

7ci fgY⁻Cj Yfj]Yk

GHJZZ7cbHJWh8YHJ]`g

7cbj Ybcfg

B Ua Y	9a U]`	5j U]`UV]`] m	@cWUh]cb	D\cbY
7 fU]['F cVYfhg	WfcVYftg4 i bgk "YXi "Ui	VmYa U]`	79(‰	-',) ((*(

@YWhi fYfg

B Ua Y	9a U]`	5j U]`UV]`] m	@cWUh]cb	D\cbY
6fi WY -< Ufj Ym	<u>V"\Ufj Ym4 i bgk "YXi "Ui</u>	Vm'Ya U]`	7 9 & \$ +	- ' ,) '(%+,

@UV GHJZZ

B Ua Y	9a U]`	5j U]`UV]`]hm	@cWUhjcb	D\cbY
M]bWU]^N\ci	m'n\ci 4 i bgk "YXi "Ui	VmYa U]`	79(%\$	-',)')&)&
DYHYf Aia ZcfX	<u>d"a i a 7cfX4 i bgk "YXi "Ui</u>	VmYa U]`	79(\$*	

GWXcc`7cbHJWh ±bZcfa Uh]cb

9b[]bYYf]b['Gh XYbhGi ddcfhGYf]]WYg'-'H\Y'Bi WYi g'!'Ybfc`a Ybhž'dfc[fYgg]cb'W\YW_gž'WUg\'fYei Yghgž Wci fgY']ggi Yg'cf'dfc[fUa!fY`UhYX'ei Yf]Yg'

9b[]bYYf]b[*\int Xi glf]U``HfU]b]b[-\int \int Xi glf]U``lfU]b]b['ei Ygh]cbg`

<u>I_BGK_'Gh_Xm5VfcUX</u>'--gh_XmUVfcUX'gh_XYbhYbei]f]Yg'fZcf']bVci bX'gh_XYbhgŁ'

<u>I BGK '91 VX Ub[Y</u>'-'gh XYbhYl VX Ub[Y'Ybei]f]Yg'fZcf']bVci bX'gh XYbhgŁ'

7ci fgY 8YHJ] g

I b]hg~cZ7fYX]h~*

Gi a a UfmcZh\Y 7ci fgY

5 b c ZI W a di g gi fj Ym W a džk \YfY gi fj Ym dfc Y W g c Zgi VgHUbhJU`YI hY bh UfY `WUff]Y X ci h jbj c j jb['Wcbffc` gi fj Ym XYg][b Ub X ja d Ya YbhUh]c b ž XYhU]` gi fj Ym g ž Wcbfc i f gi fj Ym g ž h Y XYg][b Ub X g Yhh]b [!ci h c Z U fi fu fc UX ž Ub X c h Yf g Y Y W X dfc Y W g " H \ Y dfc W g g]b ['c Z h \ Y Z]Y `X X UhU `Ub X h \ Y dfYd UfUh]c b c Z d `Ub g `Ub X f Y dc fhg `]g `Xcb Y `Xi f]b ['g Y g g]c b " G h X Y b hg `Uf Y f Y ei]f Y X hc `Uhh b X `U c b Y! k Y Y _ f Y g]X Y b h]U` gi fj Ym W la d `Uh h \ Y g h Uf h c 'h \ f Y Y `W c b h U h \ C 'h \ f g 'd Y f k Y Y _ ž Z c ``c k Y X `V m h k c '\ ci fg 'd Y f k Y Y _ df c Y W h X Uh U df c W g g]b ['Xi f]b ['g Y g g]c b "

7 ci fgY 5]a g

Hc 'VfcUXYb' UbX'XYYdYb' h\Y'_bck 'YX[Y'cZgi fj Ym]b[']bghfi a YbhUh]cbž' Z]Y`X'a Yh\cXgž' UbX'gi fj Ym]b[gcZk UfYž'Vmghi XYbhg' WcbXi Wh]b['h\Y]f'ck b' Z]Y`X'gi fj Ymcj Yf'U'cbY'k YY_']bhYbg]j Y'dYf]cX'UhU'g]hY'fYa chYZfca 'I BGK 'WJa di g"'H\Y'U]a ']g'hc']bj c'j Y'ghi XYbhg']b'a YUgi fYa Ybhz'gi fj YmXYg][bž'UbX'UbU'mg]gž'UbXhc'[]j Y'h\Ya 'WcbZ|XYbW']b'h\Y]f'UV]]mhc'WJffmci hZ]Y`X'gi fj Ymg"

7 ci fgY @YUfb]b[Ci hWca Yg

%"; U]b`YI dYf]YbWY`k]h\`\UbX`\Y`X`UbX`F H?!; DGžfcUX`gi fj YmgžXYhU]``gi fj YmgžYb[]bYYf]b[gi fj YmgžUbX`WcgY`fUb[Y`d\chc[fUa a Yhfm

&"; U]b Wcbq]XYfUV Y YI dYf]YbWY Uha UbU[]b['U'ga U```[fci d

HYUW]b['GhfUhY[]Yg'

H\Y'Z\Y'X'gi fj Ymg'k]```VY'WcbXi WMX'Ug'[fci d'k cf_"'=h]g'bchdcgg]V`Y'Zcf'cbY'dYfgcb'hc'Xc'a cghcZh\Y k cf_'UbX'`"WUffm''h\Y'ch\Yfg']b'h\Y'[fci d"''Gi VgYei Ybhhc'h\Y'cbY'k YY_']bhYbg]j Y'WJa d']g'cb'WJa di g dfcWygg]b['cZh\Y'Z\Y'X'XUHUž']bWi X]b['d`Ub'dfcXi Wf]cb'UbX'fYdcfrgž'Ug']bX]j]Xi U'g"'H\YfY'UfY'bc''YWi fYg]b'h\]g'Wci fgY"'< ck Yj Yfž'h\YfY'UfY'Vf]YZ\b['UbX'XYVf]YZ\b['gYgg]cbg'Uhih\Y'Z\YX*WJa d'g]hY'UbX'HU]b]b[gYgg]cbg"'H\]g'Wci fgY'\Ug'VYYb'j Yfmgi WWggZ ``mWcbXi WhYX'UhUbch\Yf'g]hY'fA cfdYh\Eg]bWY'\% +*ž cVj]ci g`mk]h\'Wcbf\bi U``a cX]Z\WJh]cbg'hc'h\Y'YI YfW]gYg'Ug']bglfi a YbhUbX'gcZhk UfY'\Uj Y'XYj Y'cdYX"'H\Y 6Yffmg]hY'k Ug'i gYX'Zcf'h\Y'Z\fghha Y']b'&\$\$, k]h\'gca Y'g]a]`Uf'YI YfW]gYg'hc'h\cgy'UhA cfdYh\žVi hgca Y

5ggYgga Ybh

HYWkb]WU``±bglfi Wf]cbg'k]``dfcj]XY'gdYW]Z]WfYei]fYa Ybhg'Zcf'gi Va]gg]cbg"'@YWi fYfg'k]``_YYd'ghi XYbhg]bZcfa YX'cZWkUb[Yg'Xi Y'hc'W]fW a gHUbWrg'UbX'UfY'kY'Wca Y'hc'fYei Ygh'WUf]Z]WUh]cb'Xi f]b['WUa d'cf'`UhYf Xi f]b['gWkYXi 'YX'`UV'gYgg]cbg'cf'j]U'Ya U]`"

5ggYgga YbhhUg_	K Y][\h	8iY'8UHY	7 ci fgY @YUfb]b[Ci HWca Yg 5ggYggYX
%".7 cbffc`Gi fj YmF Ydcfh	&%	% #\$' #&\$&&`\$(.\$\$`DA	%ž [*] &
&"'8YKU]`Gi fj YmDfcYWh	&, 1	\$, #\$(#&\$&&`\$(.\$\$`DA	%ž [*] &
' "'F cUX'Gi fj Ym'Dfc YWh	' *	&&#\$(#&\$&&`\$(.\$\$`DA</td><td>%ž[*]&</td></tr><tr><td>("'Ch\Yf'gi fj Ym</td><td>%) ।</td><td>&&#\$(#&\$&&`\$(.\$\$`DA</td><td>%ž[*]&</td></tr></tbody></table>	

5ggYgga Ybh% 7cbffc`Gi fj YmF Ydcfh

GhUfh:XUhY. '&, #\$&#&\$&&:\%.\$\$.5A

Gi Va]gg]cb bch/g. HYV\\b]\W\`=bghfi \W]cbg'[]j Yb

8 i Y XUhY. % #\$' #&\$&& \$(.\$\$ DA A Uf_g fYh fbYX. "K]h\]b hk c k YY_g

Gh XYbhg Xc 'U'Wcbhfc``gi fj YmUg'U'[fci d'cZ' "'H\]g']bWi XYg'hYgh]b['cZ\UbX'\Y`X'; DG'UbX']hg'i gY'Zcf ZbX]b['gi fj Yma Uf_g/Wcbhfc``gi fj YmZ]Y`Xk cf_'UbX'fYWcj Yfmg_YhW.Yg'UbX'UbU`mg]g'UbX'fYdcfhcZh.Y

5ggYgga Ybh'Wf]hYf]U

GYY"HYW\b]\W\``\#oglfi Wf]cbg

5 hmy b X Ub Wy F Yei] f Ya Yb hg

 $H\Y'Z_fghcb`]bY'Vf]YZ_b[``YWhifY']b'k YY_'`%]g'Wcadi`gcfm''A Ubmei Ygh]cbg'k]```VY'fU]gYX'UbX'h\Y'`YWhifYfau UmfYei]fY'X]fYWhiUbgk Yfg'`]j Y'hc'U]X'd`Ubb]b['Zcf'h\Y'Wuad']b'k YY_'' "'5'fYWcfX]b['cZh\]g'gYgg]cb'k]```VYUj U]`UV'Y'Zcf'fYj]g]cb''H\Y'(!XUmWuad']g'Wcadi`gcfm''$

7 ci fgY GWX YXi `Y

 $\label{thm:charge} $$HY^"UV'gYgg]cbg'UfY'U''cWUfYX'gc'fh\Ufi[fci dg'WUb'k cf_'fc[Yfh\Yf'cb'dfc'YWg'UbX'Ug_'ei Ygff]cbg'cZfh\Y]f'YWfi fYfg'''H\Y'fla Y']g'gWkYXi 'YX'fc'Uj c]X'WUg\Yg'k]fh 'cfh\Yf'WUggYg'Zcf'gfi XYbfg'UbX'gfUZZ''Gfi XYbfg'UfYYbWci fU[YX'fc'Uffh\YgY'gYgg]cbg''$

J JYk 'WUqq'Ha YHUV'Y

H]a YHJV`Y

8UhY	HmdY	7 cbhYbh
K YY_'%'%(': YVfi Ufm! % ': YVfi Ufm	Hi H@UV	7`UggʻgWXYXi`YX`]b`79&\$%!``UV`cf`cb`]bY"'H\]gʻ]g U`Wta di`gcfmVf]YZb['WUggʻ[]j]b[']bZcfa Uh]cb UVci hh\Y`Gi fj YmWUa d`k\]WX`k]``VY`\Y`X`h\]g mYUf`Uh'h\Y`7UHUfUWiGWti hDUf_`]b`kYY_'' "
		5Xa]b]ghfUh]j Y`]ggi Yg`gi W.`Ug`dUma Ybhg`UbX Zcfa g`k]```bYYX`hc`VY`Z]bU`]gYX`Vm'h\Y`YbX`cZh\]g gYgg]cb"
		H\]g`WUgg`k]```U`gc`VY`dfYgYbhYX``]j Y`cb`]bY`i g]b[6671 "
		5 ZhYf'h.Y'Vf]YZ b['UbX'ei Ygh]cbgž'ghi XYbhg'k]``h.YbdfUWf]W'i d`cUX#Xckb`cUX'cZGc]U#C \=]bghfi a Ybhg']b'dfYdUfUh]cb'Zcf'h.Y'WJad"
		FcUX`WU`W``Uhjcbg`WUb`U`gc`VY`dYfZcfaYX`Uh'h\]g hjaY"
K YY_'&.'&%: YVfi Ufm! &) ': YVfi Ufm	Hi H@UV	DfuWjWrigYcZYei]daYbh]b'dfYdufuh]cb'Zcf'Z]Y'X Wad"
		7 ca d`YhY`dfYdUfUhcfmifcUX`WU`W``Uh]cbg"
		DfYdUfY``c[]g]h]Wg`UbX`hfUjY``d`Ubg`Zcf`kYY_'' WUad"
K YY_" . '&, ': YVfi Ufm! ('A UfVX	:]Y`Xk cf_	:]Y`X`WJa d`Uh'7 UhJfUWhGWci hDUf_'ZFca 'A cbXUm &, ': YVfi Ufm! 'H\i fgXUm' 'A UfW\"
K YY_'(.'+'A UfVX'!'%% A UfVX	Hi H@UV	K cf_'cb'UWij]hjYg'Wta d'YhYX'Uh'Z Y'X'WUa d']b [fci dg"'Gh XYbh'[fci dg'UfY'YbWti fU[YX'hc'[c'hc h\Y'79&\$%'`UV'ftf'cb`]bYŁk\YfY'h\Ymk]``'fYW']jY

		gi dYfj]g]cb'UbX'[i]XUbW'Zfca 'h\Y]f'gi dYfj]gcfg"
		K_cf_'cb'7cblfc`'Gi_fj_YmfYdcfhUbX'8YHJ]`'d`Ub
K YY_")."%("A UfVX"!"% A UfVX	Hi H@UV	

FYgci fWyg

DfYgWf]VYX F Ygci fWYg

Ghi XYbhgʻg\ci `X`fYZYf`hc`h\Y`XcW a Ybhgʻa UXY`Uj U]`UV`Y`cb`h\Y`A ccX`Y`g]hY"`Ghi XYbhgʻg\ci `X`U`gc`fYZYf`hc `YWhi fY`bchYgʻZfca `dfYj]ci gʻWci fgYgʻYgdYWJU``m; A 5H&) \$\$`UbX`; A 5H&)) \$"

7 ciffgy juli Unic Uhlo to sub X coly i Yorcda Ybh

H\]g`Wci fgY`\Ug`Yj c`j YX`cj Yf`a UbmmYUfg"'\di]g`Ub`]bhYbg]j Y`Z]Y`X`WJa d`YI dYf]YbW``UbX`\Ug`VYYb\\]- 'gi dfYj]ci g`mWcbXi WfYX`]b`A cfdYh\`UbX`6Yffm''H\]g`]g`H\Y`gYWcbX`h]a Y`]hk\]``H_Y`d`UW\`Uh7 UhJfUWfGWci h\\DUf_"'K\YY_\%k\]``'dfcj]XY`U`Wca di `gcfmgh XYbhVf]YZ]b[\"'H\]g`k\]``'U`gc`VY`fYWcfXYX''`Gh XYbhg`k\]``VY\\YI dYWYX`hc`dfUWfJWY`i g]b[\"Yei]da YbhfY[\"i d`cUX]b[\"UbX`Xck\b`cUX]b[\"Zfca\"hchU``ghUh]cbzi g]b[\"F\H?\"YhWL\]b`k\YY_\%'\%']b`dfYdUfUh]cb`Zcf`h\Y`gi fj YmWJa\d"\

 $8i f]b["h\Y'gi fj YmiWla d'h\YfY'k]"`VY'Ub']b]h]U`K < G'Vf]YZ]b["UbX'cf]YbhUh]cb'VYZcfY'Wca a YbW]b["gi fj YmhUg_g""H\YfY'k]"`VY'Vf]YZ]b["gYgg]cbg'VYZcfY'YUW\"hUg_"UbX#cf'YUW\"b][\h"H\]g']g'U'j U'i UV'Y'h]a Y'k\YfY ghi XYbhg'Wlb'Ug_'ei Ygh]cbg']b'U'fY`Ul YX'Ybj]fcba YbhUbX'`YUfb'Zfca 'YUW\"ch\Yf'Ug'k Y``'Ug'fYW']j]b[[i]XUbW'Zfca 'h\Y'YWhiffg"$

57AY f WUa džci h

Gi Va]gg]cb cZ5ggYgga YbhHUg_g

D`YUgY`fYZYf`hc`h\Y`A ccX`Y`dU[Y`cZh\Y`Wci fgY`Zcf`Z fh\Yf`[i]XUbW\`cb`UggYgga Ybhigi Va]gg]cb"

I BGK `\Ug`U`ghUbXUfX``UhY`gi Va]gg]cb`dYbU`hmcZ

•)ı 'dYf'XUmž'Zcf'U``'UggYgga Ybhg'k \YfY'U'dYbU'hm'Udd`]Ygž'WUddYX'Uh'Zjj Y'XUmg'f1%&\$`\ci fg\z'UZhYf k\]WX'U'ghi XYbh\WUbbchgi Va]h'Ub'UggYgga Ybhž'UbX'bc'dYfa]hhYX'j Uf]Uh]cb"

5 WUXYa]W<cbYghmUbX D`U[]Uf]ga

 $6 \ Yk \ UfY \ "5b" Ugg][\ ba \ Ybh'h \ Uh']b \ XYg" d`U[\]Uf]g YX \ 'a \ UhYf]U \ "k \] \ "fYWY]j \ Y \ "U" \ ": \ U] \ "ž \ UbX" ghi \ XYbhg" k \ \ "c$

5 WUXYa] W + DZcfa Uh]cb

:]bU`'9I Ua]bUh]cbg.

:]bU``YI Ua g`]b`H%`&\$&&`k]```VY`\Y`X`cb`]bY`VYhk YYb`&- h\`5df]`!`%&h\`A Um`]bWi g]j Yž'UbX`gi dd`Ya YbhUfm YI Ua g`VYhk YYb`&' fX`!`&+h\`A Um`]bWi g]j Y"`Mci `UfY`fYei]fYX`hc`VY`Uj U]`UV`Y`cb`h\YgY`XUhYg"`D`YUgY`Xc bchhc`a U_Y`UbmdYfgcbU``cf`hfUj Y``UffUb[Ya Ybhg`Xi f]b[`h\]g`dYf]cX"`

57589A = 758J = 79