf j cb 9!GWcchYfb U`g Ui W\X]Y UbXYfYb J Yf_Y\fghY]`bY\a Yf X]Y F Y[Y`b i bX X]Y F]g]_Yb _YbbYb"

8 UhYb i b X GhUh]gh]_Yb

8]Y'I bZU``ghUh]gh]_Yb'ZØf'9!GWcchYf'nY][Yb'XYi h`]W\ž'XUgg'X]Y'NU\`XYf'JYf`YhnhYb'ØVYfU```ghY][h"=a '\\\f'&\&\k' k i fXYb'`\Ui h'XYa
8 Yi hgW\Yb'JYf_Y\fgg]W\Yf\Y]hgfUh'fBJF\L']bg[YgUa h'ZUgh'\&\+"\\$\\$
JYf_Y\fgjYf`Yhni b[Yb'a]h'9!GWcchYfb'fY[]ghf]Yfhž'k Ug'Y]bYb
5 bgh]Y['jcb'-ž+'i ']a 'JYf[`Y]W\'ni a 'Jcf'U\f'XUfghY``h"'8]Y
a Y]ghYb'X]YgYf'JcfZ\'Y'g]bX'Ui Z'5`_c\c`!'i bX'8fc[Yb_cbgi a ni fØW_ni ZØ\fYb"'8]Yg'i bhYfghfY]W\h'X]Y'Bchk YbX][_Y]h'j cb
f][cfcgYb'?cbhfc``Yb'i bX'df\'AjYbh]jYb'AU*bU\aYbži a'X]Y

I a 'XYa '5bgh]Y['XYf'I bZÀ``Y'Ybh[Y[Ybni k]f_Ybž'k]fX'Ui W j YfghÀf_h'Ui Z'X]Y'J YfUbhk cfh`]W_Y]h'XYf'9!GWcchYf!5bV]YhYf \]b[Yk]YgYb"'8]YgY'I bhYfbY\a Yb'gc``hYb'g]W\YfghY``Ybž'XUgg']\fY Bi hnYf'ØVYf'X]Y'FY[Y`b']bZcfa]Yfh'g]bX'i bX'X]Y'F]g]_Ybž'X]Y'a]h Y]bYf'i bgUW\[Ya À»Yb'Bi hni b['j YfVi bXYb'g]bXž'j YfghY\Yb"

 $GWX^{]}Y * [WX^{]}gh^{'}Yg^{'}Yb^{'}gWX^{'}]XYbXZ^{'}XUgg^{'}gc^{'}k^{'}c^{'}X]Y^{'}Bi^{'}hnYf^{'}U^{'}g^{'}Ui^{'}WX^{'}hgWX^{'}yhgWX^{$

X]Y'5bV]YhYf'j cb'9!GWcchYfb']b'X]Y'JYfUbhk cfhi b['[Ybca a Ybk YfXYbž'i a 'Y]bY'g]WkYfY'i bX'bUWk\U`h][Y'Bi hni b['X]YgYg'bYi YbJYf_Y\fga]hhY`g'ni '[Yk À\f`Y]ghYb"'8]Y'Dc`]nY]'k]fX'Ui WkkY]hYf\]b'j YfghÀf_h'?cbhfc``Yb'Xi fWkZØ\fYbž'i a 'X]Y'9]b\U`hi b[XYf'JYf_Y\fgfY[Y`b'g]WkYfni ghY``Yb'i bX'X]Y'JYf_Y\fgg]WkYf\Y]hni 'Yf\O\Yb"

8 YhU]`g

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