

@YVYbga]hhY`Ui g[UVY`]b`GØ`n.`Gc i bhYfghØhnh`X]Y`?]fWXY`6YXØfZh][Y°

9fZU\fYb`G]Y`a Y\f`ØVYf`X]Y`@YVYbga]hhY`Ui g[UVY`]b`XYf ?]fWXY`Gh"`?Uf`ž`?Ò`bž`i bX`XUg`9b[U[Ya Ybh'j cb`8]U_cb <Ubbc`Gdf]gg`Yf"



?]fWX Y 'Gh" '? Uf`ž'? Ò`bž'8 Yi hgWX `Ub X '! '\ '? Ò`b!GØ`n'\]Y» 'Yg'Ua
A]hhk cWXa]hhU['k]YXYf' < U``Y`i 'U 'VY]'XYf'@YVYbga]hhY`Ui g[UVY
]b'XYf'?]fWX Y 'Gh" '? Uf`" 'GWX cb'i a '\U`V'nk Y]'XfÀb[hYb'g]WX'X]Y
; ÀghY'j c``Yf'J cfZfYi XY']b'XYf``]WX hXi fWX Zi hYhYb'?]fWX Yž'i a 'g]WX
a]h'Zf]gWX Ya 'C Vghž'; Ya ØgYž'6UW_k UfYb'i bX'? Ø\`dfcXi _hYb
Y]bni XYW_Yb"'J YfUbghU`hYh'k]fX'X]Y'5i g[UVY'j cb'Y]bYa
Yb[U[]YfhYb'HYUa 'j cb'Yhk U'%) \$'9\fYbUa h`]WXYbž'X]Y'k Yfhj c``Y
<]`ZY'`Y]ghYb' 'gc'k]Y'GUgWX Už'Y]b'`Ub['À\f][Yf'; Ughž'XYf'gY]h'ØVYf
Y]bYa '\U_hjj 'a]hUfVY]hYh": Øf']\b']gh'Yg'b]WX h'bi f'Y]bY
A Ò[`]WX_Y]hž'UbXYfY'ni 'i bhYfghØhnYbž'gcbXYfb'Ui WX'Y]bY
; Y`Y[Yb\Y]hž'gcn]U`Y'?cbhU_hY'ni '_bØdZYb'i bX'Yhk Ug
ni fØW_ni [YVYb"

8]Y @Y VY bga]hhY`Ui g[UVY`k i fXY`]a `Bcj Ya VYf`&\$&\$`]bg`@Y VY b
[Yfi ZYbž`U`g`X]Y`DUbXYa]Y`j]Y`Y`A YbgWXYb`]b`Bch`VfUWXhY''8 Ug
YfghY`A U``\UhhYb`g]WX`XUa U`g`bi f`) \$`6Ygi WXYf`i bX`ZØbZ
ZfY]k]``][Y`< Y`ZYf`Y]b[YZ bXYb''`< Yi hY`g]bX`X]Y`GWX`Ub[Yb`cZh`V]g
Ui Z`X]Y`NØ`d]WXYf`GhfU» Y`g]WX hVUfž`Y]b`NY]WXYb`XUZØfž`k]Y`ghUf_
XYf`6YXUfZ`]b`XYf`; Ya Y]bXY`[Yk UWXgYb`]gh''`< Ubbc`Gdf]gg`Yfž
8]U_cb`gY]h`&\$%' ž`]gh`XYf`?cdZ`\]bhYf`X]YgYf`i bX`j]Y`Yb`k Y]hYfYb
_Uf]hUh]j Yb`\b]h]Uh]j Yb`]b`XYf`FY[]cb''`I bhYf`gY]bYb`Dfc`Y_hYb
Z]bXYb`g]WX`b]WXh`bi f`X]Y`: 7!@YVYbga]hhY`Ui g[UVY`i bX`X]Y
9ggYbgUi g[UVY` GØ`n`i bX`DZYZZYf ž`gcbXYfb`Ui WX`XYf
J YYXY`ggWXfUb_`i bX`?f]a g_fUa g!?Uf`ž`X]Y`A YbgWXYb`a]h`GYWcbX!
<UbX!?`Y]Xi b[ii bX`< Ui g\U`hqk UfYb`i bhYfqhØhnYb''

; $YfYWXh][Y]h^{T}ZØf^{T}U^{Y}$

 $: \emptyset fia] WX] gh Yg X] Y [f \mathring{O} wh Y < Yf Ui g Zc f X Yf i b [\check{z}; Yf Y WX h] [_Y] h \\ Yf ni gh Y `Yb \check{z} g U [h G d f] gg Yf \check{z} X Yf [f c w Yb K Yfh Ui Z X] Y K \emptyset f X Y i b X K Yfhg WX Å hni b ['X Yf'; Å gh Y 'Y [h '' 8] Yg Y *\fi X Y U Y 'X f Ø W_Y b 'g] WX '] a G `c [Ub 'X Yf'?] f WX Y 'Ui g. '?] f WX Y 'ZØ f @ Y] V i b X 'G Y Y Y "'I a '[Yf Y WX h Y J Yfh Y] `i b ['g] WX Yf ni gh Y `Yb \check{z} [] Vh Yg 'Y] b 'F ch Uh] c b g g m gh Ya \check{z} V Y] X Ya X] Y 'H Y] `b Y \ a Yf'] b 'j] Yf 'U` d \ UV Yh] g WX 'g c f h] Yfh Y'; fi d d Y b 'Y] b [Yh Y] `h k Yf X Yb "'Ni X Ya '] gh Yg 'k] WX h] [\check{z} X Y b '; Å g h Y b 'Y] b Y Ya d Uh \] g WX Y I bh Yfgh Øhni b ['ni 'V] Yh Yb Ž k Ug 'X i f WX 'Y] b 'g c [Yb Ub bh Yg ': YY `'; c c X ! H Y Ua 'Yf Z c `[h Ž X Ug '] b 'g W X k] Yf] [Yb 'A ca Ybh Yb 'ni f 'G Y] h Y 'g h Y \ h''$

8]Y 'HY]`bU\a YVYX]b[i b[Yb'g]bX'_`Uf. I a 'Ub'XYf
@YVYbga]hhY`Ui g[UVY'hY]`ni bY\a Ybž'a ØggYb'6Ygi W\Yf'Y]bYb
BUW\k Y]g'ØVYf']\fY'6YXØfZh][_Y]h'Vf]b[Ybž'gY]'Yg'Y]b'? Ò`b!DUggž
Y]b'&VW\bhYf!6YgW\Y]X'cXYf'Y]bY'5i ZYbh\U`hg[YbY\a][i b["'I bX
XUg'b]W\h'bi f'a]hhk cW\g'j cb'%(.'\\$'V]g'%*.'\\$'I\fž'XYbb'Ui W\
gUa ghU[g'g]bX'A YbgW\Yb'Ui g'UbXYfYb'? Ò`bYf'JYYXY`b'\Yfn`]W\k]``_ca a Yb"

8]Y'NU\`Yb'XYf'?O`bYf'HUZY`

8] Y '? Ò`b Y f`HUZY``\ Uh`Y]b Y`k] W\ h] [Y 'F c``Y '] a 'gcn] U`Y b 'B Y hn`X Y f GhUX h" '9g` [] V h' j Y fg W\] Y X Y b Y '5 i g [U V Y gh Y ``Y b ž' X] Y ' [f Ò» h Y b h Y] `g` j c b ?] f W\ Y b [Y a Y] b X Y b ž' J Y f Y] b Y b 'c X Y f '6 Ø f [Y f] b] h] U h] j Y b 'c f [U b] g] Y f h k YfXYb"'<]Yf'Y]bY', VYfg]W\h'ØVYf'Y]b][Y'XYf @YVYbga]hhY`Ui g[UVYghY``Yb']b'?Ò`b.

GhUXhhY]`	5 X f Y g g Y	² ZZbi b[gnY]hYb	5ba Y`Xi b[
5`hghUXh	5b'@mg_]fWXYb	8cbbYfghU[g	6YghUbXg_i bXY
BcfX#GØX	%\$ž [*]) \$*+* '? Ò`b	%) .\$\$``%*.\$\$	b'%).\$\$'l\fž'B
		l \f	YifY[]ghf]Yfib[
			Yb'%(.\$\$'
			%(.' \$`I \f
6UmYbh\U`	6fØ\`Yf'Ghf"'+(ž	AcbhU[g ⁻ %).\$\$	A cbhU[g [:] %).\$\$
) \$- *, '? Ò`b	'%*.' \$'I \f	'%*.' \$'l \f
6]W_YbXcfZ	CggYbXcfZYf	8cbbYfghU[g	A]hhkcWig
	K Y[') ž') \$, &+	%) .\$\$``%, .\$\$	%(.\$\$ ' '%* .\$\$
	? Ò`b	l \f	l ∖f
			fbYfgÒb`]WXŁ
6]`XYfghÒW_WXY	9g\\\Yf`Ghf"'\\$(8cbbYfghU[g	8cbbYfghU[g
b		%, .\$\$``%, .'\$	%\$.\$\$ [*] *%%.\$\$
		l ∖f	I∖f`fBUWkY]g
			XYf
			6YXØfZh][_Y]hŁ
7\cfkY]`Yf	DUf]gYf'D`Uhn'%ž	8]ž'A]ž'8c	A]hhkcWig
) \$ + *) '? O`b	%) .\$\$``%*.'\$	%' .\$\$` `%(.' \$
		l \f	l∖f⁻f₽Ò`b!
			DÀggY
			YfZcfXYf`]WXŁ

Gdf]gg`Yf`a ÒWkhY`X]Y`gcn]U`Y`8]Ybgh`Y]ghi b[`k Y]hYf`ghÀf_Yb`i bX j cf`U``Ya `X]Y`A YbgWkYb`]b`5fa i hii bhYfghØhnYb"`GY]bY`J]g]cb`ZØf XYb`CVYfVØf[Yfa Y]ghYf`n]Y`h`XUfUi Z`UVž`X]Y`6YfUhi b[`ZØf 6YXØfZh][Y`ni 'j YfVYggYfb`i bX`X]Y`<YfUi gZcfXYfi b[Ybž`XYbYb g]Wk`j]Y`Y`ghY``Yb`a ØggYbž`a Ò[`]Wkgh`ni ``]bXYfb"`8Ybb`Y]bYg`]gh _`Uf.` 8]Y`K ØfXY`XYg`A YbgWkYb`]ghii bUbhUghVUf ž`i bX`XUg`k]fX`]b GØ`n`hU[hÀ[`]Wk`[Y`YVh"

: Øf'k Y]hYfY' \pm bZcfa Uh]cbYb'ØVYf'X]Y'5i g[UVYghY``Yb'i bX'X]Y ? Ò`bYf'HUZY`'_ObbYb'G]Y'X]Y'K YVgY]hY'hUZY`"_cY`b'VYgi W\Yb"

 $\pm 0.1 \text{NY]} \text{hYb} \, \text{\check{z}} \text{]} \text{b.} \text{XYbYb.} \text{[YgY``gW\ UZh`]W\ Y`< YfUi gZcfXYfi b[Yb]}$

U``[Y[Ybk Àfh]['g]bXž'nY][h'XUg'HYUa 'i a '8]U_cb'<Ubbc'Gdf]gg`Yfž XUgg'g]W\'[Ya Y]bgW\UZh`]W\Yf'Ni gUa a Yb\U`h'i bX'I bhYfghØhni b[Xi fW\'Y\fYbUa h']W\Yg'9b[U[Ya Ybh'a Ub]ZYgh]Yfh"'8Ug']gh']b'XYf GhUXh'? Ò`b'Y]bY'k]W\h][Y'6chgW\UZhž'X]Y'A i h'a UW\h'i bX'<c\ZZbi b[]Vh"

8 YhU]`g	
Cfh	?]fWXY'Gh"'?Uf`ž'?Ò`bž'8Yi hgWX`UbX
EiY``Yb	• k k k "_ghU"XY
	hUZY`"_cY`b

6Ygi WXYb G]Y i bg Ui Z a Y]b!_cY`b"bYh