



LING5024

@ $b[i]ghWg^cZGdc_Yb^9b[^]g\$

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

7ci fgY⁻Cj Yfj]Yk

'GhJZZ'7cbhJWh'8YhJ]`g'

'7cbj Ybcfg'

B Ua Y	9a U]`	5j U]`UV]`]m	@cWJhjcb	D\cbY
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GWXcc``7cbHJWhi±bZcfa Uh]cb

GW.cc``cZ<iaUb]h]Yg'UbX'@Ub[iU[Yg

@cWUhjcb. GWkcc`CZZJWYž'AcfjYb'6fckb'6i]X]b[ž'@YjY``&ž'&),

CdYb]b['< ci fg. 'A cbXUm! ': f]XUmž'- Ua '!') da

D\cbY. 'Ž*%'&'-',)'%*,%

: UI . Ž*%'&'-' ,) ', +\$)

9a U]`. \<u>U`4 i bgk "YXi "Ui</u>

7ci fgY 8YHJ] g

7 fYX]h'Dc]bhg'*

Gi a a UfmcZh\Y 7ci fgY

Mci 'k]``YI d`cfY'h\Y'dUhYfbg`cZgdc_Yb`9b[`]g\":Mci 'Z̄fghYI Ua]bY'h\Y'Zcfa UhJcb`cZgci bXg`UbX'h\Y gci bXg`H\Uha U_Y'i d'h\Y'9b[`]g\ gci bX'gmghYa "'Mci 'h\Yb'Vi]`X'Z̄fca 'g]b[`Y'gci bXg'hc'h\Y'Wca V]bUhJcb`cZ gci bXg']bhc'gm`UV'Yg'UbX'h\Y'fc'Y'cZgm`UV'Yg']b'9b[`]g\'f\nth\a ž'h\Uh]gž'h\Y'a Y`cX]\W\cbrci f'cZ gYbhYb\Wg"'\Ci 'U'gc'YI Ua]bY'h\Y'\cbghfi \WJcb'cZk cfXg'Z̄fca 'gci bXg'UbX'h\Y'\wca V]bUhJcb'cZk cfXg']bhc d\fUgYg'UbX'gYbhYb\Wg"':]bU``mž'mci 'YI d`cfY'k\UhHU_Yg'd`U\W'U\Vcj Y'h\Y'gci bXgž'h\Uh]gž'U\W\bhi UhJcb UbX']bhcbUhJcb']b'Vch\'Zcfa U``UbX'\\cei]U``\wcbhYl fg"'H\]g'\wci fgY'\Ug'Udd`]\WJhJcbg'Zcf`]b[i]ghg'k\c Yj U`i UhY'UbX'UbbchUhY'gdc_Yb'`Ub[i U[Y'XUhU']b'`Ub[i U[Y#]b[i]gh]\\g'']bXi ghf]Ygž]bhYfdfYhYfg'k cf_]b[']b a i `h]`]b[i U`gYhJb[g'k]'g\'g\'g\'g\'y\g''\U\X'Yfg'cZ9b[`]g\'U\X'YbC'\cgY'k\c k]q\'hc'_bck 'a cfY'U\ci h'9b[`]g\'g\'d\cbYh\\g'UbX'd\cbc`c[m'

7 ci fgY @YUfb]b['Ci hWca Yg

%" XYgWf]VY`h\Y`_YmZYUhi fYg`cZh\Y`9b[`]g\`gci bX`gmghYa`]bWi X]b[`UVW\bhi Uh]cb`UbX`]bhcbUh]cb" &" UbU`mgY``]b[i]gh]WXUhU`UbX`Uf[iY`h\Y`aYf]hg`cZh\UhUbU`mg]g" \" WaadUfY`Wa``cei]U``UbX`ZcfaU``dUhhYfbg`cZgdc_Yb`9b[`]g\"

HYUWX]b['GhfUhY[]Yq'

H\Y`Wci fgY`]g`HJi [\hJg`U`k YY_`mih\fYY`\ci f`gYa]bUf"'<U`ZcZh\Y`gYa]bUf`dfYgYbhg`h\Y`WcbW\dhi U`_bck`YX[Y`cZh\Y`dUhh\fbg`cZgdc_Yb`9b[`]g\"``+b`h\Y`gYWcbX`\U`ZcZh\Y`gYa]bUf`dfYgYbhg`k\cf_ik]h\gdYYW\`gUad`Yg`]b`k\]W\`h\YmUdd`mh\Y`WcbW\dhi U``_bck`YX[Y`hc`h\Y`UWhi U``dfcXi Wh]cb`UbX\Wcadf\\Ybg]cb`cZgdc_Yb`9b[`]g\"

5ggYgga Ybh

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5ggYgga Ybh'HJg_	K Y][\h	8iY'8UHY	Gh XYbh@YUfb]b[Ci hWca Yg 5ggYggYX	
Dfc YWi) \$1	\$, #\$) #&\$% `\$%\$\$`DA	% <u>ž&</u> Ž	
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### ##################################			
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SggYgga YbhflYgft			@UV`k cf_
Sgg][b 'N'Y WebhybhcZh\Y 'h'ghXi Y ']b 'k YY) * K YY(. '9%A UrW.'! %+ GYa]bUf) "'Vi]`X]b['U'fYgYUfW\']bglfi a Ybh
K YY(. %%A UrW.! %+ A UrW.! %+ A UrW. GYa]bUf 8]gW gg]cb %""7 cbj YfgUhjcbU"dfcWrggYg"]b gdc_Yb 9b["]g\ %""7 cbj YfgUhjcbU"dfcWrggYg"]b gdc_Yb 9b["]g\ dufn& 8""F YUX]b["gYh" C j Yfj]Yk ""F YUX]b["GYh(@UV k cf			5ggYgga YbhfHYglŁ
A UPWX %"-7 cbj YfgUlfjcbU"dfcWrggYg"]b"gdc_Yb'9b["]g\ dUfh& &""F YUX]b["gYh" Cj Yfj]Yk ""F YUX]b["GYh(@UV"k cf_ ""Vi]X]b["U XYa c[fUd\]Wei YgfjcbbU]fY K YY). % "A UPWX T %(5ggYgga Ybh Bc ZJW "tc ZJW \circ fg" H\Y h'gh]g"Xi Y Vm).\$\$ d"a " cb"A UPWX K YY**.8)"A UPWX T " GYa]bUf 8]gW gg]cb" %"F YUX]b["gYh) @UV"k cf_ """Wcfdi g"]b[i]gf\W]" K YY'+. %5df]"! + 5df] GYa]bUf 8]gW gg]cb %"F YUX]b["gYh)			5gg][b'h\Y'WcbhYbhcZh\Y'hYghXiY']b'kYY_')"
%""7 cbj YfgUhjcbU"dfcWYggYg"]b gdc_Yb 9b[]g\ dufh& &""F YUX]b[gYh' Cj Yfj]Yk ""F YUX]b["GYh(@UV"k cf_ *""Vi]X]b["U"XYa c[fUd\]Wei Yghjcbbu]fY K YY), % "A UfW." 1" 8(GYa]bUf	8]gW gg]cb
C j Yfj]Yk ""F YUX]b['GYh(@UV 'k cf_ *"'Vi]X]b['U'XYa c[fUd\]Wei Yghcbbu]fY K YY').'% 'A UfW.'I '&(
""FYUX b['GYh(@UV'k cf_ *"'Vi]'X b['U'XYa c[fUd\]Wei Ygh]cbbU]fY K YY_') . '% 'A UfW.'! '&(5ggYgga Ybh B c ZUW' 'hc ZUW' '\ci fg" H\Y 'H'gh]g 'Xi Y 'Vm) . \$\$'d"a " cb''A UfW. '%			&"``F YUX]b['gYh'
@UV k cf_ *"'Vi]X]b['U'XYa c[fUd\]Wei Ygf]cbbU]fY K YY_'). % 'A UfW.'! &(5ggYgga Ybh Bc ZUWY hc ZUWY \ci fg"H\Y hYgh]g Xi Y Vm).\$\$ d"a " cb 'A UfW. % Z&\$% K YY_'*. '&) 'A UfW.'! " % GYa]bUf 8]gW gg]cb ' A UfW. Cj Yfj]Yk &"'F YUX]b['gYh) @UV k cf_ ' "''Wcfdi g'`]b[i]gf]Wg" K YY_'+. '%5df]''! + '5df]' GYa]bUf 8]gW gg]cb %"'F YUX]b['gYh)			C j Yfj]Yk
"'Vi]'X]b['U'XYa c[fUd\]Wei Ygr]cbbU]fY K YY). % 'A UfW.'! &(5ggYgga Ybh Bc 'ZJWY 'bc 'ZJWY '\ci fg"'H\Y 'hYgh]g'Xi Y 'Vm) .\$\$'d"a " cb'A UfW. % ž&\$% K YY. '&) 'A UfW.'! " % GYa]bUf 8]gW gg]cb' A UfW. Cj Yfj]Yk &"'F YUX]b['gYh) @UV'k cf_ ""'Wcfdi g'']b[i]gr]Vg" K YY_'+. '%5df]''! '+ '5df]' GYa]bUf 8]gW gg]cb %"'F YUX]b['gYh)			' "'F YUX]b['GYh'(
K YY_'). '%, 'A UfWX'! '&(5ggYgga Ybh B c 'ZUWY' 'bc 'ZUWY '\c i fg" 'H\Y 'hYgh]g 'Xi Y 'Vm) . \$\$ 'd"a " cb 'A UfWX '% ž &\$% K YY_'*. '&) 'A UfWX'! '' % A UfWX'! '' % GYa]bUf 8]gW gg]cb ' A UfVX %" F YUX]b['gYh(C j Yfj]Yk %" F YUX]b['gYh) @UV'k cf_ " " " Wcfdi g "]b[i]gh]Wg" K YY_'+. '%'5df] ''! '+ '5df] GYa]bUf 8]gW gg]cb %" F YUX]b['gYh)			@UV`k cf_
A UfVX cb'A UfVX '% 2'&\$% K YY_'*. '&) 'A UfVX '! '' % GYa]bUf 8]gW gg]cb' A UfVX %" F YUX]b['gYh(Cj Yfj]Yk &" 'F YUX]b['gYh) @UV 'k cf			*"'Vi]'X]b['U'XYa c[fUd\]Wei Ygh]cbbU]fY
A UfWX %"F YUX]b['gYh'(C j Yfj]Yk &"'F YUX]b['gYh') @UV'k cf_ ' "''Wtfdi g'']b[i]gh]Wg" K YY_'+. '%'5df]` GYa]bUf 8]gW gg]cb %"F YUX]b['gYh')		5ggYgga Ybh	
%" F YUX]b['gYh'(C j Yfj]Yk &" F YUX]b['gYh') @UV k cf_ ' " ' Wcfdi g `]b[i]gh]Vg'' K YY_`+. '%'5df]` ! '+ '5df]` GYa]bUf 8]gW gg]cb %" F YUX]b['gYh')		GYa]bUf	8 JgW gg]cb
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1		' "'F YUX]b['gYh'*
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K YY_', .', '5df]`'!'%('5df]`	GYa]bUf	8]gW gg]cb
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K_YY_''%)	GYa]bUf	8]gW gg]cb
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		C fU``dfYgYblUljcb
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K_YY_`%\$.`&&`5df]``!`&, 5df]`	GYa]bUf	5df]``&&`]g`9UghYf`AcbXUmžU`diV`]W\c`]XUm'`Bc WUgg"

Fygci fWyg

DfYgWf]VYX F Ygci fWYg

 $\label{eq:hammer} $$H\Y'WcifgY'fYUX]b[g'UfY'cifbU`Ufh]WYg'UjU]`UV`Y'h\fci[\Y'BGK'']VfUfm'$$$

FYWca a YbXYX FYgci fWfg

 $\label{eq:cc_point} 6cc_'-Gci~bX'DUlttYfbg'cZ9b[~]g\'Vm@bXU'G\cW\underline{Y}m''6`UW\underline{k}~Y```Di~V`]g\Yfg''$

7 ci fgY '9j U'i Uh]cb 'UbX '8 Yj Y`cda Ybh

Gi Va]gg]cb cZ5ggYgga YbhHUg_g

Gi Va]gg]cb cZ5ggYgga YbhHUg_g

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

#mci 'YbWci bhYf'U'dfcV'Ya 'k \Yb'UhYa dhJb['rc'gi Va]hmci f'Ugg][ba YbhNhfci [\'Hi fb]hJbž'd'YUgY
hY'Yd\cbY'9I hYfbU'Gi ddcfhcb'-',) "''' %cfYa U]''h\Ya 'cb'YI 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'f1 *) 'XUmg'U'mYUf\zero
UfY'i bUV'Y 'rc'gi Va]hmci f'Ugg][ba YbhXi Y'rc'U'ZJi 'hk]h\'Hi fb]hJb'mci 'a Um'Udd'mZcf'Ub'YI hYbg]cbz'Vi hmci
a i ghfYhJ]b'mci f'hJW_Yhbi a VYf'Zfca '9I hYfbU''Gi ddcfhfU'cb['k]h\'Ubmch\Yf'fY'Yj UbhXcW a Ybhg\zero
]bWi XY'Ug'Yj]XYbWY 'rc'gi ddcfhmci f'YI hYbg]cb'Udd']WUh]cb'''=\mainin' Ya U]''9I hYfbU''Gi ddcfhmci 'k]'`
Ui hca UhJWJ'`mfYWY]j Y'U'hJW_Yhbi a VYfz'Vi h]Zmci 'hY'Yd\cbY'mci 'k]'`'bYYX'hc'gdYWJZJWJ'`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)``mij]U'Y]h\Yf'Hi fb]h]b'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'\\ci fgY'g'A ccX`Y'g]hY'k]h\ U`hYfbUh]j 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 `]g`i g]b['h\Y`k cfXg`cf`]XYUg`cZch\Yfg`UbX`dfYgYbh]b['h\Ya `Ug`mci f`ck b"'=hWJb'hU_Y`a Ubm Zcfa gžZfca `XY`]VYfUhY`W\YUh]b['hc`UWW]XYbhU`mWcdm]b['Zfca `U`gci fWY'k]h\ci hUW_bck `YX[Ya Ybh'

IBGK [fcidgdu[]uf]ga]bhch\YZc``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'dfcYWgž'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 Whi fY 'UbX#cf'dfc[fYgg]cb'cZ]XYUg'cZh\Y'cf][]bU`ž'UbX']bZcfa Uh]cb'k]h\ci h\UW_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 h\UhYX]hUbX'hc
d]YW]b['hc[Yh\Yf'ei chYg'UbX'dUfUd\fUgYg']bhc'U'bYk 'k \c`Yž'k]h\ci h\Uddfcdf]UhY'fYZYfYbW]b["

7 c``i g]cb.'k cf_jb['k]h\ch\Yfg'Vi hdUgg]b['cZZh\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_'hc'Ubch\Yf'ghi XYbhVYZcfY'h\Y'Xi Y'XUhYžcf'Zcf'h\Y'di fdcgY'cZh\Ya d`U[]Uf]g]b['UhiUbmh]a Yž'dUm]b['Ubch\Yf'dYfgcb'hc'dYfZcfa 'Ub'UWUXYa]WhUg_ž'ghYU']b['cf'UWei]f]b[Ubch\Yf'dYfgcb'g'UWUXYa]Wk cf_'UbX'Wcdm]b[']hz'cZYf]b['hc'Wca d'YhY'Ubch\Yf'dYfgcb'g'k cf_'cf'gYY_]b[dUma YbhZcf'Wca d'Yh]b['UWUXYa]Wk cf_"

±bUddfcdf]UhY`W]hUh]cb.`7]h]b[`gcifWrg`k\]W\`\UjY`bchVYYb`fYUXžk]h\cihUW_bck`YX[]b[`h\Y`´gYWcbXUfm´gcifWrZfca`k\]W\`_bck`YX[Y`cZh\Ya`\Ug`VYYb`cVhU]bYX"

8 i d`]\W\n]cb`ffgY`Z\d`U[]\Uf]ga "Ł`gi Va]\n]b[`mci f`ck b`k cf_z`]b`k \c`Y`cf`]b`dUffz`k \YfY`]h\Ug`dfYj]ci g`m VYYb`dfYdUfYX`cf`gi Va]\nYX`Zcf`Ubch\Yf`UggYgga Ybhcf`\\cf\\text{i fgY`UhI_BGK_`cf`Ubch\Yf`i b]j Yfg]\m'

7 cffYWnfYZYfYbWlb['dfUWnWyg.

- DUfUd\fUg]b[žgi a a Uf]g]b[žYggUmk f]h]b['UbX h]a Y a UbU[Ya Ybh
- 5ddfcdf]UhY'i gY'cZUbX'Uhtf]Vi h]cb'Zcf'U'fUb[Y'cZa UhYf]U`g']bWi X]b['hYl hž']a U[Ygž'Zcfa i `UY'UbX WbWYdhg"

±0X]j]Xi U``Ugg]ghUbWr`]g`Uj U]`UV`Y`cb`fYei YghZfca `H\Y`@YUfb]b[`7 YbhY`f\hd.#k k k "`Wi bgk "YXi "Ui #£" Gh XYbhg`UfY`U`gc`fYa]bXYX`h\UhWUfYZ ``ha Ybu[Ya Ybh]g`Ub`]a dcfhUbhdUfhcZgh XmUbX`cbY`cZh\Y]XYbh]Z]YX`WUi gYg`cZd`U[]Uf]ga `]g`dccf`h]a Y`a UbU[Ya Ybh'`Gh XYbhg`g\ci `X`U``ck `gi Z]W]Ybh'h]a Y`Zcf fYgYUfW\žXfUZh]b[`UbX`dfcdYf`fYZYfYbW]b[`cZgci fWfg`]b`dfYdUf]b[`U``UggYgga Ybh']hYa g"

IBGK @]VfUfmU`gc`\Ugʻh\Y`9@G9`hcc``UjU]`UV`Y`hc`Ugg]ghmci`k]h\`mcif`ghiXmUhIBGK "'9@G9`]gXYg][bYX`hc`]bhfcXiVW`bYk`ghiXYbhg`hc`ghiXm]b[`UhIBGK`Vih]hWUb`U`gc`VY`U`[fYUhfYZfYg\Yf`Xif]b[`mcifqhiXm"

7 ca d'Yhlb['h\Y'9@&9'hi hcf]U`'UbX'ei]n'k]`'YbUV'Y'mci 'hc.

 UbU`mgY`hcd]\Mgž'd`Ub`fYgdcbgYg`UbX`cf[Ub]gY`fYgYUf\W\`Zcf'U\WXYa]\Wk f]hjb[`UbX`ch\Yf UggYgga YbhiHUg_g

5WUXYa]W = DZcfa Uh]cb

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

- fYei Yghg Zcf Yl hYbg]cb/
- `UhY`gi Va]gg]cbg`[i]XY`]bYg/
- fYj]Yk 'cZa Uf_g/
- I BGK '<YU`h\ 'UbX'GUZYhm'dc`]W[Yg/
- YI Ua]bUh]cb dfcWYXi fYg/
- gdYWJU``Wcbg]XYfUhjcb`]b`h\Y`Yj YbhcZ]``bYgg`cf`a]gUXj Ybh fY/
- gh XYbhYei]lmUbX X]gUV]]lm/
- ÜbX'ch\Yf'YggYbhJU`'UWUXYa]W]bZcfa UhJcbž'gYY

\hdg.#k k k "Ufhg"i bgk "YXi "Ui #W ffYbhghi XYbhg#UWUXYa]W]bZcfa Uhcb#dfchcWc`g![i]XY`]bYg#