

ARTS1090

A YX]Už7i `hi fY`UbX`9j YfmXUm@]ZY

HYfa 'C bY''##'&\$&\$

7ccfgfgYiGjyYfj]Yk

GHJZZ:7cbHJWh:8YHJ]`g`

7cbj Ybcfg

7ci fgY 8YHJ] g

7 fYX]hDc]bhg**

Gi a a UfmcZh\Y 7ci fgY

A YX]Užī7 i `hi fY`UbX`9j YfmXUm@]ZY`cZZYfg`Ub`UWWgg]V`Y`[fci bX]b[`]b`h\Y`HfUX]h]cbgž'dYfgdYWhj Yg`UbX WcbW'dhg`cZa YX]U`ghi X]Yg"`GhUffi]b[`k]h\Y`XJUa]`]Uf`UbX`h\Y`Yj YfmXUmž'h\]g`Wci fgY`]bHcXi WYg`mci `hc`h\Y VfYUXh\`cZWcbhYa dcfUfma YX]U`ghi X]Yg`Zca `hY`Yj]g]cb`UbX`h\Y`HfUX]h]cb`cZa Ugg`a YX]U`ghi X]Ygž'hc hY`Yd\cbmUbX`h\Y`ghi XmcZbYhk cf_YX`a YX]U`UbX`Wca a i b]WUh]cb`hYW\bc`c[]Yg"`K]h\`Ub`YmY`cb`h\Y`k Um h\Uh'hY`Yj]g]cb`UbX`hY`Yd\cbm\Uj Y`UXUdhYX`hc`W\Ub[]b[`fYU`]h]Yg`cj Yf`h\Y`XYWUXYgž'h\]g`Wci fgY`Yl d`U]bg \ck `a YX]U`UbX`Wca a i b]WUh]cb`hYW\bc`c[]Yg`\Uj Y`HfUbgZcfa YX`h\Y`f\mh\a g`cZYj YfmXUm`]ZYž'h\Y cf[Ub]gUh]cb`cZXca Ygh]WgdUVWž'h\Y`Vci bXUf]Yg`VYhk YYb`df]j UhY`UbX`di V`]Wž'UbX`ci f`gYbgY`cZ]bj c`j Ya Ybhk]h\`bUh]cbU``UbX`di V`]WWc``YWhj]h]Yg"`\d\cbmg\UdY`h\Y`Yl dYf]YbW'`cZha YžX]ghUbW'ž a YX]Uh]cb`VmYl d`cf]b[`\ck `Vch\`hY`Yj]g]cb`UbX`hY`Yd\cbmg\UdY`h\Y`Yl dYf]YbW'`cZha YžX]ghUbW'ž

 $H\Y'WcifgY'k]```U`gc'igY'U'@AG"'H\]g'WUb'VY'UWWfggYX'Zfca'h\Y'IBGK''KYV'G]b[`Y'G][b'Cb'Uh\hrd.##a m''ibgk "YXi"Ui$

5`h\ci [\'h\Y'\\ci fgY']g'\\cbXi \\\Y\X'dfYXca]bUbhm]b'\\ZJ\\\!hc!\ZJ\\\'h\U\\\]b['a cXY\zi]h]g'YggYbh]U`'h\Uhmci \\\cho bgi `hih\Y'\\ci fgY'@A G'cb'U'k YY_`m\Vug]g'UbX'dUfh]\\\dUhY'U\\\]j Y`m]b'UbmX]g\\\gg]cbg'cf``YUfb]b[\\\cappa a dcbYbhg'h\UhUf]gY'Xi f]b['h\Y'\\ci fgY''

5ggYgga Ybh

 $\label{eq:localization} $$Mci^* A I GH'a U_Y'U'gYf]ci g'UhhYa dh'Uh'h\Y'k f]hhYb'UggYgga Ybh'hUg_g'f5ggYgga Ybh' 'UbX'5ggYgga Ybh' (£''hc'VY'Y')[]V'Y'hc'UWX]Yj Y'U'DUgg'[fUXY'Zcf'h\Y'Wci fgY'''$

5ggYgga Ybh'HUg_g'

5ggYgga Ybh'hJg_	K Y][\h	8i Y'8UHY	Gh XYbh@YUfb]b[CihWca Yg 5ggYggYX
±b!WUgg⁻Ei]n⁻%⁻	%\$ı	±b"hi hcf]U`g"Xi f]b["K YY_""	% <u>₹</u>
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FYUX]b['FYgdcbgY'	' \$1		

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J]Yk 'WUgg'hja YhUV'Y

H]a YHJV`Y

8UhY	HmdY	7 cbh/bh
K YY_'%'%+': YVfi Ufm!'&% : YVfi Ufm	@YWnifY	A YX]U'F]hi U`g'UbX'9j YfmXUm'@]ZY
		H\]g`k YY_`k]``Hu`_`UVci hih\Y`fY`Uh]cbg\]d`VYlk YYb a YX]U`UbX`W``hi fY`UbX`\ck `WcbhYa dcfUfm`]ggi Yg Ufci bX`h\Y`a YX]U`WUb`VY`YI d`cfYX`Zfca `h\]g
		dYfgdYWjj Y"
	Hi hcf]U`	H\]g`kYY_fg`hihcf]U``k]```WcjYf`h\Y`Zc``ck]b[`dc]bhg.
		<pre>%" 5WUXYa]WfYUX]b['g_]``g'UbX`glfUhY[]Yg &" K \UhXc'k Y'a YUb'VmfYj YfmXUm`]ZYfB ' " 8]ZZYfYbh'UddcfUWXYg'fc'h\Y'ghi XmcZa YX]U" (" < ck ']g'h\Y'ghi XmcZa YX]U'X]ZZYfYbh'Zfca ch\Yf'X]gWJd`]bYg'gi W\'Ug'dgmVXc`c[mž Wf]a]bc`c[mcf'gcWJc`c[m8) " K \Uh']g'U'f]hi U`3'K \Uhf]hi U`g'gi ffci bX'ci h i gY'cZh\Y'a YX]U'UbX'k\Uh'WUb'k Y'`YUfb Zfca 'h\Ya 3</pre>
K YY_'&.'&(': YVfi Ufm!'&, : YVfi Ufm	@YWhifY	A YX]U'UbX'Df]j UhY#Di V`]W@]ZY
. TVII UIIII		5acb['ch\Yf'h\]b[gž\]g'kYY_fg'hcd]W'cc_g'Uh'h\Y \]ghcf]WU`fY`Uh]cbg\]d'VYhkYYb'ficaYgfiUbX'aYX]U hYW\bc`c[]Yg"'KY'k]``Uf[iY'h\Uh'aYX]U']g'VYgh ibXYfghccX'Zfca'h\Y'dYfgdYWf]jY'cZh\Y'df]jUhY

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K_YY_', . '* '5df]`'! '%\$'5df	eyWh fy	@]j]b['k]h\ 'A cV]`Y'GcW] U`'A YX]U
		H\Y`K YY_`, ``YWi fY`YI d`cfYg`h\Y`WcbWfdhg`cZacV]]hm'UbX`h\Y`]XYU`cZ`]j]b[`k]h\`gcW]U``a YX]U"`K Yk]```cc_`Uhh\Y`XYj]Wfg`UbX`i gYf`dfUWjWfg`h\Uh\Uj YYa Yf[YX`U`cb[g]XY`h\Y`VfcUXYf`gcW]c`c[]WU``hfYbXcZ]bWfYUgYX`a cV]`]hmž`[`cVU``mž`UbX`YI d`cfY`h\YbYYX`hc`ghUmfWcbbYWfXfik\]`Y`a cj]b[`h\fci[\gdUWf''KYk]``U`gc``cc_`Uhh\Y`fc`Y`cZU`[cf]h\]a g`]bg\Ud]b[`h\Y`a YX]U`hcXUm'
	Hi læf]U`	H\Y`a U]b`WcbWYdhg`YId`cfYX`h\]g`k YY_`]b`h hcf]U`g]bWi XY/h\Y`fc`Y`cZgcW]U``a YX]U`]b`Yj YfmXUm`]ZYž k\Uh]g`a cV]`]hmž`]b`k\Uhk UmXcYg`a cV]`Y`a YX]U ZUW]`]hUhY`a cV]`]hm'`K Y`k]```U`gc`Wf]h]WU``miYIUa]bY`h\Y fc`Y`cZU`[cf]h\a g`UbX`]b`a YX]U`hcXUm'
		K Y'U`gc`Wcad`YhY'h\Y'gYWcbX'ei]n`]b'hihcf]U`g'h\]g k YY_"'
K YY_``% '5df]`'!`%+ 5df]`	@YWhi fY	A YX]UžGY`ZUbXʻ=XYbIJIm Cif`Ugh`]jY`YWIfY`cc_g'UhINY'fY`UIJcbg\]d VYIK YYb']XYbIJImUbX'a YX]U"K Y'k]``'Ug_'k\Uhfc`Yž]ZUbmžNY'a YX]U'd`Um]b'dfcXi WJb['UbX dYfdYhi UIJb['INY'WUgg]ZJWJIcfmfY[a]Yg'Vmk\]W\kY WJHY[cf]gY'UbX'i bXYfgHJbX'ci fgY`j Yg'UbX'YUW\ ch\Yf" .
	Hi Icf]U`	Hi hcf]U`g`h\]g`k YY_`k]``X]gW gg`h\Y`fc`Y`cZa YX]U`]b dfcXi W]b[`UbX`YbUW]b[`mci f`]XYbh]hm'`5fY`]XYbh]h]Yg X]gW fg]j Y`mdfcXi WYX3`5fY`h\Ym]bX]j]Xi U`]gYX`cf Wc``YW]j]g]b[3
K YY_'%\$.'&\$'5df]`'!'&(5df]`	@YWhi fY	F Yj]Yk '@YWn fY'! '=b'h\]g 'YWn fY'k Y'k]``fYj]Yk 'h\Y hcd]Wg'Wcj YfYX']b'h\Y'Wci fgY'UbX'Ubgk Yf'mci f ei Ygh]cbg']b'fY`Uh]cb'hc'h\Y':]bU`'9ggUm'Xi Y'bYI h k YY_"'
	Hi Icf]U`	H\]g`k YY_fg`@YWn fY`k]``fYj]Yk 'h\Y`Wci fgY`VUgYX cb`mci f`ZYYXVUW_`UbX`ei Ygh]cbg`UbX`cZZYf`hUf[YhYX Ugg]ghUbWY`k]h\'h\Y`:]bU``9ggUmUggYgga Ybh'
K YY_'%%`&+`5df]``!`&, 5df]`	Hi læf]U`	Hi hcf]U``gYWf]cbg`h\Uha YYhcb`: f]XUmg`k]```\Uj Y`U a U_Y!i d`h hcf]U``cb`Hi YgXUm5df]``&, h\"`D`YUgY Wcgbi `hmci f`a mi bgk 'h]a YhUV`Y`Zcf`K YY_''%%'Zcf h]a Yg`UbX``cWUh]cbg"'H\]g`k ci `X`VY`mci f`Z]bU` W\UbWY`hc`hU`_'k]h\`mci f`h hcf`UbX`[Yh\Y`d`k]h\`h\Y :]bU``9ggUmUggYgga Ybhg\ci `X`mci 'bYYX`]h'

FYgci fWyg

DfYgWf]VYX F Ygci fWfg

F Yei]fYX'HYI hVcc_'!'A Uf_\Ua ž'H"'? WW[S * 7hWdkVSk >[XW'DU`[fUj Yž'@cbXcbž'&\$%+"

 $H\Y'hY'l'hVcc__']g'Uj'U)'Y'Zcf'difWkUgY']b'h\Y'l BGK '6cc_g\cd'cb'h\Y'a U]b'GmXbYmWUa dig'''7cd]Yg'UfY U'gc'Uj U]'UV'Y']b'h\Y'\][\ \ 'i gY'Wc``YWf]cb'cZh\Y'l BGK '@]VfUfm''=Zmci'k]g\'hc'difWkUgY'h\Y'YVcc_'mci'WUb Zc``ck'h\YgY'']b_g'\YfY'!$

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 $C \, h \, Yf \, F \, Yei \,]fYX \, F \, YUX]b[\, g. \, '5 \, ``ch \, Yf \, fYUX]b[\, g \, `UfY \, `Uj \, \, U] \, `UV \, `Y \, 'j \,]U \, `h \, Y \, `Wei \, fgY \, `A \, ccX \, `Y \, 'g]hY \, " \, `=h \,]g \, ']a \, dcfh \, Ubh \, hh \, Uh \, mci \, `Wea \, d \, `YhY \, \, `U \, ``fYUX]b[\, g \, 'Zcf \, YUW \, 'k \, YY \, _'df]cf \, 'hc \, `UhhY \, bX]b[\, 'mci \, f'hi \, hcf]U \, "$

FYWca a YbXYX FYgci fWYg

9@G9"! @]VfUfmUbX'Ghi Xm'G_]``g'8Yj Y`cda Ybh'5@'i bXYf[fUXi UhY'ghi XYbhg']b'h\Y]f'Z]fghgYa YghYf'bYYX hc'Wca d'YhY'h\Y'`]VfUfmfg'9@G9'ghi Xm'g_]``g'hfU]b]b['a cXi `Y'VYZcfY'h\Y'YbX'cZK YY_') "'GYY'h\Y''9`]gY''hUV cb'h\Y'`]VfUfm\ca YdU[Y.`\hhd.#gi V'YWf i]XYg"`]VfUfm'i bgk "YXi "Ui #\`]gY'Zcf'Z fh\Yf']bZcfa Uhcb"

: i fh\Yf`]bZcfa Uh]cb`UVci hih\Y`@]VfUfmig`Wc``YWf]cb`UbX`gYfj]WYg`WJb`VY`Zci bX`\YfY`! \hd.#|bZc"`]VfUfmii bgk "YXi "Ui #\ YV#gYfj]WYg#gYfj]WYg"\ha`

H\Y'@YUfb]b['7YbffY'!'H\Y'@YUfb]b['7YbffY'cZZYfg'UWUXYa]Wg_]``g'gi ddcfhirc'U```ghi XYbfg'Ybfc``YX'Uh I BGK "'H\Y]f'gYfj]WYg']bWi XY']bX]j]Xi U``Wcbgi `HUf]cbgž'UWUXYa]Wg_]``g'k cf_g\cdgž'7cbj YfgUf]cb'7UZÅ [fci dgž'UbX'cb`]bY'UWUXYa]Wg_]``g'fYgci fWYg"'Mci 'WUb'a U_Y'Uddc]bha Ybfg'UbX'fYUX'UVci h'U```f\Ym\Uj Y hc'cZZYf'Uh\hd.#k k k"'Wi bgk "YXi "Ui #

7ci fgY 9j U'i Uhjcb UbX 8Yj Y'cda Ybh

DYf]cX]WU``mighi XYbhiYj U`i Uh]j Y`ZYYXVUW_`cb`h\Y`Wci fgY`]g`[Uh\YfYXži g]b[`Ua cb[`ch\Yf`a YUbgži BGK fig A m9I dYf]YbW'`dfcWYgg"

Gh XYbhZYXVUW_`]g`hU_Yb`gYf]ci g`mžUbX`Wcbh]bi U``]a dfcj Ya Ybhg`UfY`a UXY`hc`h\Y`Wci fgY`VUgYX`]b`dUfh cb`gi W\`ZYYXVUW_"DfYj]ci g`gh XYbhZYXXVUW_`UVci hh\Y`Wci fgY`fYUX]b[g`UbX`UggYgga YbhHUg_g`\Uj Y VYYb`UXXfYggYX`]b`h\]g`j Yfg]cb`cZh\Y`Wci fgY"`Mci `WUb`fYUX`U`XYgWf]dh]cb`cZW\Ub[Yg`k Y`a UXY`]b fYqdcbqY`hc`dUghqh XYbhZYXXVUW_`]b`h\Y`A ccX`Y"

Gi Va |gg|cb cZ5ggYgga YbhHUg_g

Gi Va]gg]cb cZ5ggYgga YbhHUg_g

Hi fb]h]b Gi Va]gg]cb

Image: Ybwci bhYf'U'dfcV'Ya k \Yb'UhYa dhJb['hc'gi Va]hmci f'Ugg][ba Ybht\fci [\ 'Hi fb]hJbž'd'YUgY

HY'Yd\cbY'9| hYfbU''Gi ddcfhcb'-',) '' ' ' %cf'Ya U] 'h\Ya 'cb'Y! hYfbU'hY'hgi ddcfh4 i bgk "YXi "Ui '"'Gi ddcfh
\ci fg'UfY', .\$\$Ua '-'\\$.\$\$da 'cb'k YY_XUmg'UbX'-.\$\$Ua '-') .\$\$da 'cb'k YY_YbXg'fl *) 'XUmg'U'mYUfŁ" Image:

UfY'i bUV'Y'hc'gi Va]hmci f'Ugg][ba YbhXi Y'hc'U'ZJi 'hk]h\ 'Hi fb]hJb'mci 'a UmUdd'mZcf'Ub'Y! hYbg]cbž'Vi hmci
a i ghfYhJ]b'mci f'hJW_Yhbi a VYf'Zfca '9! hYfbU''Gi ddcfhfU'cb['k]h\ 'Ubmch\Yf'fY'Yj UbhXcW a YbhgŁ'hc
]bWi XY'Ug'Yj]XYbW' 'hc'gi ddcfhmci f'Y! hYbg]cb'Udd']WUh]cb" Image: Ya U]''9! hYfbU''Gi ddcfhmci 'k]''

Ui hca UhJWJ''mfYW'] Y'U'hJW_Yhbi a VYfž'Vi h]Zmci 'hY'Yd\cbY'mci 'k]'''bYYX'hc'gdYWJZWJ''mUg_'Zcf'cbY"

Hi fb]hJb'U'gc'dfcj]XYg'i dXUhYg'cb'h\Y]f'gmghYa 'ghUh' g'cb'Hk]hYf"

; YbYfU``mž'UggYgga YbhiHug_g'a i ghVY'gi Va]hhYX'Y`YVWfcb]\W)``mj]U'Y]h\Yf'Hi fb]hjb'cf'U'A ccX`Y Ugg][ba Ybh'' =b']bgHJb\W'g'k \YfY'h\]g']g'bchdcgg]V`Yž']hk]``'VY'gHJhYX'cb'mci f'\\circ i fgY'g'A ccX`Y'g]hY'k]h\ U`hYfbUhj Y'gi Va]gg]cb'XYHJ]`g''

cfi]bZcfa Uh]cbicbi\ckihcigi Va]hUgg][ba Ybhgicbi]bYij]UiA ccXiY.i\hdg.#gh XYbh'i bgk "YXi "Ui #\ck! qi Va]hUgq][ba Ybha ccXiY

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

D`U[]Uf]ga i]gii g]b[ih\Yik cfXgicfi]XYUgicZch\YfgiUbXidfYgYbh]b[ih\Ya iUgimci fick b"i±iWUbihU_Yia Ubm Zcfa qžZfca iXYi]VYfUhYiW\YUh|b[ihciUVW]XYbhU`mWcdm]b[iZfca iUiqci fWYik]h\ci hiUW_bck iYX[Ya Ybh'i

IBGK '[fci dg'd'U[]Uf]ga ']bhc'h\Y'Zc``ck]b['WUhY[cf]Yg.

7 cdm]b[.'i g]b['h\Y'gUa Y'cf'j Yfmg]a]`Uf'k cfXg'hc'h\Y'cf][]bU`hYl h'cf']XYU'k]h\ci h'UW_bck `YX[]b['h\Y gci fW'cf'i g]b['ei chUh]cb'a Uf_g"'H\]g'U`gc'Udd`]Yg'hc']a U[Ygž'Ufh'UbX'XYg][b'dfcYWhgž'Ug'k Y``'Ug dfYgYbhUh]cbg'k\YfY'gca YcbY'dfYgYbhg'Ubch\Yf'g']XYUg'cf'k cfXg'k]h\ci h'WfYX]h'

⇒ Uddfcdf]UhY 'dUfUd\fUg]b[...7\Ub[]b['U'ZYk 'k cfXg'UbX'd\fUgYg'k \]'Y 'a cghmfYhJ]b]b['h\Y'cf][]bU` ghfi Wh fY 'UbX#cf'dfc[fYgg]cb'cZ]XYUg'cZh\Y'cf][]bU'žUbX']bZcfa Uh]cb'k]h\ci hUW_bck `YX[Ya Ybh'H\]g'U`gc Udd`]Yg']b'dfYgYbhUh]cbg'k \YfY'gca YcbY'dUfUd\fUgYg'Ubch\Yf'g']XYUg'cf'k cfXg'k]h\ci hWfYX]hUbX'hc d]YW]b['hc[Yh\Yf'ei chYg'UbX'dUfUd\fUgYg']bhc'U'bYk 'k \c`Yžk]h\ci hUddfcdf]UhY'fYZYfYbW]b["

7 c``i g]cb. 'k cf_]b['k]th 'cth Yfg'Vi hidUgg]b['cZZth Y 'k cf_'Ug'U'dYfgcb'g']bX]j]Xi U``k cf_"'7 c``i g]cb'U`gc]bWi XYg'dfcj]X]b['mci f'k cf_'thc'Ubcth Yf'ghi XYbh'VYZcfY'th Y'Xi Y'XUlfYZcf'Zcf'th Y'di fdcgY'cZth Ya

- i bXYfgfUbX mci f'f][\hg'UbX'fYgdcbg]V]`]hJYg'Ug'U'gh XYbhUhl BGK
- VY`Uk UfY`cZd`U[]Uf]ga ž`Wcdmf][\hzil BGK `Gh XYbh7cXY`cZ7cbXi WhUbX`5VWWdhUv`Y`I gY`cZ I BGK `=\forall H`F Ygci f\W\g`Dc`]\wh
- VY 'Uk UfY 'cZh\Y 'ghUbXUfXg 'cZVY\Uj]ci f'Yl dYWYX 'cZYj YfmcbY ']b 'h\Y 'l BGK 'Wca a i b]hm
- `cWUHY 'gYfj]WYg'UbX ']bZcfa UH]cb'UVci hI BGK 'UbX'I BGK '@]VfUfm

Gca Y'cZh\YgY'UfYUg'k]``VY'ZJa]`]Uf'hc'mci ž'ch\Yfg'k]``VY'bYk"'; U]b]b['U'gc`]X'i bXYfgHJbX]b['cZU``h\YfY`UhYX'UgdYWng'cZ9@+69'k]``\Y`d'mci 'a U_Y'h\Y'a cghicZmci f'ghi X]Yg'UhI BGK "'\\hd.##qi VYWfi |XYg"`]VfUfm'i bqk "YXi "Ui #\`]qY#JVci hY`]qY

5 WUXYa]W±bZcfa Uhjcb

: cf'YggYbhJU`gh XYbh]bZcfa UhJcb'fY`UhJb['hc.